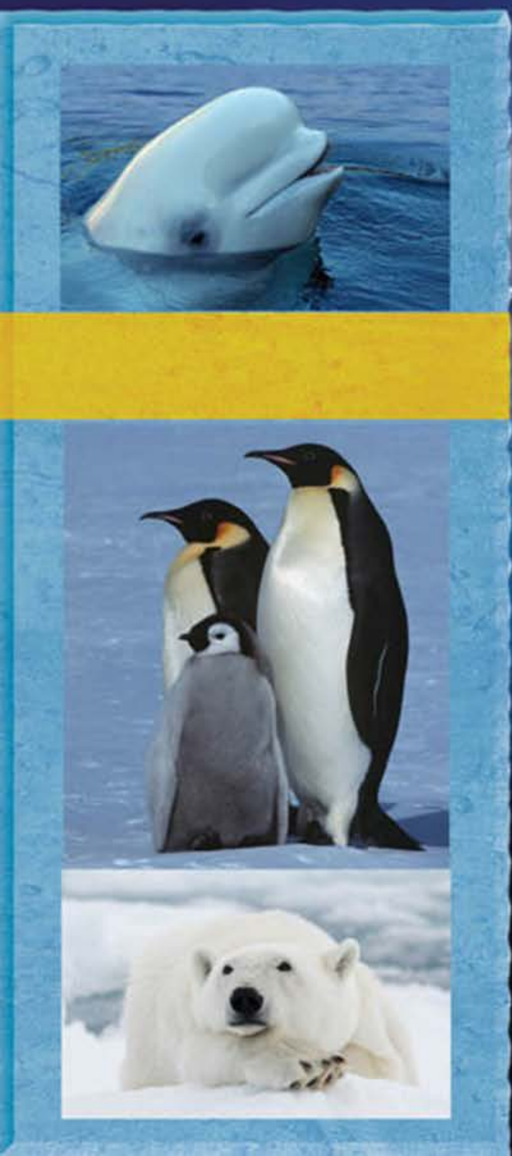
Antarctica and the Arctic Circle

A Geographic Encyclopedia of the Earth's Polar Regions



Andrew J. Hund, Editor

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Volume 1: A–I

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Preface

The polar regions are the most frigid, desolate, and seemingly inhospitable places on the earth. To many people, the polar regions are simply a frozen wasteland that offers little but danger and treachery, while others see only the Arctic for its riches in natural resources. Some people view the frozen lands as a tranquil, captivating, and awe-inspiring place of wonder. Still others have been calling the Arctic home for thousands of years. This interdisciplinary two-volume alphabetically organized encyclopedia has about 350 entries covering polar region topics within the humanities (history, linguistics, and religion); social sciences (archaeology, anthropology, indigenous studies, economics, geography, political science, and sociology); natural sciences (space sciences, earth sciences, life sciences, chemistry, and physics, especially astrophysics); and the applied sciences (environmental studies and forestry, law, military sciences, and transportation).

This encyclopedia covers the Arctic and Antarctic lands, including the abandoned, uninhabited, and presently inhabited places in the Arctic, the disputes between countries over the various lands and island territories, and the continental shelf ownership. The Canadian Archipelago, Franz Josef Land, New Siberian Islands, Hershel Island, and Greenland in the Arctic are discussed. Some of the Antarctic geographic places include the Antarctic Circle, Antarctica Ice Sheet, Antarctic Peninsula, East Antarctica, Transantarctic Mountains, Antarctic volcanoes, West Antarctica, Vinson Massif, Lake Vostok, the Lambert Glacier, and the Paulet, Ross, South Sandwich, and Snow Hill Islands to name only a few.

The original inhabitants of the Arctic region are the central feature of this work. The Northern indigenous groups' history, ways of life (past and present), and world view are highlighted throughout the work. The various cultures of the Northern indigenous people include the Aleuts/Unangax, Chukchi, Dolgans, Enets, Eskimos, Evens, Evenks, Eyak, Gwich'in, Inuit, Ket, Khanty, Koryak, Mansi, Nenets, Nganasan, Sami, Selkup, Siberian Yup'ik, and Yukaghir, which provide a unique window into Arctic life throughout time. The sociopolitical issues of the Northern indigenous groups within their respective countries and the world are examined. Some examples are the recent Inuit lawsuits over climate change, sovereignty and policy issues (past and present), and present political realities for the Northern indigenous groups.

Mixed in the entries are the early Europeans expeditions to the polar regions. Some of the first explorers are highlighted as are the 3 major Arctic expeditions and the 16 major expeditions that make up the Heroic Era of Antarctic Exploration.

The explorers and their triumphs and tragedies are highlighted. Some explorers are well known (Amundsen, Bartlett, Cook, Nordenskjold, and Shackleton) and others are not so well known (Crean, Klënova, Henson, and Gerritsz). The commonly known expedition tragedies are discussed as well as lesser known ones, such as the lost patrol, the Eskimo Coast disaster of 1885, B52G Stratofortress crash of 1968, the Lena Massacre of 1912, the human impacts on the Antarctic wilderness, the radioactive iodine (I-131) human experiments in Alaska, and the Ogotoruk Creek, Alaska radioactive tracer experiment.

The polar regions are the lands of unique animals. Some of the unique animals that live in the polar regions include the Arctic fox, Arctic ground squirrel, Arctic hare, Arctic salmon species, caribou, lemmings, musk oxen, polar bear, and wolverine. The grolar bear species is also highlighted as well as human's use of animals for subsistence and dogs in the Arctic. Prehistoric animals such as dinosaurs and Mesozoic marine reptiles that once roamed the Antarctic region are included. The prehistoric animals of the Arctic include the baby woolly mammoths, woolly mammoth, Yukaghir mammoth, and even a ginger mammoth. There was even an Arctic camel.

The various birds unique to each of the polar regions include Antarctic penguins (Adélies, chinstrap, emperor, gentoo, king, macaroni, and rockhopper);, Arctic seabirds; seals from both polar regions, such as the Antarctic fur, bearded, crabeater, harp, hooded, leopard, ribbon, ringed, ross, southern elephant, spotted, and Weddell seals; and many songbirds (Arctic redpoll, Lapland longspur, snow bunting, etc.) and birds of prey (gyrfalcon, snowy owl, etc.) that are characteristics of the Arctic. Special attention is given to how animals survive in the frozen lands.

Beside seals, the other marine mammals of the polar regions include the beluga, bowhead, Gray's beaked, gray, humpback, long-finned pilot, narwhal, northern bottlenose, southern bottlenose, southern right, and sperm whales. Also included are the Orca and two sharks (Pacific sleeper and the Greenland shark). Whaling is discussed as is a tragic whaling fleet disaster in 1871 in Alaskan waters. The special nature parks and reserves for the Arctic wildlife, such as the Arctic National Wildlife Refuge (ANWR), Bylot Island Migratory Bird Sanctuary, Chamisso Wilderness, Gates of the Arctic National Park and Preserve, Northeast Greenland National Park; Lena Delta Wildlife Reserve, Tuktut Nogait National Park, and Vuntut National Park of Canada are discussed. There are also international laws protecting the polar regions, such as the Protocol on Environmental Protection to the Antarctic Treaty and the United Nations Convention on the Law of the Sea.

Throughout this encyclopedia, the main characteristic of the polar region is *ice*. Topics covered include ice shelves in both polar regions. The Antarctica Ice Sheet is covered extensively through many entries. Entries are also focused on how ice cores are collected and analyzed, and provide a glimpse into the earth's past climates. The classification and monitoring of icebergs as well as how ice is formed are included in the discussion. The polar desert and the ice domes Argus, Charlie, and Fuji (Valkyrie) are unique features of Antarctica as is the Arctic drifting ice stations. There are even entries on pink snow, Blood Falls Glacier, and a boat made of ice and saw dust called "Pykrete." Ice worms, the hibernating abilities of the Arctic wholly bear caterpillar, and the microbial critters' survival in the cryosphere are also discussed.

The flora of the polar regions are considered, with topics such as Arctic botany, Arctic shrub range expansion, benthic community, climate change and invasive species proliferation in the Arctic, and tundra. Another unusual topic is the snowless McMurdo dry valleys of East Antarctica. In addition to these traditional topics, the encyclopedia covers general science knowledge about the polar regions, such as the three definition of the Arctic, boreholes, pingo formation, magnetic field and longitude, radioactivity in the Arctic, cryoprotectorants, Erebus crystal formation, polar night, and the midnight sun. Unique science topics include how to launch a rocket, the freezing point of a chemical substance, and meteorites in Antarctic.

The marginal seas of the Arctic and Antarctic are covered in detail. These include the Amundsen, Bellingshausen, Ross, and Weddell Seas as well as the Barents, Beaufort, Chukchi, East Siberian, Greenland, Kara, and Laptev Seas. The disputes linked to these seas are also discussed, such as the Arctic shipping, the Beaufort Sea dispute, sector principle in the Arctic, and the Northwest Passage claims and disputes. Beneath the seas are also examined such as the Arctic basin and the continental shelf claims in the Arctic. The rivers and watersheds flowing into these marginal seas are included, such as the Colville, Indigirka, Kolyma, Khatanga, Lena, Yana, Ob, Pechora, Yenisey, Mackenzie, and Yukon Rivers. The effects of human's interactions on these waters are discussed with such entries as environmental legacy of Novaya Zemlya, nuclear waste in the Arctic, the nuclear tests at Novaya Zemlya, and the sunken Soviet/Russian nuclear submarines.

The various human activities taken place in polar regions are also highlighted, such as the growing tourist industry, the effects of natural resource extraction/development, and influence of climate change on Arctic and Antarctic ecosystems. The polar institutes and the research being conducted in the polar regions are discussed. Some of the research stations and institutes included are the Alfred Wegener Institute, Amundsen–Scott South Pole Station, Bharati Research Station, Dirck Gerritsz laboratory, King Sejong Antarctic Station, and Vostok Station.

Lastly, the encyclopedia also covers topics above the land and seas and include atmospheric and astrophysics topics such as Arctic air pollution, Arctic haze, atomic detonations and weapons in the Arctic, aurora australis, aurora borealis, aurora sound, auroral substorm, grasshopper effect, geospace, incoherent scatter radar, the polar ionosphere, rocket ranges in the Arctic; solar energetic protons

(SEPs), solar winds, and space weather. The effect of climate change and the introduction of invasive species, melting of permafrost, ice caps, and glaciers are examined. Lastly, it is hoped this work will result in people having a better appreciation of the polar regions and even inspire young minds to become a researcher in the polar regions.

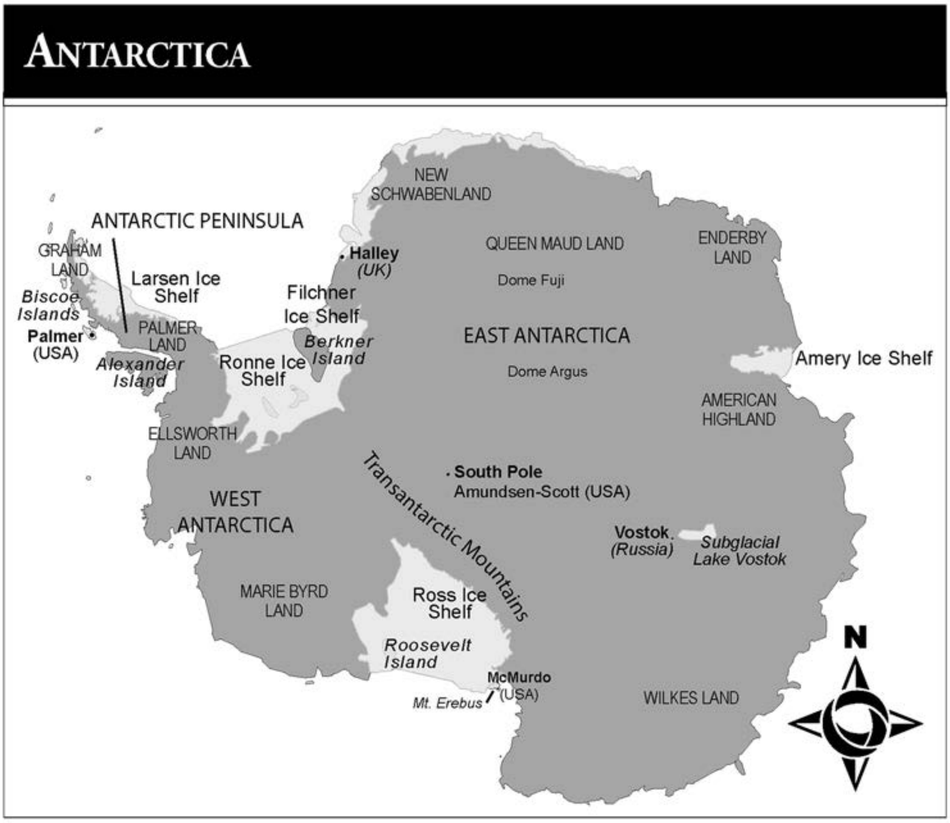
Andrew J. Hund

INTRODUCTION

Polar regions are considered to be the most frigid, desolate, and seemingly inhospitable places on earth. Light and temperatures are extreme and ever changing throughout the year. Summers are short and winters are long, and most of the Arctic terrain consists of large mountain ranges separated by enormous distances that consist of fields of tundra, glaciers, and impassable river systems, which rest atop large areas of permafrost. Antarctica is barren and predominately ice covered. To many people, the polar regions are simply frozen wasteland that offers little but danger and treachery. To others, the frozen lands are tranquil, captivating, and awe-inspiring places of wonder. Some value the Arctic solely for its abundance of natural resources for capital gain, while others value the Arctic as a sacred, interconnected ecosystem that must be protected to maintain a natural/subsistence way of living that has sustained peaceful polar societies for thousands of years. Modern science has also revealed that diverse plant and animal species had developed sophisticated genetic adaptations to survive in the polar regions. Invariably, the study of polar regions contributes to a vast and fascinating repertoire of human knowledge that beckons further study and seemingly serves as a self-perpetuating source of inspiration for learning in several different areas.

The study of polar regions offers a rich historical account of early inhabitation, exploration, and trade in Arctic and Antarctic regions. The Northern indigenous people were the first humans to settle in and call the Arctic home. After that, the earliest explorers to the Arctic were the Vikings, who voyages pre-dated those of other Europeans by several hundred years. Erik the Red is perhaps the most famous Viking known to have traveled to Greenland around 982, even though other Norsemen are believed to have traveled to Greenland prior to that time. European Exploration into the polar regions started during the "Age of Discovery," or what is sometimes called the "Age of Exploration." The Age of Discovery began in the early fifteenth century and ended in the seventeenth century, a period that represented a noteworthy span of time between the Middle Ages and the Modern Era. This time period started around 1453, when the Ottoman Empire captured Constantinople. In 1494, the Treaty of Tordesillas was signed, and with it, the trade links between Europe and Asia were cut off. With the loss of access to the profitable Asian markets, Europeans began exploring the world by sea and land with the intention of locating new trade routes to Asia.

During the Age of Discovery, attempts to travel and explore every corner of the world were undertaken, and with these attempts, a wealth of new cartographic



knowledge was gained. This new knowledge was distributed widely via Johann Gutenberg's (1395–1468) invention of the printing press in 1452. New maps and knowledge about the world included the Americas, Oceania, and the polar regions. The new information about the existence of these other largely unexplored parts of the world captured popular imagination and inspired expeditions, some described of a heroic nature. Those persons willing to travel to largely unexplored regions of the world commonly lacked the necessary resources and were thus dependent on governments and wealthy benefactors for providing the vessels, supplies, and men to carry out the expedition. Nations and benefactors sought a return on their investment in the form of precious metals (e.g., gold and silver) and trade goods (e.g., tea, silk, textiles, and spices).

A trade route to Asia that would bypass the Ottoman Empire was highly desired by the Europeans because the journeys around Africa or South America, though possible, were extremely time consuming. Naturally, European merchants sought a shorter trade route. At the time, the two possible shorter alternate trade routes were the Northwest and Northeast Passages. These routes had not yet been established, so many explorers were sent out with the distinct goal of locating these passages. In 1497, King Henry VII of England enlisted John Cabot (1450–1499) to search for the Northwest Passage. The Northwest Passage is a series of Arctic maritime passages from the Atlantic to the Pacific running through the northern waters of Canada and North America (Alaska). The Europeans also sought to find a suitable Northeast Passage, that is, a trade route from Atlantic and Pacific over northern Russia. One of the first to locate the Northeast Passage was the Englishman Hugh Willoughby in 1553.

Navigating the Arctic waters for an Asian trade route proved to be more of a challenge than the Europeans had envisioned. Early explorers who searched unsuccessfully for the Northeast and Northwest Passages were Richard Chancellor (1533), Martin Frobisher (1576), John Davis (1587), Willem Barentsz (1554), John Hearne (1769), Semyon Dezhnev (1648), James Cook (1776), and George Vancouver (1793). Notable Northwest Passage expeditions included the Baffin (1616), Foxe (1632), and Middleton (1746) explorations. During the eighteenth and nineteenth centuries, other expert land and sea explorers continued to search for the northern maritime passages, including Joseph Billings (1785), William Edward Parry (1819, 1821, and 1827), Peter Warren Dease (1836–1839), Ferdinand Petrovich Wrangel (1820), Pyotr Fyodorovich Anjou (1820), and John Ross (1829). All failed to locate an Asian trade route. Collectively, these early polar explorers experienced extreme weather conditions and were mostly ill-prepared for traveling, which resulted in unnecessary mishaps, tragedies, and even death from various illnesses (e.g., scurvy, starvation, and exposure to the cold).

In 1851, Robert McClure (1807–1873) was credited with being the first to discover the Northwest Passage, but his route was not passable. In 1854, John Rae (1813–1893) discovered a usable passage. In 1845, the Franklin Expedition under the command of John Franklin (1786–1847) attempted to navigate the passage, but the vessels HMS *Erebus* and HMS *Terror* became trapped in the ice, and the crews of about 130 men perished by the late 1840s. The search for Franklin and his crew was monumental and helped popularize the dangers and adventure of Arctic exploration. Some of the Franklin search expeditions were the Rae–Richardson Polar Expedition and the expeditions led by James Clark Ross and William Pullen, all in 1848; and those led by Saunders in 1849; Horatio Austin, Erasmus Ommaney, William Penny, and John Ross in 1850; Edward Belcher and Edward Augustus Inglefield in 1852; John Rae in 1854; and Francis Leopold McClintock in 1857.

The Northwest and Northeast Passages were not successfully crossed until the early twentieth century. In 1906, Roald Amundsen and his crew of six spent three years successfully navigating through the Northwest Passage in the small ice-fortified fishing ship, the *Gjøa.* Boris Vilkitsky (1885–1961) was the first captain to successfully lead a Russian expedition from Vladivostok to Arkhangelsk with the icebreaker vessels *Taymyr* and *Vaygach*, in 1915. In 1909, Robert Peary became

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the first person to reach the North Pole (90° N). Unfortunately, Peary's North Pole accomplishment is accepted only by some.

During the Age of Discovery, a great deal of knowledge about the Arctic was discovered with less known about Antarctica. A significant reason for this was that Antarctica did not have a trade route nor did it lead to the prized Asian markets. Early exploration in Antarctica was limited to whalers and the occasional explorers. Some early explorers to venture near Antarctica included Ferdinand

Magellan (1520), Anthony de la Roché (1675), James Cook (1773), and James Clark Ross (1839–1843). The first explorers to discover Antarctica were Fabian von Bellingshausen, Edward Bransfield, and Nathaniel Palmer in 1820. An American sealer and captain, John Davis, is believed to have been the first person to set foot on Antarctica in 1821. The next confirmed people to set foot on Antarctica included Alexander von Tunzelmann, a New Zealander, and Henrik Johan Bull and Carsten Borchgrevink, both from Norway. They landed in 1895, 74 years after Davis.

In 1895, the Sixth International Geographical Congress (1895) passed a general resolution claiming that Antarctic was the last unexplored area on the earth. The European countries were no longer searching for trade routes, so the focus became showcasing the honor, status, and prestige of a particular country. In short, the explorations to Antarctica served nationalistic purposes. The resolution of the Sixth International Geographical Congress sparked nationalistic rivalries and launched 16 major expeditions, as well as numerous scientific and geographical quests. Some of the early vessels became ensnared in the ice, trapping them for extended periods of time or even crushing them. Media coverage of the Antarctic explorations and tragedies popularized and highlighted the difficult and seemingly hopeless rescue missions in the harsh frozen Antarctic region as well as personified individual courage, bravery, and, at times, impetuous actions. These reports made heroes of the explorers and helped solidify the idea that the polar regions were a place for ensuring bravery, manhood, and even bravado. The primitive nature of modes of transportation and technology used during these early expeditions resulted in heroic feats of human endurance. Collectively, the expeditions resulted in 17 people losing their lives (13 died during service and 4 from expedition-related illnesses). This period of time in Antarctic history is called the "Heroic Age of Antarctic Exploration" and lasted roughly 20–25 years. Nonetheless, the politics of early exploration and discovery in polar regions offers a treasure trove of excitement for connoisseurs of ironic accounts of history, survival, and heroic adventure.

The heroic age ended with the Imperial Trans-Antarctic Expedition or Endurance Expedition (1914–1916) or with Shackleton's death during the Shackleton–Rowett Expedition (1921–1922). The achievements during the heroic age were considerable in regard to gaining scientific knowledge and in the mapping and exploration of coasts and the interior of Antarctic, and also saw the reaching of the South Pole and the traversing of numerous ice shelves, mountains, volcanoes, and glaciers. After this time period, the explorers commonly used modern machinery for exploration and expeditions.

During the 1940s and 1950s, activities in the polar regions were primarily military based. For example, the U.S. Navy directed several operations in the Antarctic, such as Highjump (1946–1947), Windmill (1947–1948), and Deep Freeze (1955–1956). In 1943, the British military conducted Operation Tabarin" After World War II, the U.S. military regarded the Arctic as a vitally and strategically important region for U.S. defense forces. The U.S. military conducted Operation Chrome Dome and Operation Iceworm, and set up the DEW line and conducted nuclear tracer and radioactive iodine experiments in rural Alaska. These military operations during and after World War II and into the Cold War set a hostile tone over the polar regions, which fortunately thawed at the end of the Cold War.

Modern exploration of polar regions focuses on social, environmental, and natural resource research. For example, the effects and influence of climate change, rapid economic growth, and technological advances on terrain, plants, animals, and humans in polar regions are of considerable interest. The changes in the well-being of indigenous people are of concern and interest to indigenous people and scientists alike. In addition, modern Antarctic and Arctic regional exploration primarily centers on the use of natural resources and the generation of scientific research.

Antarctica and the Arctic Circle: A Geographic Encyclopedia of the Earth's Polar Regions is an interdisciplinary encyclopedia that covers the past and present of the polar regions through topics within the humanities (history, linguistics, and religion); social sciences (archaeology, anthropology, indigenous studies, economics, geography, political science, and sociology); natural sciences (space sciences, earth sciences, life sciences, chemistry, and physics, especially astrophysics); and the applied sciences (environmental studies and forestry, law, military science, and transportation). It is designed to provide a holistic view of the past and present as well as future directions in polar research. The entries in this work redesigned to raise curiosity in readers to further explore the lands, cultures, animals, plants, and anything else that can be envisioned and discovered of interest in polar regions.

In the book, *The Worst Journey in the World* (1922), Apsley George Benet Cherry-Garrard (1886–1959) sums up polar exploration as follows:

> Polar exploration is at once the cleanest and most isolated way of having a bad time which has been devised . . . There are many reasons which send men to the Poles, and the Intellectual Force uses them all. But the desire for knowledge for its own sake is the one which really counts and there is no field for the collection of knowledge which at the present time can be compared to the Antarctic. Exploration is the physical expression of the Intellectual Passion. And I tell you, if you have the desire for knowledge and the power to give it physical expression, go out and explore. If you are a brave man you will do nothing: if you are fearful you may do much, for none but cowards have need to prove their bravery. Some will tell you that you are mad, and nearly all will say, *"What is the use?"* For we are a nation of shopkeepers, and no shopkeeper will look at research which does not promise him a financial return within a year. And so you will sledge nearly alone, but those with whom you sledge

> will not be shopkeepers: that is worth a good deal. If you march your Winter Journeys you will have your reward, so long as all you want is a penguin's egg.

May those who read from this book experience the joy of exploring their own quest for knowledge of polar regions; may you each find your own penguin's egg!

Andrew J. Hund

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Timeline

Mesozoic (252–65 mya)	Antarctic seas are populated by marine reptiles
Cretaceous (between 145 and 65 mya)	Paleoecology of Antarctica
Pliocene (5.332–2.588 mya)	Pliocene Arctic
200,000–4,000 years ago	Woolly mammoths roamed the Arctic Rock Carvings in Alta (4,200–500 BC)
325 BC to sixteenth century	Thule Culture Dorset Culture
1614	Smeerenburg
1768–1771	First Voyage of James Cook
1772–1775	Second Voyage of James Cook
1776–1779	Third Voyage of James Cook
1819–1821	Russian Antarctic Expedition
1868	First German North Polar Expedition
1871	Whaling Fleet Disaster
1875–1876	British Arctic Expedition
1882–1883	International Polar Years (IPY)
1885	Eskimo Coast Disaster
1901–1903	Gauss Expedition
1901–1903	Swedish Antarctic Expedition
1901–1904	Discovery Expedition
1902–1904	Scottish National Antarctic Expedition
1907–1909	Nimrod Expedition
1910	Lost Patrol
1910–1912	Japanese Antarctic Expedition
1910–1913	British Antarctic Expedition
1911–1912	Second German Antarctic Expedition

1911–1914	Australasian Antarctic Expedition
1912	Lena Massacre
1913–1918	Canadian Arctic Expedition
1914–1917	Imperial Trans-Antarctic Expedition
1920	Arctic and Antarctic Research Institute
1921–1922	Shackleton–Rowett Expedition
1923	National Petroleum Reserve—Alaska (NPR-A)
1925–	Sector Principle in the Arctic
1928 and 1948	Norwegian Polar Institute
1932–1933	International Polar Years (IPY)
1938–1939	German Antarctic Expedition
1946	Operation Nanook
1950	International Geophysical Year
1953	Inuit Arctic Relocation
1955–1957	Radioactive Iodine (I-131) Human Experiments in Alaska
1957	Russian Antarctic Vostok Station
1958	United Nations Convention on the Law of the Sea (UNCLOS) I
1959	Antarctic Treaty System
1960	United Nations Convention on the Law of the Sea (UNCLOS) II
1960	South African National Antarctic Expedition (SANAE)
1961	Protocol on Environmental Protection to the Antarctic Treaty
1961	Tsar Bomba detonated
1961–1968	Operation Chrome Dome
1962	Ogotoruk Creek, Alaska Radioactive Tracer Experiment
1962–1972	Nuclear Power at McMurdo Station, Antarctica
1965–2003	Sunken Soviet/Russian Nuclear Submarines in Arctic
1966	Bylot Island Migratory Bird Sanctuary
1968	Thule Air Base, Greenland B52G Stratofortress Crash
1968	Prudhoe Bay State #1 Oil Discovery
1970	Sermilik Station

1971	Alaska Native Claims Settlement Act
1971–1981	Climate, Long-Range Investigation, Mapping, and Prediction (CLIMAP) Project
1972	Northeast Greenland National Park
1973	Lincoln Sea Dispute
1973	Distant Early Warning Line
1973	Lomonosov Ridge Claims
1973	United Nations Convention on the Law of the Sea (UNCLOS) III
1973–	Hans Island Dispute
1975	Chamisso Wilderness
1975	Toolik Field Station
1975–	United States Bases in Greenland
1980	Arctic National Wildlife Refuge (ANWR)
1980	Gates of the Arctic National Park and Preserve
1981	Georg von Neumayer Station, Neumayer Station, Neumayer III Station
1985	Lena Delta Wildlife Reserve
1988	King Sejong Antarctic Station
1989	Polar Research Institute of China (PRIC)
1989	Zhongshan (Sun Yat-sen) Station
1990	Troll Station
1992	Arctic drifting ice camp “Weddell-1”
1993	Arctic Council
1993	Barents Euro-Arctic Council
1995	Vuntut National Park of Canada established
1996	Laponian Area
1996	Tuktut Nogait National Park established
1997	Zackenberg Research Station
2001	University of the Arctic (UARCTIC)
2004	Ilulissat Icefjord
2004	Natural System of Wrangel Island Reserve
2004	Agreement on the Conservation of Albatrosses and Petrels

2006	Association of Polar Early Career Scientists (APECS)
2007–2008	International Polar Years (IPY)
2008	Ilulissat Declaration
2008–	Inuit Lawsuits over Climate Change
2010	Putorana Plateau
2012	Bharati Research Station
2013	Dirck Gerritsz Laboratory, the Netherlands

A

Abandoned Arctic Islands

There are hundreds, if not thousands, of uninhabited islands in the Arctic Circle with only about 100 being inhabited islands. There are several formerly inhabited islands in the Arctic Circle, which are now abandoned for various reasons. These islands are found in Canada (Herschel Island, Somerset Island, and Devon Island), Greenland (Alluttoq Island and Qeqertarsuaq), Norway (Edgeøya, Svalbard, and Skorpa), and Russia (Wrangel Island).

Herschel Island (Canada)

Herschel Island (69° 35′N 139° 5′W) is an uninhabited island located in the Beaufort Sea about 3 miles (5 km) off the Yukon Territory coast and 45 miles (72 km) east of the Alaskan mainland. The total area of Herschel Island is 45 square miles (116 sq. km). The island is 9.3 miles (15 km) long and 5 miles (8 km) wide. The highest point is 596 ft. (182 m) and the dominant terrain is tundra. The Western Canadian Inuit (Inuvialuit) still use the island for subsistence activities, such as gathering, fishing, whaling, and hunting. Archaeological evidence suggests that the Herschel Island was first inhabited by the Thule and Inuit people over 1,000 years ago.

Sir John Franklin is credited with being the first European to discover the island. The island was named on July 15, 1826. Due to vague note-taking by Franklin, there is some confusion as to whom the island was named after, which could be one of three people from the Herschel family (e.g., Sir William Herschel, Caroline Herschel [sister of William], or Sir John Herschel [son of William]). Upon Franklin's arrival, there were three Inuvialuit settlements on the Island, with the population ranging from several hundred to about 2,000 Inuvialuit.

In the late nineteenth century, the Beaufort Sea was found to have one of the few remaining larger populations of bowhead whales, which were valued in Europe for their oil, blubber, and baleen. The whaling season in the Arctic is short resulting in whalers overwintering to maximize the small harvest season. Herschel Island was selected as a settlement because it was close to the whales and was an adequate harbor for the whaling vessels. Pauline Cove was the first European American settlement in 1890. Whaling in the Beaufort Sea peaked in 1893–1894, with a population of more than 1,500 people involved in the process. Most people lived on the whaling vessel, and there were only a few frame buildings constructed on land. In

1893, the Pacific Steam Whaling Company (PSW Co.) built a community house at Pauline Cove. PSW Co. loaned the house to the Anglican Church, in 1896. The first Anglican missionary to visit the island was Isaac Stringer (1866–1934) in 1893. In 1896, he returned to the island where he remained until 1901. The Anglican Church utilized the community house until 1906. The Hudson Bay Company established a trading post, warehouse, and various other buildings in 1915, which operated until 1937. The Northern Whaling and Trading Company later constructed commerce-related structures on the island, in 1926.

The first Royal Canadian Mounted Police (RCMP) officer assigned to Herschel Island was Francis Joseph Fitzgerald (1869–1911), in 1903. It was the northernmost RCMP detachment. In 1904, Fitzgerald along with Constable Forbes Sutherland established an RCMP subdistrict post on Herschel Island. Fitzgerald later died on the famous Lost Patrol in 1910. The following year, the RCMP purchased all of PSW Co. assets on Herschel Island. This community house is still standing and is used as a visitor center and park office. In 1918, police officer Alexander Lamont died from typhoid fever making him the first Royal Northwest Mounted Police to die while on duty. The RCMP Herschel Island post operated from 1903 to 1933. The command of post was transferred from the Western Arctic to the Aklavik, in 1931. The post was reopened in 1948 on a seasonal basis until it was permanently closed in 1964.

Herschel Island was the site for the first jury trial in the Canadian Arctic, in 1924. It was a murder trial involving two Western Canadian Inuit men. The court representatives were from Edmonton, and the jury was selected from Fort McPherson (67° 26′N 134° 52′W) and modern-day Tsiigehtchic (67° 26′N 133° 44′W). The two Western Canadian Inuit were found guilty and hanged.

Herschel Island was designated as a Canadian National Historic Site in 1972. In 1978, the Western Canadian Inuit and the Canadian government made an agreement on land claims. In 1984, Herschel Island was included in the Inuvialuit Settlement Region, which was designated in the Inuvialuit Final Agreement. In accordance with the Inuvialuit Final Agreement, the Yukon government created Herschel Island Territorial Park, in 1987, which is jointly managed between the Yukon government and the Western Canadian Inuit to protect the cultural resources of the island. The last family to inhabit Hershel Island was the Mackenzie family, who left in 1987. In modern times, Herschel Island is partly a national park and tourist destination. The cultural resources of Herschel Island are presently threatened by global warming.

Somerset Island (Canada)

Somerset Island (73° 15′N 93° 30′W) is located in the Canadian Arctic Archipelago between Prince of Wales Island and Baffin Island. To the east is the Peel Sound and to the west is Prince Regent Inlet. South of Somerset Island is Boothia Peninsula, which is separated by the narrow 1.2-mile (2-km) wide and 15-mile (25-km) long Bellot Strait, while north Somerset Island is bordered by the Barrow Strait. The uninhabited Somerset Island is approximately 9,500 square miles (24,800 sq. km). Archaeological evidence suggests that the Thule people have inhabited the island since at least AD 1,000. The first European to sight the island was William Edward Parry (1893–1972), in 1819. James Ross Cook (1800–1862) was the first to land and winter on Somerset Island in 1848, while searching for Franklin and his lost crew. The location was Port Leopold (73° 50′N 90° 19′W). In 1937, the Hudson Bay Company established a trading post at Fort Ross. Fort Ross was located on the southeastern end of Somerset Island on the Bellot Strait. Fort Ross was the last fort of the Hudson Bay Company and closed in 1948. After the closing of Fort Ross, Somerset Island was uninhabited.

Devon Island (Canada)

Devon Island (75° 08′N 87° 51′W) is located in the Canadian Arctic Archipelago of the Qikiqtaaluk Region, Nunavut, Canada. It is surrounded by Ellesmere Island to the north, Baffin Bay to the west, the Lancaster Sound and Bylot Island to the south, Cornwallis Island and Wellington Channel to the east, and the Norwegian Bay to the northwest. At more than 21,000 square miles (55,000 sq. km), Devon Island is considered the largest uninhabited island in the world. There are several small mountain ranges on Devon Island, including Cunningham, Haddington, and Treuter Mountains. The Treuter Mountains are part of the Devon Icecap. The first European to see the island was Robert Bylot, in 1616. The island was not charted until 1819–1820 by William Edward Parry (1893–1972). In 1924, a government outpost was established at Dundas Harbor (74° 31′N 82° 23′W) to protect foreign vessels from taking whales. The Hudson Bay Company leased the outpost in 1933. Due to a drop in fur prices, the 53 Inuit families from Cape Dorset were relocated to the island, in 1934. The harsh conditions of Devon Island resulted in the Inuit returning home a couple of years later. In the late 1940s, Devon Island was again inhabited with the arrival of an RCMP detachment that remained until 1951. The RMCP detachment was relocated to and reopened the Craig Harbor outpost (76° 12′N 81° 1′W) on Ellesmere Island. The reason for the RMCP relocation was harsh conditions characteristic of Devon Island. Devon Island is presently abandoned, and only few structures remain.

Alluttoq Island and Qeqertarsuaq (Greenland)

Alluttoq Island (69° 44′N 51° 8′W) is located in the northern part of Disko Bay on the western coast of Greenland. It is part of the Qaasuitsup municipality of Greenland. Alluttoq Island is around 250 square miles (655 sq. km). On the east coast of Alluttoq Island, there is a settlement called "Ataa," which was abandoned around 1960.

In 1997, Ataa was a filming location for the feature film *Smilla's Sense of Snow*, which was directed by Bille August. In modern times, the settlement is a wilderness camp and a tourist destination.

The other abandoned Greenland Island is Qeqertarsuaq (also called "Herbert Island") (77° 25′N 70° 41′W). Qeqertarsuaq is also the name of an uninhabited village on the island. The village of Qeqertarsuaq was established in 1953 when the Inuit from Dundas were forced to relocate to make way for Thule Air Base. Qeqertarsuaq Island is 86 square miles (223 sq. km). Presently, there are no permanent inhabitants on Qeqertarsuaq Island.

Edgeøya, Svalbard (Norway)

Edgeøya, Svalbard (77° 45′N 22° 30′E), is an abandoned Norwegian island. It is located in the southwest part of the Svalbard Archipelago between the fjord Storfjorden that separates Spitsbergen from Edgeøya and Barentsøya. The Barents Sea is on the east coast. The island of Barentsøya is north of Edgeøya. Most of the Edgeøya is covered by glaciers, especially the eastern coast. The western and northern coasts are mostly ice free. Edgeøya is less than 2,000 square miles (5,000 sq. km). All of Edgeøya, Barentsøya, and several small islands and the waters surrounding them are part of the Søraust-Svalbard Nature Reserve (78° N 22° E). The island was first noted as being discovered in the seventeenth century by whalers. Some believe the first to visit the island were the Pomory of northern Russia. The island is named after the English whaler and sealer Thomas Edge (1588–1624), an employee of the Muscovy Company. During the nineteenth and twentieth centuries, the island was used by Norwegian polar bear hunters. The seasonally based Swedish Russian Arc-de-Meridian Expedition (1899–1904), under the leadership of Gerard Jacob De Geer (1858–1943), had a station at Dolerittneset. In the late 1960s, Danish researchers established a research station to study polar bears. By the early 1970, the Danish station was abandoned.

Skorpa (Norway)

Skorpa (69° 55′N 21° 41′E) is an uninhabited Norwegian island in Kvænangen municipality. It is located in the middle of Kvænangen Fjord. Skorpa is a small island a little more than 3 square miles (8.25 sq. km). During World War II, Skorpa Island was a short-lived Prisoner of War (POW) Camp. The Norwegian Sixth Division built the camp to house Nazi German POWs during the 62-day Norwegian Campaign. The POW camp closed at the end of the Norwegian Campaign. The Kvænangen municipal government moved off the Skorpa Island to the mainland village of Burfjord (69° 56′N 22° 3′E), and the remaining population had migrated off by 1980.

Wrangel Island (Russia)

Wrangel Island (71° 14′N 179° 25′W) is located in the Arctic Ocean between the East Siberian and Chukchi Seas. It is part of the Chukotka Autonomous Okrug of the Russian Federation. Wrangel Island is about 2,900 square miles (7,600 sq. km). The island is about 78 miles (125 km) in length. The highest elevation is Sovetskaya Mountain around 3,600 ft. (1,100 m) above sea level, with most of the mountains on Wrangel Island averaging around 1,500 ft. (500 m) above sea level.

Wrangel Island was sighted by American Captain Thomas Long, in 1867. Wrangel Island may have been seen as early as 1849 by British Captain Henry Kellett during his discovery of the neighboring Herald Island. The crew members of the U.S. Revenue Cutter *Thomas Corwin* are credited with being the first to explore Wrangel Island, in 1881. Famous naturalist John Muir (1838–1914) wrote the first description of the island. Wrangel Island is named after Russian explorer Ferdinand Petrovich von Wrangel (1796–1870). There were a couple of settlements on Wrangel Island, which are Ushakovskoye (70° 58′N 178° 29′W) near Rogers Bay and Zvyozdny near Somnitelnaya Bay. In 1948, the Soviet Union started reindeer herds to limit the bird population until the late 1970s. The Zvyozdny settlement was abandoned in the 1980s. The people of Ushakovskoye also started to migrate off Wrangel Island in the 1980s with the last Ushakovskoye residents leaving on October 13, 2003.

Wrangel Island is listed as a UNESCO World Heritage Site, since 2004, and most of the island is a federally protected nature sanctuary of the Russian Federation. The flora and fauna of the island are unique and diverse. The island is home to a high concentration of polar bears and walruses, and is a major feeding area for gray whales that migrate from Mexico. It is also home to more than 400 plant species and two dozen resident bird species, and is a northern nursery for about 100 migratory bird species.

Andrew J. Hund

See also: Beaufort Sea; Chukchi Sea; Herschel Island; Lost Patrol

Further Reading

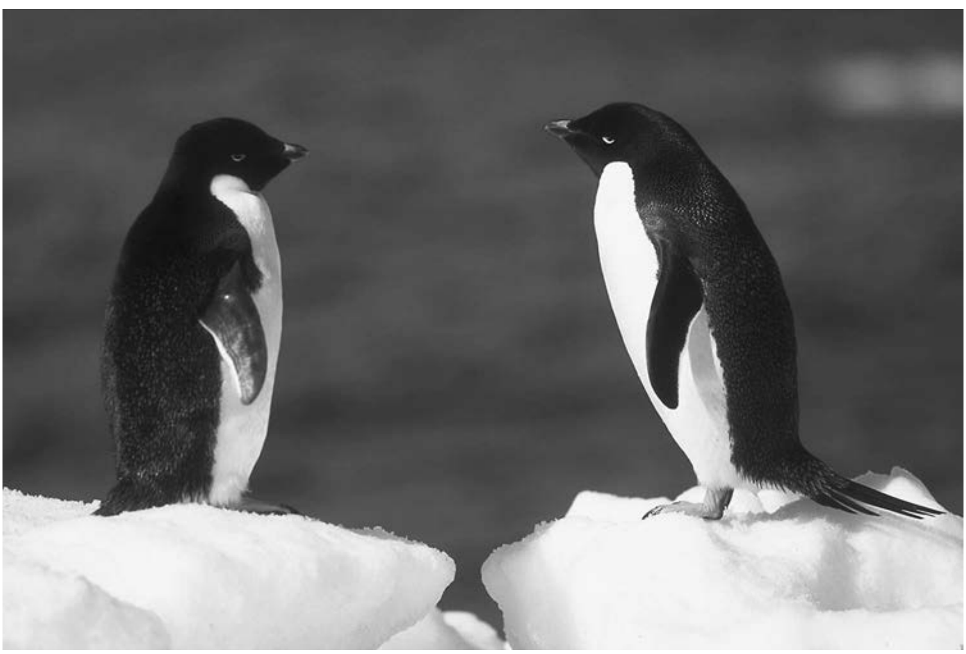
Burn, C. *Herschel Island Qikiqtaryuk: A Natural and Cultural History of Yukon's Arctic Island.* Whitehorse, Yukon: Wildlife Management Advisory Council (North Slope), 2012.

Adélie Penguin

The Adélie penguin (*Pygoscelis adeliae*) is a small penguin whose distribution is almost entirely in the Antarctic. Like other penguin species, it is flightless but a proficient swimmer with flippers designed for speed in pursuing the aquatic species for food and escaping its oceanic predators. As with most penguins, the Adélie is black above and white below. It has a black head, and atypical features include a white eye-ring and a bill half-covered with feathers, making it appear quite short. As is typical with the three species in the *Pygoscelis* genus, the Adélie has a fairly long tail. There is no sexual dimorphism in either plumage or weight; on average, birds range between 9 and 12 pounds (4–5.4 kg), and adult penguins can reach up to 28 in. (71 cm) in length.

The Adélie penguin was first described by the French naval officer Jules Dumont d'Urville, who in the early nineteenth century led several expeditions to the Southern Hemisphere. During one of his voyages to the subantarctic islands, he discovered the penguin and named it after his wife Adéle. As mitochondrial DNA sequencing would later reveal, the Adélie penguin is a fairly old species, having split off from the other members of the *Pygoscelis* genus approximately 19 mya and from the rest of the penguin genetic tree about 19 million years before that.

The majority of the breeding sites, some of which historically contained more than 1 million birds, can be found on Antarctica proper, with most of the sites occurring along the Antarctic Peninsula, the western edge of the Ross Sea, and the



Adélie penguins. (Corel)

Australian quadrant of the East Antarctica coast. Along with the emperor, the Adélie is the only penguin to breed in Antarctica away from the Antarctic Peninsula. The Adélie penguin is found on a few subantarctic islands, including South Shetland, South Orkney, South Sandwich, and Bouvet Islands. Beach-wrecked birds, many of them oiled or starving, have been found well to the north in New Zealand and the Falkland Islands.

As they live very far south, the breeding season is fairly short, lasting from late October through February. Nests are scrapes in the ground protected by stones that are often pilfered from neighboring nests. Typically, two eggs are laid per breeding season; unlike other penguin species, two chicks often survive to adulthood. Males and females take turns incubating while the other searches for food; adult birds participating in incubation often lose quite a bit of their body weight by February. Predators include Antarctic skuas, which will take eggs and chicks from unobservant parents, as well as leopard seals, who hunt the penguins while they look for krill and silverfish. The Adélie's small size and speed (they can swim up to 40 mph [64 km/h]) make them successful hunters, although climate change has been implicated in population declines due to food loss. With reductions in sea ice, the penguins have to swim further to find food. In the past three decades, the global Adélie penguin population has declined by about one-third and was recently designated as a near threatened species.

Early Antarctic explorers commented unfavorably upon the Adélie penguin, noting the species' selfishness, sexual practices, and casual disregard for its own safety. George Murray Levick, part of Robert Falcon Scott's ill-fated Terra Nova Expedition, described penguin sexual activities including rape, homosexuality, and necrophilia. This scientific paper was so controversial that it was suppressed and not published until 2012. No less a figure than Scott himself derided the birds for their fatuous conduct and pigheaded disregard for their own safety. He was particularly disturbed by the latter, as the inquisitive penguins would often disrupt his expedition. As Scott notes: "They waddle forward, poking their heads to and fro in their usually absurd way, in spite of a string of howling dogs straining to get at them." Scott goes on to state that Adélie penguins would routinely approach, and be eaten by, the expedition sled dogs.

Not everyone has felt this way about the Adélie, however. Terra Nova member Apsley Cherry-Garrard focused on the bird's bravery: "[H]e is quaint in all that he does, but still more because he is fighting against bigger odds than any other bird, and fighting always with the most gallant pluck." And perhaps due to its small size, tuxedo appearance, and inquisitive nature, the Adélie penguin has become one of the iconic images of penguins in popular culture, and it is currently one of the more common species kept in zoos and aquariums.

Andrew J. Howe

See also: Chinstrap Penguin; Emperor Penguin; Gentoo Penguin; King Penguin; Macaroni Penguin; Rockhopper Penguin

Further Reading

Ainley, D. *The Adélie Penguin: Bellwether of Climate Change.* New York: Columbia University Press, 2002.

Baker, A., S. Pereira, O. Haddrath, and K-A. Edge. "Multiple Gene Evidence for Expansion of Extant Penguins Out of Antarctica Due to Global Cooling." *Proceedings of the Royal Society B: Biological Sciences* 273, no. 1582 (2006): 11–17.

Cherry-Garrard, A. *The Worst Journey in the World.* London: Picador, 2000.

Russell, D., W. Sladen, and D. Ainley. "Dr. George Murray Levick (1876–1956): Unpublished Notes on the Sexual Habits of the Adélie Penguin." *Polar Record* 48, no. 4 (2012): 1.

Agreement on the Conservation of Albatrosses and Petrels (ACAP)

The Agreement on the Conservation of Albatrosses and Petrels (ACAP) is a multilateral agreement that seeks to conserve albatrosses and petrels by coordinating international activity to mitigate known threats to their populations. The most significant threat facing albatrosses and petrels is mortality resulting from interactions with fishing gear, especially longline and trawl fishing operations. In addition, birds may be threatened at their breeding sites by introduced predators, diseases, habitat loss, and human disturbance. The agreement provides a focus for international cooperation and the exchange of information and expertise, and the action plan annexed to the agreement offers a framework for the implementation of effective conservation measures for these threatened seabirds, both on land and at sea.

Development of the agreement commenced in 1999. It was concluded rapidly with only two meetings required to agree the text. These meetings, held in Hobart, Australia, and Cape Town, South Africa, were attended by 16 countries and 5 international organizations. ACAP was opened for signature in June 2001 in Canberra, Australia, and entered into force on February 1, 2004, at which time all Southern Hemisphere species of albatrosses and seven petrel species were listed under its auspices. Currently, there are 13 parties to the agreement—Argentina, Australia, Brazil, Chile, Ecuador, France, New Zealand, Norway, Peru, South Africa, Spain, the United Kingdom, and Uruguay. The agreement is managed by a small secretariat based in Hobart, Tasmania, Australia, with an executive secretary and a science officer, supported by an honorary information officer.

The First Session of the Meeting of the Parties (MoP1) was convened in November 2004 in Hobart, preceded by a two-day scientific meeting. A key outcome

Royal Albatross. (Shutterstock.com)

of MoP1 was the establishment of an advisory committee to guide the implementation of the agreement. The advisory committee is supported by three working groups—the Population and Conservation Status Working Group, the Seabird Bycatch Working Group, and the Taxonomy Working Group. Sessions of the Meeting of Parties are ordinarily held at three-year intervals, with the advisory committee meeting more often.

At the Third Session of the Meeting of Parties, held in Norway in 2009, the three North Pacific albatrosses (short-tailed *Phoebastria albatrus*, Laysan *P. immutabilis*, and black-footed *P. nigripes*) were added to the agreement. At the Fourth Session of the Meeting of Parties, held in Peru in 2012, the Balearic Shearwater *Puffinus mauretanicus*, endemic to the Mediterranean Sea, was added to the agreement, bringing the total number of species covered to 30.

A key area of ACAP's work is the review of the population status and trends of all ACAP-listed species by way of maintaining a global database and producing a series of species assessments. These assessments provide up-to-date information on each species' distribution, threats facing individual populations, the conservation measures in place to protect them, and identify any gaps in knowledge about the species. ACAP has also developed Conservation Guidelines on biosecurity and quarantine for breeding sites; Conservation Guidelines on the eradication of introduced mammals from islands; best-practice advice for mitigating seabird bycatch in fisheries operations, and an Action Conservation Plan for the Waved Albatross *P. irrorata* of Ecuador's Galapagos Islands.

The agreement has been working with tuna Regional Fishery Management Organizations (TRFMOs), the Commission for the Conservation of Antarctic Marine Living Resources, and other relevant fisheries management organizations to encourage the adoption of best-practice mitigation measures to reduce seabird mortality in longline fisheries in areas outside of national jurisdictions (the high seas). All of the TRFMOs have recently adopted conservation measures incorporating ACAP's best-practice advice for seabird bycatch mitigation in pelagic longline fisheries (night setting, line weighting, and deployment of bird-scaring [tori] lines). ACAP has also been working to reduce seabird mortality in trawl and other fisheries where seabird bycatch occurs. Other activities undertaken by ACAP include funding research projects, supporting capacity-building initiatives, and enhancing awareness among the concerned public of the plight facing albatrosses and petrels, primarily via news stories posted to its Web site at www.acap.aq.

Much more still needs to be achieved. A key challenge is to obtain accurate data on where and in what numbers seabirds are being caught as bycatch in fisheries operations, to assist the effective implementation of conservation measures. Another challenge is to seek the active involvement of those range states who are not currently participating in the agreement's work, as it is only through such cooperation that ACAP's objective of achieving and maintaining a favorable conservation status for albatrosses and petrels can be met.

John Cooper

See also: Arctic Seabirds; Sooty Albatross; Wandering Albatross

Further Reading

Agreement on the Conservation of Albatrosses and Petrels. Summary of Population Data, Conservation Status and Foraging Range of Seabird Species at Risk from Long Line Fisheries in the Convention Area (SC-CCAMLR XXIII/BG/22). C. Secretariat: 10, 2004.

Cooper, J. Albatross and Petrel Mortality from Long Line Fishing International Workshop. Honolulu, Hawaii, May 11–12, 2000.

Peat, N. *Seabird Genius: The Story of L.E. Richdale, the Royal Albatross, and the Yellow-Eyed Penguin.* Dunedin, New Zealand: Otago University Press, 2011.

Alaska Native Claims Settlement Act (ANCSA) (1971)

In 1971, the Alaska Native Claims Settlement Act (ANCSA) was signed into law by President Richard Nixon (Public Law [PL] 92–203). The act abolished Alaskan

Native claims to their traditional lands in exchange for $963 million and 44 million acres (17.8 million hectares). The objective of ANCSA was to formally settle the long-standing land claims of Alaska Native groups and for Alaska to develop the recently discovered Prudhoe Bay oil field. ANSCA compensated Alaska Natives for the collaborative use of their lands and resulted in the creation of 13 regional and more than 200 village corporations.

ANCSA and other legislation exchanged approximately 148 million acres (60 million hectares) of federally owned land in Alaska to the state of Alaska and Alaska Native groups. The act abolished most Alaska Native claims to their land. ANCSA repealed the Alaska Native Allotment Act of 1906 (43 USC §1634), which allowed for Alaskan Natives to obtain the title to up to 160 acres (65 hectares). ANCSA revoked future Alaskan Natives from receiving title to land, but did not resolved the pending cases of approximate 300,000 acres (121,405 hectares) under the Alaska Native Allotment Act. Of the 44 million acres, the village corporations received surface rights to the respective land, while the 12 regional corporations were granted subsurface rights. These corporations are Native by the virtue of Alaskan Native being the stockholders. Under 43 USC §1606, §1607

PRUDHOE BAY STATE #1 OIL DISCOVERY

On March 12, 1968, the Atlantic Richfield Company (ARCO) and EXXON discovered Prudhoe Bay State #1 oil well in Prudhoe Bay off the Arctic coast of Alaska (70° 18'N 148° 43'W). Prudhoe Bay was a major discovery and the largest oil field in North America measuring 213,543 acres (86,418 hectares). Original estimates claimed that the oil well had 25 billion barrels of oil with 13 billion barrels considered recoverable. Prudhoe Bay also contained 26,000 billion cubic feet of natural gas. The remote Arctic location of the oil made it impractical to transport it to market by conventional means. The solution was to build an 800-mile pipeline from Prudhoe Bay to Valdez, Alaska, where the oil would be loaded on oil tankers and shipped to market. A permit was granted for the construction of the pipeline; however, the proposed pipeline route would cross many important archeological and historic sites of the Alaskan Natives. For the pipeline to be built, the long-standing Alaskan Native land claims needed to be settled. In 1971, the Alaska Native Claims Settlement Act (ANCSA) was signed into law by the president Richard Nixon (Public Law [PL] 92–203).

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of ANCSA, stock in these corporations were to remain with Alaska Natives for about 20 years until January 1, 1992. Of the $963 million payment, $462.5 million came from the U.S. government and the remaining $500 million from oil revenue sharing.

Under the ANCSA of 1971, the federal government created 12 regional corporations; all 12 were based on geographic locations within the state of Alaska. The 12 Alaska regional corporations are as follows: (1) the Aleut Corporation (TAC); (2) Arctic Slope Regional Corporation (ARSC); (3) Bering Straits Native Corporation (BSNC); (4) Bristol Bay Native Corporation (BBNC); (5) Calista Corporation; (6) Chugach Alaska Corporation (CAC); (7) Cook Inlet Region, Inc. (CIRI); (8) Doyon Ltd. (DOYON); (9) Koniag, Inc.; (10) NANA Regional Corporation, Inc. (NANA); (11) Sealaska Corporation (SEAC); and (12) Ahtna, Inc. (AHTNA). Around 80,000 Alaska Natives of one-quarter native ancestry (or a village or Native group regarded one as Alaska Native—called the "Aleut Provision") were enrolled into a regional and village corporation, which represented two-thirds of the Alaska Native population. Each Alaskan Native born before December 18, 1971, became a shareholder in one of the 12 regional corporations and received 100 shares of stock. A 13th corporation based out of Seattle, Washington, was created later to represent around one-third of Alaska Natives living outside the state as of December 18, 1971. Members of the thirteenth corporation were provided with 100 shares. The thirteenth corporation were given revenue rights to natural resources but received no land. Alaskan Natives born after December 18, 1971 (commonly called "after-born"), were not eligible to receive corporation shares, but were allowed to inherit them.

1991 Amendments

On February 3, 1988, there were several amendments to ANCSA under the Alaska Native Claims Settlement Act Amendments of 1987 (PL 100–241). These amendments are referred to as the "1991 Amendments." The 1991 amendments sought to address and clarify three major issues, which are as follows: the after-born, taxation and protection of land, and stock alienation. The new amendments allowed present stockholders (by majority vote) of each corporation the ability to decide whether to include those born after 1971. Shareholders also could decide whether to grant the after-borns voting rights, the type of stock they could receive (unrestricted or restricted), and whether the new shareholders could receive dividends. Shareholders could also increase the shares for elders and enroll ANCSA-eligible Natives who missed the original enrollment.

Under ANCSA, Alaska Native Corporation lands were exempt from taxation for 20 years after conveyance, but the act did not provide protection for loss due to corporate debt. The new amendments extended the protection from taxation indefinitely, providing the land remained undeveloped. The amendments also prevented undeveloped land from being taken over as a result of corporation debt or bankruptcy. Mortgaged land was not included in the amendments. Other exceptions were tax liabilities owed to the U.S. IRS, eminent domain rights, and unpaid obligations on resource revenues shared with all regional corporations. An amendment in 1998, titled the ANCSA Land Bank Protection Act of 1998 (PL 105–333) allowed the undeveloped land to be placed in a trust.

Prior to 1991, ANCSA prohibited shareholder stock from being transferred to non-Natives via inheritance. Before the amendments, non-Native shareholders could not be voting members, and corporations reserved the right to purchase stock first under ANCSA. Native corporation stock could be purchased by non-Natives and thus was vulnerable to possible takeover by outside interests after 1992. The 1991 amendments addressed these issues, by allowing the extension of stock restrictions and altering restrictions by requiring a majority vote by the shareholders to alter the agreement. Not addressed in the 1991 amendment was the issue of tribal control and sovereignty, and the Congress neither validated nor invalidated the issue with the amendment. The Native Village of Stevens went to court in May 1988, where the Alaska Supreme Court ruled in a split decision that Alaska Native groups do not have tribal sovereignty, with the exception being the Annette Island Reserve (see *Native Village of Stevens v. Alaska Management and Planning*, 1988).

Andrew J. Hund

See also: Aleuts/Unangax; Eskimos; Siberian Yup'ik

Further Reading

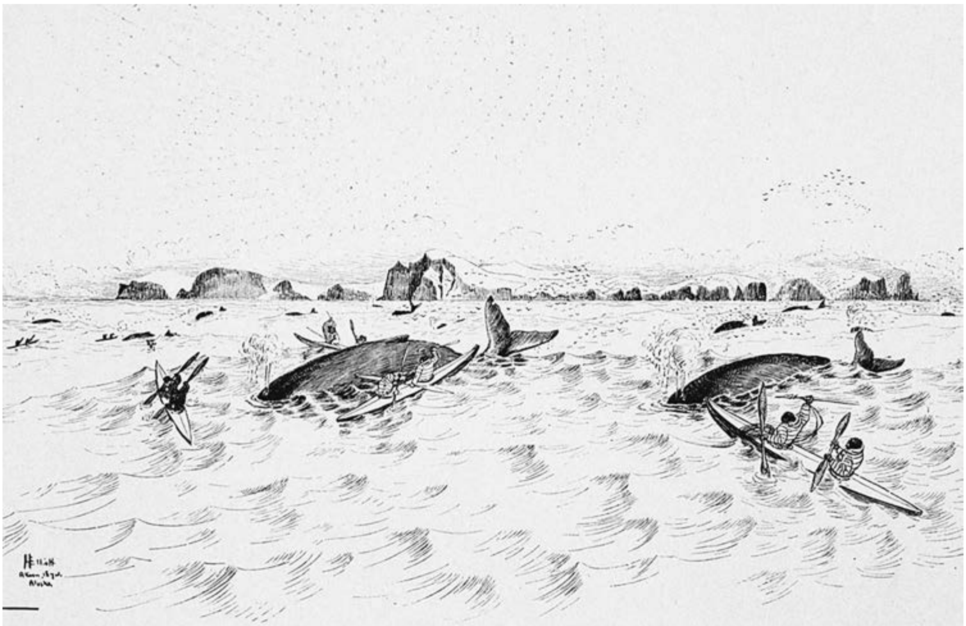
Alaska Federation of Natives. "1991: Making It Work, a Guide to Public Law 100–241, 1987 Amendments to the Alaska Native Claims Settlement Act." Alaska Federation of Natives, 1991.

Kentch, G. "A Corporate Culture? The Environmental Justice Challenges of the Alaska Native Claims Settlement Act." *Mississippi Law Journal* 81, no. 4 (2012): 813–42.

Movitz, D. "How to Exploit and Destroy a People: The Case of the Alaskan Native." *Civil Rights Digest* 2, no. 3 (1969): 6–13. Washington, DC: U.S. Commission Civil Rights.

Aleuts/Unangax

Unangax is the self-designated name of the indigenous group of the Aleutian Islands in Alaska and Kamchatka Krai of the Russia Federation. The common name of this group used by non-Native groups is "Aleut." In the eighteenth century, the Russians labeled the Unangax as the Aleut. There are two main groups of the Unangax, which are the Unangan/Unangas. The Unangan is the self-designated name



Unangan in Aleut baidarka hunting whales. (National Oceanic and Atmospheric Administration)

for the western group and the Unangas is for the eastern group. The Unangax have inhabited the Aleutian Islands for at least 9,000 years and are an ocean-based culture. In 2010, the population of the Aleuts was just more than 11,000, with just under half living in Unalaska.

History

Vitus Bering (1681–1741), a Danish-Russian explorer, first sighted the Aleutian Islands, in 1741. Georg Wilhelm Steller recorded the flora and fauna of the Aleutian Islands as part of the expedition. The following year, a scientific study of the North Pacific fur seals was conducted. After the discovery of fur-bearing animals, the Unangax were in regular contact with the Russians. Fur-bearing animals of the Aleutian Islands were exploited to near-extinction levels, with the Steller Sea Cow becoming extinct in 1768. Sea otter hunting in the Aleutian sea peaked between 1760 and 1780. In 1750, Arctic foxes were introduced to Attu Island from Bering Island by the Russian Merchant, Tolstykh. A Russian fur trader, named Glotov, was first to trade peacefully with the Aleuts of Umnak and Unalaska Islands, in 1758. Glotov later introduced the sea otter net to the Attuans. Permanent buildings of the Russians merchants started being constructed in 1770 with a warehouse in Unalaska by fur traders. In 1781, the Northeastern Company and, in 1799, the Russian-American Company were organized.

Due to cultural differences and competition over sea mammals, the relations between the Aleut and Russians were hostile and antagonistic resulting in destroyed or burned Russian vessels as well as many armed conflicts and massacres perpetrated by both sides. For example, fur hunters of the Russian vessel *Evdokim* upon landing on Agutta Island were met by armed Aleuts in 1745; a Russian merchant vessel was destroyed at Unalaska in 1764 by the Aleuts; and a Russian group was massacred at Umnak Island in 1764. In 1765, the Soloviev or Solov'ev party massacred the Aleuts of the Unalaska region. The Russians and Aleuts also joined together to destroy other Aleut villages, such as during the 1767 raids and destruction of the villages of Amukta, Carlisle, Chagulak, Chuginadak, Herbert, Kagamil, Uliaga, and Yunaska Islands (called “Islands of Four Mountains”). In 1784, the Russians on Amchitka took about 40 Aleut women and children captive while the Aleut men were away; upon returning to the village, the men rebelled. The Aleuts surrendered after a brief combat with the Russians. The rebellion resulted in four high-status Aleut leaders being executed. The remaining Aleuts left Amchitka and relocated to neighboring islands. The Russian government was informed of the executions, and the Russian leader, Nevizimov, was imprisoned.

In 1808, the first Russian Orthodox Church was constructed in Unalaska. The Russian Orthodox Church is still present throughout the Aleutian Islands. In 1942,

WATERPROOF PARKAS (KAMEIKAS) OF THE ALEUTS

An essential part of the Aleuts’ sailing was parkas called “kameikas.” Kameikas were waterproof rain gear that were made of bird skins, the guts of seals or sea lions, or the intestines of bear, walrus, and/or whales. The parkas were for different purposes and were made out of different material. Men, women, and children all wore kameikas to keep them warm and repel rain. Men’s kameikas were made out of bird skins, and different parkas could be used for hunting and daily activities. The bird feathers in men’s kameikas could be turned in or out depending on the type of weather. The women’s kameikas were made out of sea otter and/or seal skin, while children’s kameikas were bird skin caps made from tanned eagle skin. The men’s and women’s parkas went below the knees. The parkas were fitted with a hood and sleeves, which could be cinched tight to prevent water from entering. A kameika took about a year to make and could last for up to two years. The pants that went with the kameikas were also waterproof and were made from the skin of seals’ esophagus. The Aleut’s craft work embodied their spiritual and cultural way of life, which embraced unity with nature.

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the Japanese made air strikes on Dutch Harbor. The Japanese also captured Attu Islanders and held them as prisoners of war at Hokkaido, Japan. The U.S. government placed more than 800 Aleuts from the western Aleutian chain and the Pribilof Islands to southeast Alaska and the Wrangell Mountains in internment camps. Many Aleuts interned died, and in 1988, the U.S. Congress compensated each eligible survivors of the families with $12,000 under the Aleutian and Pribilof Islands Restitution Act of 1988 (PL 100–383). The act was amended in 1993 to compensate churches whose property was damaged and/or lost during World War II. In 1969, 1970, and 1971, three underground atomic tests were conducted on Amchitka Island as part of the Ploughshare Project. In 1971, the Aleut Corporation was formed with the passage of the Alaska Native Claims Settlement Act. In 1997, the Adak Naval Air Station was closed and is presently a superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

Language

The Aleut language is one branch of the Eskimo-Aleut family. The Aleut language is considered endangered and/or near extinct. Presently, a few hundred people speak the Aleut language, and fluent speakers are extremely rare. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) lists the Aleut language as critically endangered with 150 fluent speakers in Alaska and about 15 in Siberia (Commander Islands). The Aleut language is divided into three dialects: the Fox, Atkan, and Attuan. The Fox dialect (sometimes called "Unalaskan") is spoken in the Eastern Aleutian, Pribilof, Fox, and Shumagin island areas. The Atkan dialect is spoken on the Bering and Atka Islands. The Attuan dialect is extinct.

Sailing and Navigation

The Aleuts are widely known for their sailing and navigation abilities and utilized two types of skin boats: a baidarka and a baidara. A baidarka is a small one or a two-person boat made from sea lion skin similar to an Eskimo/Inuit kayak but more aerodynamic. The one-person craft was 4.8 m (16 ft.), and the two-person craft was 6 m (20 ft.) long. The craft was used for hunting and was sturdy enough that a hunter could stand up in it. The baidara is a large skin boat made of walrus skin and used as a transport boat for warriors to combat or families and their belongings to other islands. Other than the highly maneuverable baidarka, Aleuts hunted small sea mammals with throwing boards equipped with harpoons and barbed dart tips. The Aleuts used three different harpoons: a simple, toggle-head, and a throwing lance (for large sea mammals and in combat). An essential part of the Aleuts' sailing uniform was the waterproof parkas called "kameikas" and bent wood hats called "chagudax." The chagudax are intricately made with colorful designs and commonly trimmed with sea mammal whiskers, bird feathers, and/or ivory.

Andrew J. Hund

See also: Migration Waves of the Eskimo-Aleut

Further Reading

Black, L. *Aleut Art: Unangam Aguqaadangin*. Anchorage, AK: Aleutian/Pribilof Islands Association, 2005.

Torrey, B. *Slaves of the Harvest: The Story of the Pribilof Aleuts*. St. Paul Island, AK: Tanadgusix Corporation, 1978.

Turner, L. *An Aleutian Ethnography*. Edited by Raymond L. Hudson. Fairbanks: University of Alaska Press, 2010.

Alexander I Island

Alexander I Island (71° S 71° W) is the largest Antarctic Island measuring about 240 miles (390 km) long and 50 miles (80 km) wide. The total area of the Alexander I Island is about 19,000 square miles (49,000 sq. km). This island is the second largest uninhabited island in the world, with Devon Island (75° 8′N 87° 51′W) in the Canadian Arctic Archipelago being the largest.

Alexander I Island is located between the Ronne Entrance (east) and Marguerite Bay (west) and Palmer Land and the Bellingshausen Sea. Alexander I Island was discovered by Admiral Fabian Gottlieb Thaddeus von Bellingshausen (1778–1852), who explored the area in 1821. Bellingshausen named the island after the Russian Tsar Alexander I (1777–1825).

Alexander I Island is separated from the Antarctica continent (Palmer Land) by George VI Sound (71° 45′S 68° W). The George VI Sound is filled with ice, making an ice bridge from Palmer Land to Alexander I Island. The George VI Ice Shelf is the ice body that fills George VI Sound. There are two bays on each side of Alexander I Island, which are the Ronne Entrance and Marguerite Bay. The Ronne Entrance (72° 30′S 74° W) is on the eastern side in between the George VI Sound (71° S 68° W) and the Bellingshausen Sea just southwest of Alexander I Island. On the Ronne Entrance side is the 45-mile (72-km) Bach Ice Shelf (72° S 72° W). Marguerite Bay (68° 30′S 68° 30′W) is on the west side located between the Adelaide Island in the north, and runs along the Fallieres Coast of the Antarctic Peninsula, and Alexander I Island and the George VI Sound to the south.

On the Bellingshausen Sea side of Alexander I Island is the Wilkins Sound. Alexander I Island partly surrounds the Wilkins Sound. Within the Wilkins Sound is the ice-covered Charcot and Latady Islands. The Wilkins Ice Shelf fills the Wilkins Sound with ice. The Wilkins Ice Shelf is approximately 90 miles (145 km) in length and 70 miles (110 km) in width. The ice-covered Charcot Island (69° 45′S 75° 15′W) is about 30 miles (48 km) long and around 25 miles (40 km) wide and lies approximately 55 miles (89 km) west from Alexander I Island. Latady (70° 45′S 74° 35′W) is west of Alexander I Island, about 50 miles (80 km) south of Charcot Island. This island is about 40 miles (64 km) long and 11 miles (18 km) wide.

Alexander I Island is largely ice covered. There are several mountains located on Alexander I Island, such as Havre (69° 8′S 71° 40′W), Rouen (69° 10′S 70° 53′W), Sofia University (69° 26′S 71° 23′W), Lassus (69° 35′S 71° 38′W), Colbert (70° 35′S 70° 35′W), and Walton (71° 12′S 70° 20′W) Mountains. A few nunataks push through the ice. A significant mountain range on the island is the Douglas Range (70° S 69° 35′W). The highest point on Alexander I Island is Mount Stephenson of the Douglas Range at 9,800 ft. (2,987 m). The notable groups of peaks and nunataks on Alexander I Island are Staccato Peaks (71° 47′S 70° 39′W) and Lully Foothills (70° 49′S 69° 38′W). There is a perennial lifeless subglacial lake on Alexander I Island, which is called "Hodgson Lake." This ice-covered subglacial lake is just more than 1 mile in length, 1.5 mile in width, and more than 300 ft. (95 m) in depth.

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See also: Bellingshausen Sea; Ice Shelf

Further Reading

"Alexander Island." *The Encyclopedia of Earth*, 2011. http://www.eoearth.org/view/article/149980. Accessed January 1, 2014.

Alfred Wegener Institute (AWI)

The main offices of Alfred Wegener Institute (AWI) for Polar and Marine Research (Alfred-Wegener-Institutfür Polar-und Meeresforschung) are located in Bremerhaven on Germany's northwestern bourne. The AWI directs a consortium of research facilities and programs dedicated to global systems research in the Arctic, Antarctic, and temperate latitudes. Its services are coordinated within a larger network of research institutions, the renowned Helmholtz Association of German Research Centers. The Helmholtz Association integrates the programs of 18 centers scattered throughout Germany. These centers are clustered into six research groups specializing in core topics related to energy, the earth and environment, health, key technologies, and the structure of matter (aeronautics, space, and transport). Memorializing the legacy of Hermann von Helmholtz, one of Germany's great universal scholars of the nineteenth century, this cooperative effort supports the association's mission to better understand the complex systems that orchestrate human life and the physical environment. The association originated in 1958; since the reunification of Germany in 1990, the association has played an instrumental role in expanding scientific research throughout the new German landscape.

Like the Helmholtz Association, the AWI is named for another renowned German scholar and polar scientist, Alfred Lothar Wegener (1880–1930). Wegener was a meteorologist who dedicated his life to polar research. He was born in Berlin, Germany, and died on an expedition to Greenland. He was the first scholar to propose the theory of continental drift, a controversial explanation of why fossil remains, scattered over the Earth's separate continents, nevertheless have similar biological structures and features.

In addition to its primary facilities in North Germany, the institute conducts research at the Otto Schmidt Laboratory for Polar and Marine Research, established at the State Research Center of the Russian Federation with the joint directorship of the Arctic and Antarctic Research Institute (AARI) in Saint Petersburg. The OSL, named after the Russian polar scholar Otto Yulievich Schmidt (1891–1956), serves as a joint venture of the German Ministry of Education and Research,

Ice front at the Alfred Wegener Institute (Germany). (Joerg Sarbach/AP Photo) the Ministry of Education and Science of the Russian Federation, the AARI, the AWI, and the Leibniz Institute of Marine Sciences at the University of Kiel If M-Geomar. Other localities for research include the Forschungstelle Potsdam, the Wadden Sea Station on the island of Sylt, and the Biologische Anstalt at Helgoland. Important Arctic and Antarctic research stations include the Neumayer-Station III, the Dallmann Laboratory (operated jointly with the Instituto Antártico Argentino), the Koldeway Station in Ny-Ålesund on Svalbard, Kohnen Station in Dronning Maud Land, Antarctica, and the Samoylov Station on the Lena Delta adjacent to the Laptev Sea.

The institute owns and operates six research vessels: the icebreaker RV *Polarstern*, the RV *Heincke*, the RV *Uthōm*, the catamaran *Mya* and two motorboats, the *Aade* and *Diker.* It also owns and operates a small fleet of research airplanes.

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See also: Antarctic Programs and Research Stations/Bases; Khatanga, Lena, and Yana Rivers; Laptev Sea; Svalbard Archipelago

Further Reading

Otto Schmidt Laboratory for Polar and Marine Research. http://www.otto-schmidt-laboratory.de/. Accessed July 15, 2013.

Selzer-McKenzie, D. "Alfred Wegener 1880–1930 Polar Expedition in 1930." YouTube video. Uploaded February 5, 2012.

"Uncertainty in Regional Climate Change Predictions." Lecture by Thomas Jung, Professor, Climate Sciences. Sponsored by the Alfred Wegener Institute for Polar and Marine Research. YouTube. ICD Channel (Institute for Cultural Diplomacy). Published by ICD on April 19, 2013. http://www.youtube.com/watch?v=UGJCzmPpWoI. Accessed January 1, 2014.

Amundsen, Roald Engebrecht Gravning (1872–1928)

During his lifetime, Amundsen was the first European explorer to successfully navigate the Northwest and Northeast Passages. The Antarctic event also honored Robert Falcon Scott, a competitor who completed the trek to the South Pole just a month after Amundsen's hard drive. On December 14, 2011, polar scientists and enthusiasts, several groups of whom skied across Antarctica, attended a ceremony honoring the 100th anniversary of the Norwegian native Roald Amundsen's discovery of the South Pole. The event was attended by Norway's prime minister Jens Stoltenberg, scientists, and employees from the U.S. Antarctic Program at the Amundsen–Scott research station at the South Pole and members of the Norwegian Polar Institute.

Roald Amundsen was born on July 16, 1872, near the town of Sarpsborg in southeastern Norway. For generations, his family lived as farmers and seamen.

Roald's father, Jens Amundsen, in operation with family members, directed a shipping business located in Oslo, Norway. It was a beautiful and happy life for the young Roald, who thrived in a hardworking family determined to see its children prosperous and well educated. As a young Norwegian, he took particular interest in the stories of polar exploration. Like many youths of his age, Amundsen absorbed the accounts of the tragic fate of Sir John Franklin's lost expedition and his hapless search for the Northwest Passage in the treacherous waters of the Arctic in 1845.

Fridtjof Nansen's influence on Roald endured a lifetime. A Norwegian native born on October 10, 1861, in Store Frøen, just north of what is now Oslo, Norway, Nansen was a prolific polymath whose international renown included champion performances on skis and ice skates, skills that supported his ventures as a primary explorer of the Greenland interior in 1888.

At the helm on the Amundsen Expedition. (National Oceanic and Atmospheric Administration)

Crew members of the *Fram* measure ice depth during Roald Amundsen's expedition to the Antarctic, about 1911. Amundsen established base camp at the Bay of Whales, on the Ross Ice Shelf, which he deemed stable enough to support his men and supplies. (National Oceanic and Atmospheric Administration)

Several years later, during the years 1893–1896, Nansen's stature rose to new heights when he explored the North Pole region. His methods and techniques influenced generations of polar exploration and scientific field research. Nansen was at the center of a flowering of international scientific polar inquiry. He completed his doctorate in neurology before beginning detailed studies in oceanography, mainly in the North Atlantic region. Prior to his death on May 13, 1930, he was awarded the Nobel Peace Prize in 1922 for his diplomacy and statesmanship on behalf of Norway's independence and his participation in the League of Nations during the post–World War I period.

Nansen's legendary stature had a kinetic influence on Amundsen, who early in his youth determined to follow in Sir John's footsteps across the Northwest Passage. He honored his mother's desire to see him pursue a medical career until her death in 1893, after which he sold his medical books and began a systematic program of training to realize his ambitions as a polar explorer. Rigorous physical training was augmented with careful preparation for his licensure as a shipmaster. His first experience was aboard the sealer *Magdalena.* He was certified as a first mate in 1895 and conferred his captain's title in 1900. His first polar voyage was aboard the *Belgica*, a Belgian Antarctic venture led by Adrien de Gerlache de Gomery from 1897 to 1899. The voyage was a near disaster as the ship floundered in ice near Peter I Island. Dire circumstances gave young Amundsen the opportunity to assume the command of the ship, successfully leading its crew through a rough winter-over until the spring of 1899. The experience was a valuable one, strengthening his belief in the essential role of the captain in the precarious direction of polar exploration.

Fridtjof Nansen. (John Clark Ridpath, *Ridpath's History of the World*, 1901)

With growing attention to the demands of the scientific polar community, Amundsen traveled to Hamburg to visit with Dr. G. von Neumayer, the internationally renowned expert in terrestrial magnetism. The study of magnetism was the rationale for his long-range plan to locate the true North Magnetic Pole. This goal gave him the professional standing he needed to secure adequate financial funding for the venture. For two years, Amundsen made preparations for his trip. Amundsen chose to make the voyage with a small, albeit talented, group of seaman aboard a 47-ton herring fishing vessel, outfitted with a small petroleum motor. Six men accompanied him aboard the *Gjøa.* They were Godfred Hansen, a Danish naval officer with expertise in navigation, geology, and astronomy; Anton Lund, his first mate chosen for his experience in ice navigation; Peder Ristvedt, an engineer skilled in meteorology; Helmer Hansen, a sealer serving as second mate; Gustav Juel Wilk, selected for his skill as a magnetic observer; and Adolf Henrik Lindstrøm, the ship's cook.

The party took leave of Oslo, Norway, at midnight on June 16, 1903, keeping close to the Greenland shoreline, sailing past Baffin Bay and the Parry Channel, and then southward into what is now known as Gjøa Haven, where the teammates Wilk and Ristvedt built a magnetic observatory. For two years, they collected meteorological data that to this day serve as an important baseline for understanding current climatological phenomena. In 1904, Amundsen and Ristvedt traveled via dog sledge to the Boothia Peninsula to collect data at the magnetic pole. Their measurements confirmed the location established by James Clark Ross in

1831. From April 2 through June 23 in 1905, Hansen and Ristvedt ventured out to chart the eastern coastline of Victoria Island, previously undocumented at the time.

While at Gjøa Haven, the team was visited on numerous occasions by the Netsilik Inuit, an indigenous tribe that set up tents at the harbor during their seasonal migrations. Inuit Arctic lifestyles and clothing provided valuable models for Amundsen's team. Over the course of his stay at the harbor, he entered into a brisk program of exchange with the natives, trading tools and weapons in exchange for fox and caribou garments, beadwork, and tool implements. Eventually, Amundsen's collections were given to museums in Norway.

The seamen broke camp on August 13, 1905, to sail a track through the shallow depths of Simpson Strait, a difficult challenge completed in three weeks' time. Their efforts were rewarded when their ship was hailed by a whaling vessel, the *Charles Hansson*, traveling eastward from San Francisco around the northern coast of Alaska. The crew cleared the Canadian Archipelago in August before traveling on to Alaska. Amundsen traveled overland by sledge to Eagle City, Alaska, where he telegraphed the news of his successful passage on December 5, 1905. The achievement was received with enthusiasm by the then recently appointed king of the newly sovereign nation of Norway. The *Gjøa* is currently preserved at the Fram Museum in Oslo.

Several lackluster years after his polar expedition, Amundsen was eager to return to the Arctic. Fund-raising for a venture to the North Polar Basin were not successful, and so Amundsen turned his sights to the Antarctica and the South Pole. He did not divulge his intentions, despite similar arrangements by Englishman Robert F. Scott. Amundsen secured Fridtjof Nansen's ship, the *Fram*, and left Oslo on June 3, 1910, for Antarctica. His team set up camp at the Bay of Wales on the Ross Ice Shelf. The crew traveled by dogsled, a distance of 1,860 miles, to the South Pole and then back to camp in 99 days. Authorities today estimate that Amundsen's careful preparation, including ample provisions and the use of skis and dog sleds, gave him a margin of advantage in the bitter contest to reach the South Pole.

Again in 1918, Amundsen returned to the north to attempt to drift on the Arctic Ocean to the North Pole. During these numerous attempts, he also sailed his ship, the *Maud*, through the Northeast Passage, a waterway across the Eurasian coastline of the Arctic Ocean. On May 11, 1926, Amundsen flew to the North Pole aboard a dirigible, designed and piloted by Umberto Nobile; the trip was financed by the noted explorer Lincoln Ellsworth. Two years later, Amundsen took to the skies once again to search for Nobile's remains following his former partner's unsuccessful attempt to fly over the Arctic region. Amundsen's flight was lost on June 18, 1928. Amundsen was 55 years old at the time of his disappearance.

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See also: Amundsen–Scott South Pole Station; Amundsen Sea; Antarctic Circle; Antarctic Ice Sheet; Arctic Ocean; Canadian Arctic Archipelago; Northeast Passage; Northwest Passage; Ross Sea

Further Reading

American Geographical Society. "Amundsen's North West Passage." *Bulletin of the American Geographical Society* 38, no. 1 (1906): 27–29.

Amundsen, R. *The South Pole: An Account of the Norwegian Antarctic Expedition.* New York: L. Keedick, 1913.

Hinks, A. "The Observations of Amundsen and Scott at the South Pole." *Geographical Journal* 103, no. 4 (1944): 160–80.

Sverdrup, H. "Roald Amundsen." *Arctic* (Arctic Institute of North America) 12, no. 4 (1959): 221–36.

Amundsen–Scott South Pole Station

The Amundsen–Scott South Pole Station is a year-round research facility of the U.S. Antarctic Program located near the geographic South Pole. Construction of the station began in November 1956 as part of the scientific efforts of the United States during the International Geophysical Year (1957/1958). The station is named after the polar explorers and researchers Roald Amundsen (1872–1928) and Robert Scott (1868–1912).

The station is only a short distance away from the actual geographical pole and lies 9,300 ft. (2,835 m) above sea level on the central high plateau of Antarctica. Prior to the construction of the Amundsen–Scott station, there were only a few temporarily used research stations at the pole, most notably Roald Amundsen's camp Polhem used during his expedition to the pole in December 1911 and Robert Scott's camp used after his arrival at the pole in January 1912. Both camps consisted of tents that were used for a couple of days.

The original Amundsen–Scott South Pole Station was an in-the-ice station constructed by the U.S. Navy and used up to 1975 when the snow and ice accumulation on top of the station reached a level that compromised structural integrity. Between 1975 and 2003, the main station was located in a geodesic dome that housed basically the whole station on top of the ice under a steel–aluminum dome measuring 164 ft. (50 m) wide and 52 ft. (16 m) tall. An upgrade of the station was begun in 1997, finally resulting in the official opening of the new elevated main station in 2008. The original station and the dome station were demolished or dismantled in 2009/2010.

The new station provides support for up to 50 scientists and support personnel for overwintering and up to 150 people for summer operations. It is the second largest research station in Antarctica after McMurdo Station. The average temperature at the station is −56°F (−49°C) with temperatures ranging from −18°F in summer (−28°C in December) and −76°F in winter (−60°C in July). The station is drifting with the ice sheet approximately 33 ft. (10 m) per year. The station is supplied from McMurdo by a C-130 aircraft and using the Jack F. Paulus Skiway adjacent to the station area. Aircraft operations are limited to the summer months and require ski-equipped aircraft.

Main research areas at the Amundsen–Scott South Pole Station include atmospheric and meteorological research, astronomy and astrophysics, and topics like glaciology, geophysics, seismology, and a variety of other fields including biology and medicine. The longest continuous set of meteorological data for the interior of Antarctica has been collected at the station.

Despite the fact that the Amundsen–Scott South Pole Station is mainly a research station, it has been visited frequently by the media and politicians, most notably during the centenary of the exploration of the South Pole during the season 2011/2012, and has been featured as well in documentaries as in science fiction settings. During the centenary, a monument for the arrival of Amundsen and Scott at the South Pole in 1911/1912 has been dedicated in the vicinity of the Amundsen–Scott South Pole Station.

Ingo Heidbrink

See also: Antarctic Circle; Antarctic Ice Sheet; Antarctic Programs and Research Stations/Bases; Ice Domes: Argus, Charlie, and Fuji (Valkyrie); South Pole

Further Reading

Hollin, J., and D. Belanger. "Deep Freeze: The United States, the International Geophysical Year, and the Origins of Antarctica's Age of Science." *Arctic, Antarctic, and Alpine Research* 40, no. 1 (2008): 264–65.

Rugg, J. *Pinnacle of Antarctica: The Amundsen-Scott South Pole Station.* Bloomington, IN: AuthorHouse, 2001.

United States Antarctic Program and Antarctic Support Associates. *Your Stay at Amundsen-Scott South Pole Station, 1993.* Englewood, CO: Antarctic Support Associates, 1993.

Amundsen Sea

The Amundsen Sea is a marginal sea of the Southern Ocean, located off of Marie Bird Land between an unnamed Sea (west) and Bellingshausen (east) Sea (72.5° S and 112° W). Just beyond the unnamed Sea is the Ross Sea. The western border is Cape Flying Fish (72° 3′S, 102° 20′W) on Thurston Island and the eastern border is Cape Dart (73° 7′S 126° 9′W) on Siple Island. The Amundsen Sea is named after the Norwegian explorer Roald Amundsen (1872–1928), who explored the area in 1929 under Captain Nils Larsen.

The Amundsen Sea is mostly covered by ice. There are a number of glaciers and tongues that extend from land into the Amundsen Sea. There are two open bays on the Amundsen Sea coast, which are Russell Bay (73° 27′S 123° 54′W) and Pine Island Bay (74° 50′S 102° 40′W). Russell Bay is located between Carney Island and northwest side of Siple Island off of the Grez Ice Shelf. Russell Bay was photographed, detailed, and described by the U.S. Navy as part of the International Geophysical Year of 1957–1959. It is named after Admiral James S. Russell.

Pine Island Bay is an open bay around 40 miles (64 km) in length and 30 miles (48 km) in width. There are two major ice formations that flow into Pine Island Bay, which are Pine Island and Thwaites Glacier. Pine Island Glacier (75° 10′S 100° W) is located near Cape Flying Fish and Thwaites Glacier (75° 30′S 106° 45′W) extends into Pine Island Bay forming an ice spit or tongue about 30 miles (50 km) wide and is called "Thwaites Ice Tongue" (75° S 106° 50′W). The average thickness of the Thwaites Ice Tongue ice is almost 2 miles (3 km). Icebergs that have broken off the Thwaites Ice Tongue have formed the Thwaites Iceberg Tongue (74° S 108° 30′W). The Pine Island and Thwaites Glaciers were photographed, detailed, and described by the U.S. Navy during Operation Highjump, in 1946. Its name is derived from the seaplane USS *Pine Island* used during the operation. Thwaites Glacier was named after the glacial geologist Fredrik T. Thwaites.

Pine Island and Thwaites Glaciers make up most of the Amundsen Sea Embayment. The Amundsen Sea Embayment is one of three significant ice drainage basins of the West Antarctic Ice Sheet (the other two are the Ross Sea Embayment and Weddell Sea Embayment). The Amundsen Sea Embayment has a total area of 68,800 square miles (175,000 sq. km) and drains around 10 percent of the West Antarctic Ice Sheet. Some scientists are closely monitoring the Pine Island and the Thwaites Glaciers because they are viewed as being the weak link in the overall health of the West Antarctic Ice Sheet. It is estimated that if these glaciers melt, it would threaten the entire West Antarctic Ice Sheet and could raise the global sea level by from 3 to 6 ft. (1–2 m).

The Amundsen Sea has holes in the ice called "polynyas." A polynya is a hole of unfrozen ice surrounded by frozen ice due to upwelling, currents, or winds. These polynyas make the Amundsen Sea productive for the entire food chain, including phytoplankton, copepods, algae, fish, birds, and mammals. Seals are native to the Amundsen Sea. Species found here are the Crabeater, Ross, Southern Fur, and Weddell. Common species of birds are fulmars (southern and southern giant), petrel (snow and storm), blue-eyed shag, skua (south polar and brown), and Antarctic tern.

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See also: Bellingshausen Sea; Benthic Community; Ross Sea; Weddell Sea

Further Reading

Jacobs, S., A. Jenkins, H. Hellmer, C. Giulivi, F. Nitsche, B. Huber, and R. Guerrero. "The Amundsen Sea and the Antarctic Ice Sheet." *Oceanography* 25, no. 3 (2012): 154–63.

Nitsche, F., S. Jacobs, R. Larter, and K. Gohl. "Bathymetry of the Amundsen Sea Continental Shelf: Implications for Geology, Oceanography and Glaciology." *Geochemistry Geophysics Geosystems* 8 (2007): Q100009.

Shepherd, A., D. Wingham, and E. Rignot. "Warm Ocean Is Eroding West Antarctic Ice Sheet." *Geophysical Research Letters* 31, no. 23 (2004): L23402.

Antarctic Circle

On January 17, 1773, the ships *Resolution* and *Adventure*, under the command of James Cook, are credited with being the first vessels to cross the Antarctic Circle. In a strict definition, the Antarctic Circle is the area south of 66° 33′ 44″ latitude. The Antarctic Circle (commonly referred to as the Antarctica) is predominately a continent that is surrounded by an ocean and roughly covers 6 percent or 5.5 million square miles (14.2 million sq. km) of the earth. The Antarctic area is 97 percent covered by ice or 5.1 million square miles (13.3 million sq. km). The thickness of Antarctic ice averages about 8,850 ft. (2,700 m) with the thickest areas reaching more than 15,000 ft. (4,775 m). The total volume of ice on Antarctica is 28 million cubic km.

Beyond what is indicated on maps, the Antarctic Circle is not an actual line or specific place. The Antarctic Circle is one of five imaginary circles indicated on maps of the earth, representing major lines of latitude (e.g., Tropic of Cancer [23° 26′ 16″N], Equator [0°], Tropic of Capricorn [23° 26′ 16″S], and the Arctic Circle [66° 33′ 44″N]). The distance from the Arctic Circle to the Antarctic Circle is about 9,300 miles (15,000 km). Both poles are the same distance from the equator (0° to 66.5° N or S).

The 66.5° S latitude is considered the southernmost boundary of the Antarctic Circle. A defining characteristic of the Antarctic is that all locations above 66.5° S latitude experience a 24-hour period of sunlight on the summer solstice (around December 21) as well as 24 hours of darkness during the winter solstice (around June 21). The summer solstice is commonly called the "Midnight Sun," while the winter solstice is called the "Polar Night." The seasons of the Southern Hemisphere are the opposite to that of the Northern Hemisphere.

The Antarctic Circle ecosystem is classified as a desert because yearly precipitation is less than 10 in. (25 cm). A key difference between Antarctica's ecosystem and other desert is that there is almost no evaporation. Thus, the limited snowfall builds up and remains for hundreds and even thousands of years resulting in thick ice sheets. The Antarctic Circle can be divided into three climatic regions, which are the interior (extremely cold with little precipitation), coastal areas (less cold than the interior but still cold with little precipitation), and the Antarctic Peninsula (warmest of the regions with the most precipitation). The zone just

POLAR CIRCLE

The Polar Circle is used to represent both the Antarctic Circle and the Arctic Circle as defined by the strict definition of 66° 33′ 44″S (Antarctic Circle) or 66° 33′ 44″N (Arctic Circle). The Polar Circle as indicated on maps is not an actual line or specific place. The Polar Circle represents two of the five imaginary circles indicated on maps of the earth. The other major lines of latitude are the Tropic of Cancer (23° 26′ 16″N), the Equator (0°), and the Tropic of Capricorn (23° 26′ 16″S). The distance from the Arctic Circle to the Antarctic Circle is about 9,300 mi (15,000 km). Both poles are at the same distance from the equator (0°–66.5° N or S).

The Polar Circles are known as frigid zones and the coldest places on the earth. Temperatures are significantly lower at the South Pole than the North Pole, principally because the South Pole is in the middle of a continental landmass and at a higher altitude rather than in the middle of an ocean, which acts as a heat reservoir. Both areas at their southernmost boundaries experience 24 hours of daylight and 24 hours of night. In the Arctic Circle, the summer solstice is around June 21, and the 24 hours of darkness period occurs around December 21 called the winter solstice. The seasons of Antarctica are the opposite of the Arctic Circle. For example, the winter solstice in Antarctica occurs around June 21 and the summer is around December 21. At 90° south (South Pole) and 90° north (North Pole), these regions have roughly six months of daylight and six months of night.

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north of the Antarctic Circle called the subantarctic zone is 20–30 miles (32–48 km) running between the forty-eighth and sixty-first parallel called the "Antarctic Convergence."

Unlike the Arctic Circle, Antarctica has no tundra, shrubs, or tree lines. There are a limited but diverse species of fungi, liverworts, lichens, and mosses, all of which have evolved to survive in Antarctica environments, characterized by cold temperatures and limited precipitation. Specifically, there are around 20 different microfungi, 25 liverworts, 350 lichens, and about 100 species of mosses. There are also two types of flowering plants, Antarctic hair grass and pearlwort. There are no terrestrial mammals in Antarctica. There are a number of marine mammals, such as whales and seals, as well as various birds, such as penguins, albatrosses, sheathbills, gulls, terns, shearwaters, petrels, cormorants, ducks, geese, and swans.

Antarctica landscape. (Corel)

POLAR NIGHT

Polar night is when the sun does not appear above the horizon for more than 24 hours. This occurs only in polar circle regions above 66.5° N and 66.5° S. The 24 hours of darkness corresponds to the winter solstices in each of the Antarctic and Arctic Circles. The term "solstice" means standstill in Latin. All locations north of the Arctic Circle (66.5° N) experience at least a 24-hour period of darkness on the winter solstice (December 21). During the winter solstice, in the Northern Hemisphere, the North Pole (location 90° N) is tilted away from the sun and directly over the Tropic of Capricorn. The earth, during the winter solstice, is leaning away from the sun, and the earth receives a shorter period of sunlight due to its position relative to the sun. The extended periods of darkness coupled with shorter periods of light during the day result in decreased temperatures in the Northern Hemisphere of the earth. The winter solstice in the Southern Hemisphere occurs during the summertime in the Northern Hemisphere. The polar night in Antarctica (66.5° S) occurs around June 21st.

Andrew J. Hund

The human population of the Antarctic Circle is located at the scientific stations, which are both seasonal and year around.

Andrew J. Hund

See also: Antarctic Ice Sheet; Antarctic Peninsula; East Antarctica; Lake Vostok; Lambert Glacier; McMurdo Dry Valleys of East Antarctica; Transantarctic Mountains; Vinson Massif; Volcanoes in Antarctica; West Antarctica

Further Reading

Crossley, L. *Explore Antarctica.* Cambridge, MA: Australian Antarctic Foundation, 1995.

Mason, P. *Polar Regions—Geography Fact Files.* Suffolk, UK: Hodder Wayland, 2004.

Antarctic Cruise Industry

During the last decades of the twentieth century, Antarctica became an important destination for the international cruise ship industry. Typically, Antarctic cruises are carried out with ice-strengthened cruise ships limited in passenger capacity and offering few amenities in comparison to other cruise ship destinations. Antarctic cruises offer Zodiac landings and lectures by experts on a variety of Antarctica-related subjects, like biology, geology, glaciology, and the history of Antarctica.

Most cruises depart from the southern tip of South America and commonly include visits to the Falkland Islands and South Georgia prior to continuing to Antarctica itself. The peninsula region is the area most visited by Antarctic cruise ships, and places like Port Lockroy or Deception Island are typical destinations for nearly all ships.

The development of the Antarctic cruise industry began with the tours of the MV *Lindblad Explorer* in the late 1960s, and while still a comparable small niche sector, today more than a dozen operators offer Antarctic cruises on a regular base with more than 37,000 cruise ship passengers visiting Antarctica during the season 2009/2010 alone.

The Antarctic cruise ship industry is subject to the regulations of the Antarctic Treaty System, and since the founding of the International Association of Antarctic Tour Operators (IAATO), there are mandatory regulations for cruise ship visits to Antarctica for the members of the association. These regulations include limitations for the number of passengers on land, guidelines for encounters with the Antarctic fauna, regulations related to invasive species, contamination of the Antarctic environment, and training standards for expedition leaders and guides.

Despite of all efforts the Antarctic cruise industry is sometimes considered a significant environmental threat for the Antarctic. An example is tourists who have brought barley seeds to Antarctica, causing substantial biosecurity fears of invasive species. Some Antarctic scientists and specialists as a result argue that at least some types of tourism should be restricted or prohibited.

Due to the special situation of Antarctica as a region characterized by a lack of national jurisdiction, IAATO serves not only as a lobby group, but also as the main organization of a largely self-regulated industry. Nevertheless all visits of cruise ships to Antarctica require a permit under the Antarctic Treaty System.

Despite the operations in extreme environmental conditions including the ice-covered waters of Antarctica or the extreme weather and sea conditions of the Drake Passage, the Antarctic cruise industry experienced up to now only a very limited number of substantial accidents, most notably the loss of the MV *Explorer* in November 2007. While the ship got completely lost after a collision with an underwater obstacle, most probably ice, all 91 passengers, 9 guides, and 54 crew could be brought to safety with the support of other cruise ships and governmental vessels of various nations.

The Antarctic cruise industry is basically the only option for tourists to visit Antarctica, but even in comparison with other high-prized cruise ships' destinations, Antarctica remains one of the most expensive tourist destinations on the whole globe.

Ingo Heidbrink

See also: Antarctic Circle; Antarctic Ice Sheet; Antarctic Peninsula; Blood Falls, Antarctica; East Antarctica; McMurdo Dry Valleys of East Antarctica; Paulet Island; Ross Island, Historic Huts of; Snow Hill Island; South Sandwich Islands; Transantarctic Mountains; Vinson Massif; Volcanoes in Antarctica; West Antarctica

Further Reading

Bauer, T. *Tourism in the Antarctic: Opportunities, Constraints, and Future Prospects*. New York: Haworth Hospitality Press, 2001.

Carey, P., and C. Franklin. *Antarctica Cruising Guide.* 2nd ed. Wellington, NZ: Awa Press, 2009.

International Association of Antarctica Tour Operators. http://iaato.org/home. Accessed January 7, 2014.

Luck, M., P. Maher, and E. Stewart. *Cruise Tourism in Polar Regions: Promoting Environmental and Social Sustainability?* London: Earthscan, 2010.

Antarctic Fur Seals

Antarctic fur seals (*Arctocephalus Gazella*) live in the Antarctic regions and near sub-Antarctic islands, with 95 percent of their breeding population living on South

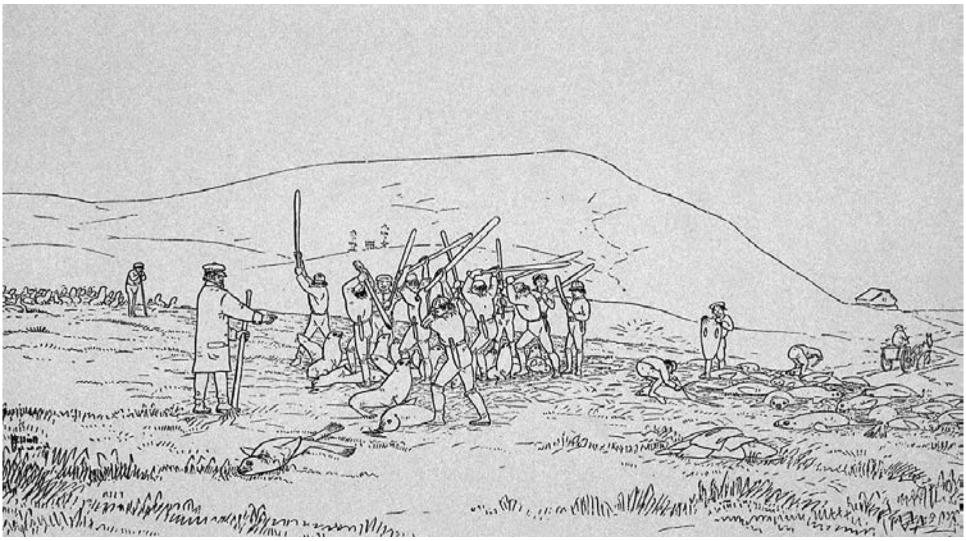
Georgia Island. The Antarctic fur seal is one of 16 species of marine mammals in the family of eared seals. Antarctic fur seals are part of the group of marine animals known as pinnipeds.

Adult males are dark brown in color. Adult females tend to be grey. Male seals can live up to 15 years, while females can live up to 23 years. Male Antarctic fur seals are heavier than female Antarctic fur seals with males weighing up to approximately 400 pounds and females weighing around 100 pounds. The seal spends most of its life at sea, hunting for food. Antarctic fur seals feed off krill, squid, and fish, and penguin. Predators of Antarctic fur seals include killer whales and leopard seals, which hunt Antarctic fur seal pups.

The Antarctic fur seal was once at grave risk of extinction due to commercial fishing in the nineteenth century. Antarctic fur seals were hunted for their pelt. As of 2011, they are protected under the Antarctic Treaty, Convention for the Conservation of Antarctic Seals, and the Convention on International Trade in Endangered Species. Researchers estimate there are between 4–5 million Antarctic fur seals.

Female Antarctic fur seals are pregnant most of their lives. The females arrive at the breeding grounds in late spring or early summer. Within a week of giving

Antarctic fur seal pup. (National Oceanic and Atmospheric Administration)



A sketch of the "killing-gang at work" by Henry W. Elliott, the Smithsonian naturalist hired to study sealing operations in Alaska. Elliott's outrage over the widespread slaughter pressured the government to enact the Convention for the Protection of Fur Seals in Alaska in 1892. (National Oceanic and Atmospheric Administration)

birth, they are fertile, mate, and become pregnant again. They are pregnant while nursing their newborn pups four months. The female after weaning the pup then heads back out to sea to feed during the gestational period then returns to the breeding ground, gives birth, and breeds again. Males have multiple breeding partners (sometimes as many as a dozen or more). Adult males can become physically aggressive defending access of their female mates. Females are pregnant for a little over a year's time.

Antarctic fur seals use vocalization to communicate. Males use two types of vocalizations: one is a warning roar used to ward off other males fur seals, often used during breeding season. That warning roar also can be used to ward off predators. The other, friendlier vocalization is used during breeding season to communicate with females. Females can communicate vocally just as male Antarctic fur seals—yet females do most of their communicating with their pups. They use sound and smell to bond with their pups.

Peter R. Dean

See also: Bearded Seal; Crabeater Seal; Harp Seal; Hooded Seal; Leopard Seal; Ribbon Seal; Ringed Seal; Ross Seal; Southern Elephant Seal; Spotted seal; and Weddell Seal.

Further Reading

Casaux, R., L. Bellizia, and A. Baroni. The diet of the Antarctic fur seal *Arctoephalus gazella* at Harmony Point, South Shetland Islands: evidence of opportunistic foraging on penguins? *Polar Biology*, 27: 59–65, 2004.

Hofmeyr, G., M. Bester, A. Makhado, and P. Pistorius. "Population Changes in Subantarctic and Antarctic Fur Seals at Marion Island." *South African Journal of Wildlife Research* 36, no. 1 (2006): 55–68.

Schwartz, L., M. Goebel, D. Costa, and A. Kilpatrick. "Top-Down and Bottom-Up Influences on Demographic Rates of Antarctic Fur Seals *Arctocephalus gazella*." *Journal of Animal Ecology* 82, no. 4 (2013): 903–911.

Antarctic Ice Sheet

The Antarctica continent is 5,339,572 square miles (13,829,430 sq. km) including ice shelves and islands. Ninety-eight percent of the Antarctica continent is covered by ice. Antarctica is the world's largest ice mass at 6.1 million cubic miles (25.4 million cubic km). The Antarctic Ice Sheet accounts for about 90 percent of the world's freshwater. The average thickness of the Antarctic Ice Sheet is 6,000 ft. (1,829 m). The total area of the ice shelves of Antarctica is 595,253 square miles (1,541,700 sq. km). The Antarctic Ice Sheet is divided into two parts: the East Antarctic Ice Sheets (EAISs) and West Antarctic Ice Sheets (WAISs). The WAISs and EAISs are divided by the Transantarctic Mountains. EAIS rests on land, while WAIS rests on land that would be submerged in the ocean.

West Antarctic Ice Sheets (WAIS)

The WAIS is called the "lesser Antarctica" and is considerably smaller than the EAIS. Of the 6.1 million cubic miles of ice of the Antarctic Ice Sheet, around 10 percent (530,000 cubic miles [2.2 million cubic km]) is in the WAIS. WAIS is classified as sea-based ice sheet, where if there was no ice, the land it sits atop would be below sea level. The average thickness of EAIS is just more than 7,300 ft. (2,226 m). The discharge rate of the WAIS inhibits ice from accumulating over 8,000 ft. (2,500 m). The borders of the WAIS are the Transantarctic Mountains, the Ross Ice Shelf, the Ronne Ice Shelf, and the Amundsen Sea. The WAIS is drained by several large ice streams into three significant ice drainages, which are the Amundsen/Bellingshausen (north), Ross (west), and Weddell Seas (northeast). The major ice streams of the Amundsen/Bellingshausen Seas are the Pine Island (75° 10′S 100° W) and Thwaites (75° 30′S 106° 45′W) Glaciers. Several ice streams drain into the Ross shelf on the western side, such as the MacAyeal (80° S 143° W), Bindschadler (81° S 142° W), Whillans (83° 40′S 145° W), and Mercer (84° 50′S 145° W) ice streams. These ice streams were formerly known as the Ice Stream E, D, B, and A, respectively. Three ice streams flowing into the Ronne Ice shelves are the Rutford (79° S 81° W), Evans (76° S 78° W), and the Foundation (83° 15′S 60° W). Scientists note that the WAIS is losing ice mass due to climate change. This loss of ice is attributed to the acceleration of ice streams primarily in the Amundsen Sea region (e.g., Pine Island and Thwaites Glaciers). Major WAIS ice shelves include the Ronne-Filchner Larsen (77° 51′ 33″S 61° 17′ 57″W), Abbot (72° 45′S 96° W), and Ross (81° 30′S 175° W).

East Antarctic Ice Sheets (EAIS)

The EAIS is called "Greater Antarctica" and rests atop a landmass that is mostly mountain ranges above sea level. The borders of EAIS are the Transantarctic Mountains and the Southern Ocean. Within the EAIS is the South Pole. The EAIS does not have high mass turnover but rather has slight positive mass balance or slight accumulation of ice. The ice on EAIS is thicker than the WAIS. The average thickness of the EAIS is more than 7,303 ft. (2,226 m), with Dome Charlie (69° 56′S 135° 12′E) having the deepest ice at 15,700 ft. (4,776 m). Some reasons for the difference in ice thickness between the EAIS and the WAIS are that the WAIS has high mass turnover with high snow accumulation and significant discharge via ice streams that exit out ice shelves. The highest elevation in EAIS is Dome Argus (81° S 77° E), which is the Antarctic highest ice feature at 13,422 ft. (4,091 m) above sea level. A major drainage of EAIS is the Lambert Glacier (71° S 70° W) and accounts for approximately 12 percent of the EAIS volume drainage. The Lambert Glacier is the world's largest and longest glacier covering more than 386,000 square miles (1 million sq. km). The ice of the Lambert Glacier originates in the Polar Plateau in Mac Robertson Land. Major EAIS ice shelves, include Riiser-Larsen (72° 40′S, 16° W), Fimbul (70° 30′S, 0° 10′W), Amery (69° 45′S 71° E), West (66° 40′S 85° E), and Shackleton (66° S 100° E). Presently, scientists note that the EAIS has a stable ice mass and may be slightly increasing.

Andrew J. Hund

See also: Antarctic Circle; Cryoconite Holes; Iceberg Monitoring and Classification; Ice Cap; Ice Core Climatic Data Proxies; Ice Domes: Argus, Charlie, and Fuji (Valkyrie); Ice Sheet; Ice Shelf; Ice Shelves of Antarctica

Further Reading

Anderson, J., S. Shipp, A. Lowe, J. Wellner, and A. Mosola. "The Antarctic Ice Sheet during the Last Glacial Maximum and Its Subsequent Retreat History: A Review." *Quaternary Science Reviews* 21, nos. 1–3 (2002): 49–70.

Chen, J., C. Wilson, D. Blankenship, and B. Tapley. "Accelerated Antarctic Ice Loss from Satellite Gravity Measurements." *Nature Geoscience* 2, no. 12 (2009): 859.

Livingstone, S., C. O'Cofaigh, C. Stokes, C. Hillenbrand, A. Vieli, A., and S. Jamieson. "Antarctic Palaeo-Ice Streams." *Earth-Science Reviews* 111, nos. 1–2 (2012): 90–128.

Steig, E., D. Schneider, S. Rutherford, M. Mann, J. Comiso, and D. Shindell. "Warming of the Antarctic Ice-Sheet Surface since the 1957 International Geophysical Year." *Nature* 457, no. 7228 (2009): 459–62.

Antarctic Peninsula

The Antarctic Peninsula (75° S 63° S) is about 1,200 miles (2,000 km) long extending from Prime Head (63° S) to roughly the Eklund Islands at the southwest end of George VI Sound. The Antarctic Peninsula is generally divided into two parts. The northern portion is Graham Land, and the southern portion is Palmer Land. The Antarctic Peninsula is primarily a mountain range. The elevation of the mountains increases as range progresses from Graham to Palmer Land. The landscape of the Antarctic Peninsula is characterized by coastal mountains, fjords, and islands.

Graham Land

The northernmost part of Graham Land consists of more than a dozen major islands. These islands are James Ross Island (64° 10′S 57° 45′W), Joinville Island group (e.g., d'Urville [63° 5′S 56° 20′W], Joinville [63° 15′S 55° 45′W], Dundee [63° 30′S 55° 55′W], and Bransfield [63° 11′S 56° 36′W] Islands), Snow Hill Island (64° 28′S 57° 12′W), Vega Island (63° 50′S 57° 25′W), Seymour Island (64° 14′S 56° 37′W), Rosamel Island (63° 34′S 56° 17′W), Paulet Island (63° 35′S 55° 47′W), Lockyer Island (64° 27′S 56° 36′W), Eagle Island (63° 65′S 57° 45′W), Jonassen Island (63° 33′S 56° 40′W), Astrolabe Island (63° 17′S 58° 40′W), and Tower Island (63° 34′S 59° 50′W). Another large group of islands offshore from Graham Land is the South Shetland Islands. The South Shetland Islands (62° S 58° W) are a group of 11 major island and many minor islands. About 85 percent of the islands are permanently glacier covered. All of these islands are located outside of the Antarctic Circle.

In the Graham Land region, there are a number of coasts. On the Bellingshausen Sea (western) side of the coasts are Davis, Danco, Graham, Loubet, and Fallières. There are several islands along these coasts, such as Deception, Trinity, Biscoe, and Adelaide. On the Weddell Sea (eastern) side of Graham Land, the coasts are Nordenskjold, Oscar II, Foyn, and Bowman. North of these coasts is the Trinity Peninsula (63° 37′S 58° 20′W) stretching to Prime Head (63° S). The Larsen Ice Shelf (67° 30′S 62° 30′W) is situated along the Oscar II, Foyn, Bowman, and Wilkins Coasts of Graham and Palmer Land. The ice shelf faces the Weddell Sea and is located between Cape Longing (64° 33′S 58° 50′W) on Longing Island of Graham Land and Hearst Island (69° 25′S 62° 10′W) off Palmer Land. The Larsen Ice Shelf covers an area about 19,000 square miles (48,600 sq. km).

Palmer Land

Palmer Land (71° 30′S 65° W) is the southern portion of the Antarctic Peninsula. The border between Graham and Palmer Land is Cape Jeremy (69° 24′S 68° 51′W) and the east tip of Hollick-Kenyon Peninsula at Cape Agassiz (68° 29′S 62° 56′W). Cape Jeremy neighbors the entrance to the George VI Sound. The southern border of Palmer Land is roughly 80° W bordering Ellsworth Land to the Carlson Inlet (78° S 78° 30′W) of the Ronne Ice Shelf. The Wordie Ice Shelf is on the southwestern coast of Palmer Land.

In Palmer Land, there are a number of coasts. On the Bellingshausen Sea (western) side is the English Coast. Alexander I Island is the major island on this side of Palmer Land. Alexander I Island (71° S 71° W) is the largest Antarctic Island

NEUMAYER CHANNEL

Neumayer Channel (64° 47′S 63° 8′W) is a 16-mile (25-km) sea channel in a northeast to southwest direction with a width of about 1.5 miles (2.4 km) located in the west coast of the Antarctic Peninsula, separating Anvers Island from Wiencke Island, in the Palmer Archipelago.

The southwest entrance of the channel was first seen by Eduard Dallmann (1830–1896), the leader of a German expedition in 1873–1874, who named it "Roosen Channel." But later, the Belgian Antarctic Expedition led by Adrien Victor Joseph de Gerlache de Gomery (1866–1934) in 1897–1899 sailed through the channel and named it after Georg von Neumayer (1826–1909), a German astronomer, geophysicist, and polar explorer who's help was very important to Gerlache's expedition. Neumayer was, since 1879, the chairman of the International Polar Commission founding the First International Polar year in 1882. The main German research station in Antarctica is also named after him: Neumayer Station.

Neumayer Channel is very well known by its astonishing views and majestic cliffs, and said to be like a labyrinth with no visible exits because of its inverted S-shape. It is one of the most desired locations to visit by Antarctic Tourist Ships, which sail through the channel to get to Port Lockroy (64° 49′S 63° 26′W), an old British Base now turned into a historic site.

Luciana M. Motta

measuring about 240 miles (390 km) long and 50 miles (80 km) wide. The total area of the Alexander I Island is about 19,000 square miles (49,000 sq. km). This island is the second largest uninhabited island in the world, with Devon Island (75° 08′N 087° 51′W) in the Canadian Arctic Archipelago being the largest.

Alexander I Island is located between the Ronne Entrance (east) and Marguerite Bay (west) and Palmer Land and the Bellingshausen Sea. The Ronne Entrance (72° 30′S, 74° W) is on the eastern side in between the George VI Sound (71° S 68° W) and the Bellingshausen Sea just southwest of Alexander I Island. On the Ronne Entrance side is the 45-mile (72-km) Bach Ice Shelf (72° S 72° W). Marguerite Bay (68° 30′S 68° 30′W) is on the west side located between Adelaide Island in the north and runs along the Fallieres Coast of the Antarctic Peninsula, and Alexander I Island and the George VI Sound to the south. Other notable islands on the English coast are Smyley and Spaatz.

On the Weddell Sea (eastern) side the Palmer Land coasts are Wilkins, Black, Lassiter, Orville, and Zumberge. There are two ice shelves running along the Palmer Land coast, which are the Larsen-D and Ronne ice shelves. The Ronne Ice Shelf is bordered by the Orville and Zumberge coasts of Palmer and Ellsworth Land. Ronne-Filchner Ice Shelf is the second largest in Antarctica (162,935 square miles [422,000 sq. km]) located at the head of the Weddell Sea.

Several inlets are found along the Weddell Sea side of Palmer Land, such the Hilton, Violante, and New Bedford. There are several mountains within Palmer Land, such as the Latady, Seward, and Sweeney.

Research Stations

Fourteen countries have more than 30 permanent and seasonal stations and bases on the Antarctic Peninsula. The countries with stations are Argentina, Brazil, Chile, China, Ecuador, Peru, Poland, Russia, South Korea, Spain, Ukraine, the United Kingdom, the United States, and Uruguay. Argentina has four permanent stations: Esperanza (63° 23′S 56° 59′W) in Hope Bay, Jubany or Carlini (62° 14′S 58° 40′W) on King George Island, Marambio (64° 14′S 56° 37′W) on Seymour-Marambio Island, and San Martin (68° 7′S 67° 6′W) on Barry Island. Argentina has also seven seasonal stations and bases: the Almirante Brown Base (64° 53′S 62° 53′W) in Paradise Bay, Base Deception (62° 52′S 60° 43′W) on Deception Island, Base Primavera (64° 9′S 60° 57′W) on the Danco Coast, Petrel Air Station (63° 28′S 56° 17′W) on Dundee Island, Teniente Camara Base (62° 2′S 58° 42′W) on Livingston Island, Base Melchior (64° 20′S 62° 59′W) on Anvers Island, and Teniente Matienzo Base (64° 58′S 60° 4′W) near Larsen Nunatak.

Brazil has a permanent station called “Comandante Ferraz Antarctic Station” (62° 8′S 58° 40′W) located in Admiralty Bay on King George Island. Brazil also has a number of shelters on the Antarctica Peninsula, which include Refuge Astronomer

Cruls (62° 14′S 58° 48′W) on Nelson Island, and Refuge Emílio Goeldi (61° 5′S 55° 20′W) and Refuge Engineer Wiltgen on Elephant Island.

The Chilean permanent bases include Base Presidente Eduardo Frei Montalva and Villa Las Estrellas (62° 11′S 58° 58′W) located on the Fildes Peninsula of King George Island, Professor Julio Escudero Base (62° 12′S 58° 57′W) on King George Island, Captain Arturo Prat Base (62° 28′S 59° 39′W), and Base General Bernardo O'Higgins Riquelme (63° 19′S 57° 53′W) on the Trinity Peninsula. The seasonal Chilean bases are Teniente R. Marsh Martin Base on King George Island, González Videla Antarctic Base (64° 49′S 62° 51′W) at Paradise Bay of Water Boat Point, and Base Yelcho (64° 52′S 63° 35′W) in South Bay of Doumer Island.

Several countries have only one research station, such as China, Ecuador, Peru, Poland, Russia, Spain, South Korea, Ukraine, the United States, and Uruguay. The Chinese station is the Great Wall Station (62°12′ 59″S 58° 57′ 44″W) on King George Island. Ecuador's seasonal station is Pedro Vicente Maldonado Base (62° 26′S 59° 44′W) at Guayaquil Bay on Greenwich Island. Machu Picchu Research Station (62° 5′S 58° 28′W) is Peru's seasonal station at Admiralty Bay on King George Island. The Poland station is the Henryk Arctowski Polish Antarctic Station (62° 9′S 58° 28′W) on King George Island. The Russian station is on King George Island and is called the "Bellingshausen Station" (62° 11′S 58° 57′W). Juan Carlos I Antarctic Base (62° 39′S 60° 23′W) is the government of Spain's seasonal base at South Bay on Livingston Island. King Sejong Antarctic Station (62° 2′S 58° 21′W) located on King George Island is South Korea's research station. The Vernadsky Research Base (65° 14′S 64° 15′W) is Ukraine's Antarctic Station and was formerly the United Kingdom's Faraday (or Base F). It is located at Marina Point on Galindez Islands. Palmer Station (64° 46′S 64° 3′W) is the U.S. station on Anvers Island. Uruguay's Artigas Base (62° 11′S 58° 54′W) is located on King George Island.

The United Kingdom has two stations on the Antarctica Peninsula run by the British Antarctic Survey. The first is Rothera Research Station (67° 34′S 68° 7′W) at Rothera Point on Adelaide Island. The other is Fossil Bluff (71° 20′S 68° 17′W) located on Fossil Bluff of Alexander I Island.

The Antarctica Peninsula has the least cold climate of Antarctica and thus is the most biological diverse place found in Antarctica. This area is where in summer algae, moss, and lichen (e.g., old-man's beard and *Bryoria* species) grow. The only two native vascular plants in Antarctica grow here, which are the Antarctic hair grasses (*Deschampsia antarctica*) and the Antarctic pearlworts (*Colobanthus quitensis*). It is also home to penguins (Adélie, chinstrap, emperor, and Gentoo); flying seabirds (southern fulmar, petrels [cape, southern giant, snow, Wilson's storm], skuas [brown and south polar], kelp gull, Antarctic tern, and the imperial shag); seals (crabeater, leopard, Weddell, and the south elephant); and sei whales. Marguerite Bay on Dion Island is only place where emperor penguins breed in West

Antarctica. The southernmost colony of gentoo penguins is found on Petermann Island. Lastly, the cryopelagic fish "bald notothen" lives in the below-zero water of the peninsula.

Andrew J. Hund

See also: Alexander I Island; Antarctic Territorial Claims; Antarctic Treaty System (ATS); Deception Island; East Antarctica; South Sandwich Islands; Weddell Sea

Further Reading

Davies, B., et al. "Antarctic Peninsula Ice Sheet Evolution during the Cenozoic Era." *Quaternary Science Reviews* 31 (2012): 30–66.

Mason, P. *Polar Regions—Geography Fact Files.* Suffolk, UK: Hodder Wayland, 2004.

Tulloch, C. *Antarctica—The Heart of the World.* Sydney: Australian Broadcasting Commission, 2003.

Antarctic Programs and Research Stations/Bases

Since there are no permanent residents in Antarctica, the researchers and support staff are the population of the Antarctica Continent. In the summer months, there are about 4,000 people in Antarctica and about 1,000 over winter. Thirty-one countries have national Antarctic programs and maintain more than 70 permanent and seasonal research stations or bases. There are approximately 45 permanent year-round stations and 30 seasonal stations. There are more than 20 airstrips that support these permanent and seasonal research stations or bases. The U.S. McMurdo station on Ross Island is the only permanent harbor.

Most of the national Antarctic program countries are members of the Council of Managers of National Antarctic Program (COMNAP) and the Scientific Committee on Antarctic Research (SCAR). There are 29 member countries of the COMNAP, which are: Argentina, Australia, Belgium, Brazil, Bulgaria, Chile, China, Czech Republic, Ecuador, Finland, France, Germany, India, Italy, Japan, Korea, Republic of the Netherlands, New Zealand, Norway, Peru, Poland, Russia, South Africa, Spain, Sweden, Ukraine, United Kingdom, United States, and Uruguay. Membership to CONMAP is limited to nations that are Antarctic Treaty signatories and have ratified the Madrid Protocol. There are 31 countries that are members of SCAR, which are Argentina, Australia, Belgium, Brazil, Bulgaria, Canada, Chile, China, Ecuador, Finland, France, Germany, India, Italy, Japan, Korea, Republic of Malaysia, the Netherlands, New Zealand, Norway, Peru, Poland, Russia, South Africa, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United States, and Uruguay. SCAR was established in 1958 and is governed under the International Council for Science, which is an international interdisciplinary research organization for the advancement of science.

Argentine Antarctic Program

The Argentinean National Antarctic Program is called the "Argentine Antarctic Program" (a.k.a. *Instituto Antartico Argentino* [IAA)]) and is governed by the Dirección Nacional del Antártico (DNA). The IAA was established on April 17, 1951. Argentina was the first country to create an organization dedicated exclusively to Antarctic research. Argentina has six permanent and seven seasonal stations and bases. The permanent stations are Belgrano II (77° 52′S 34° 38′W) on the Luitpold Coast; Esperanza (63° 23′S 56° 59′W) in Hope Bay; Jubany or Carlini (62° 14′S 58° 40′W) on King George Island; Marambio (64° 14′S 56° 37′W) on Seymour-Marambio Island; Orcadas Base (60° 44′ 25″S 44° 44′ 33″W) on Laurie Island; and San Martin (68° 7′S 67° 6′W) on Barry Island. The seven seasonal stations and bases are the Almirante Brown Base (64° 53′S 62° 53′W) in Paradise Bay; Base Deception (62° 52′S 60° 43′W) on Deception Island; Base Primavera (64° 9′S 60° 57′W) on the Danco Coast; Petrel Air Station (63° 28′S 56° 17′W) on Dundee Island; Teniente Camara Base (62° 2′S 58° 42′W) on Livingston Island; Base Melchior (64° 20′S 62° 59′W) on Anvers Island; and Teniente Matienzo Base (64° 58′S 60° 4′W) near Larsen Nunatak.

Australian Antarctic Division

The Australian National Antarctic Program is called the "Australian Antarctic Division" (AAD) and is governed by the Australian Department of the Environment. The AAD maintains four year-round research stations. Three permanent stations in Antarctica are Casey (66° 17′S 110° 31′E) on Windmill Islands; Davis (68° 35′S 77° 58′E) on the Ingrid Christensen Coast of Princess Elizabeth Land; and Mawson (67° 36′S 62° 52′E) in Holme Bay in Mac Robertson Land. The AAD also has a subantarctic station on Macquarie Island (54° 30′S 158° 57′E), which is about halfway between Australia and Antarctica.

Belgium Polar Secretariat

The Belgian Antarctic Research Program is called the "Belgium Polar Secretariat." Since 1985, the Belgian Antarctic Program has been funded by the Belgian Federal Science Policy. The Belgians constructed their seasonal research station Princess Elisabeth Base (71° 57′S and 23° 20′E) in 2009. This base is located in Queen Maud Land.

Brazil Antarctic Program

The Brazilian Antarctic Program is called "Programa Antártico Brasileiro" (PROANTAR) in Portuguese and is governed by the Brazilian Navy. The PROANTAR has a permanent station called "Comandante Ferraz Antarctic Station" (62° 8′S 58°

40′W) located in Admiralty Bay on King George Island. Brazil has also a number of shelters on the Antarctica Peninsula, which include Refuge Astronomer Cruls (62° 14′S 58° 48′W) on Nelson Island, and Refuge Emílio Goeldi (61° 5′S 55° 20′W) and Refuge Engineer Wiltgen on Elephant Island. Inland PROANTAR operates a stand-alone atmospheric station called "Criosfera 1" (84° S 79° 30′W) on Union Glacier.

Bulgarian Antarctic Institute

In 1993, the Republic of Bulgaria established their national Antarctic program named the "Bulgarian Antarctic Institute" (BAI). The BAI works on research projects with many other Antarctic programs. The BAI also participates on various Antarctic political bodies, such as the COMNAP, the European Polar Board, the Standing Committee on Antarctic Logistics and Operations, and the SCAR. The only base of the BAI is St. Kliment Ohridski located on Livingston Island in the South Shetland Islands.

Chilean Antarctic Institute

The Chilean Antarctic Research Program is called the "Chilean Antarctic Institute" (*Instituto Antártico Chileno* [INACH] in Spanish). The INACH was established in 1979 and is governed by the Chilean minister of Foreign Affairs. The Chilean permanent bases include Base Presidente Eduardo Frei Montalva and Villa Las Estrellas (62° 11′S 58° 58′W) on the Fildes Peninsula of King George Island; Professor Julio Escudero Base (62° 12′S 58° 57′W) on King George Island; Captain Arturo Prat Base (62° 28′S 59° 39′W), and Base General Bernardo O'Higgins Riquelme (63° 19′S 57° 53′W) on the Trinity Peninsula. The seasonal Chilean bases are Teniente R. Marsh Martin Base on King George Island, González Videla Antarctic Base (64° 49′S 62° 51′W) at Paradise Bay of Water Boat Point, and Base Yelcho (64° 52′S 63° 35′W) in South Bay of Doumer Island.

China (Polar Research Institute of China)

The Chinese National Antarctic Research Program directed by Chinese Arctic and Antarctic Administration is allied with the People Republic of China's State Oceanic Administration (SOA). The subsidiary research arm of the SOA is the Polar Research Institute of China. The Chinese operate two year-round stations and one summer station. The two permanent stations are the Great Wall and Zhongshan. The Great Wall Station (62° 12′ 59″S 58° 57′ 44″W) is on King George Island. The Zhongshan (69° 22′ 24″S 76º 22′ 40″E) is located on the Larsemann Hills of Princess Elizabeth Land. The seasonal Kunlun Station (80° 25′1″S 77° 6′ 58″E) is on the Antarctic Plateau close to Dome Argus.

Czech Republic

The Czech Republic seasonal research station of the Masaryk University is called the “Johann Gregor Mendel Czech Antarctic Station” (63° 48′S 57° 53′W). It was opened in 2006 and is located on James Ross Island.

Ecuadorian Antarctic Institute

Ecuador’s Antarctic Program is called the “Ecuadorian Antarctic Institute” (*Instituto Antártico Ecuatoriano*, in Spanish). Ecuador’s seasonal station is Pedro Vicente Maldonado Base (62° 26′S 59° 44′W) at Guayaquil Bay on Greenwich Island.

Finnish Antarctic Research Program

The Finnish Antarctic Research Program is governed by the Finnish Meteorological Institute. Aboa (73° 3′S 13° 25′W) is the seasonal research station of Finland located on the Basen nunatak in Queen Maud Land.

French National Antarctic Program

The French National Antarctic Program is governed by the *Institut Polaire Français Paul Emile Victor* (IPEV) (French Polar Institute, in English). The IPEV was established in 1992. France operates two permanent Antarctica stations, which are Dumont d’Urville Station (66° 39′ 46″S 140° E), in Adelie Land and the joint French Italian Concordia Station (72° 6′S 123° 20′E). The Concordia Station is located on the Antarctic Plateau near Dome Charlie.

German Antarctic Research Program

The German Antarctic Research Program is called the “Alfred Wegener Institute” (AWI). The AWI was established in 1980 and focused on both polar regions. Germany has two research stations in Antarctica, the permanent Neumayer III (70° 40′ 28″S, 8° 16′ 27″W) on the Ekstrom Ice Shelf and the seasonal Kohnen (75° S 0° 4′E) located in Queen Maud Land.

Indian Antarctic Research Program

The Indian Antarctic Research Program is currently called the “National Centre for Antarctic and Ocean Research” (NCAOR) under the Indian Ministry of Earth Sciences. NCAOR operates two research stations, the Maitri and Bharathi. The Maitri (70° 46′S 11° 43′ 56″E) research station is located on the Schirmacher Oasis in Queen Maud Land. The Bharathi (69° 24′ 28″S 76° 11′ 14″E) research station became operational in 2012 and is located near Prydz Bay on Larsemann Hills close to the Amery Ice Shelf.

Instituto Antártico Peruano

The Peruvian National Antarctic Program is called the "Instituto Antártico Peruano." The Instituto Antártico Peruano is governed by the Peruvian Ministry of Foreign Affairs. Machu Picchu Research Station (62° 5′S 58° 28′W) is Peru's seasonal station at Admiralty Bay on King George Island.

Italian Antarctic Research Program

In 1985, the Italian Antarctic Research Program was called the Programma Nazionale di Ricerche in Antartide and the National Scientific Committee for Antarctica. Italy operates two Antarctica stations. The year-round station is Concordia and the summer station is Zucchelli. The Concordia Station (72° 6′S 123° 20′E) is a joint French Italian venture and is located on the Antarctic Plateau near Dome Charlie. The Zucchelli Station (74° 42′S 164° 7′E) is located near Terra Nova Bay of Victoria Land.

Japan Antarctic Research Program

The Japanese Antarctic Research Expedition (JARE) was established in 1955. JARE is currently governed by the Japanese Ministry of Education, Culture, Sports, Science, and Technology and managed by the National Institute of Polar Research (NIPR). NIPR was established in 1973. Japan operates four Antarctic stations, which are Asuka, Mizuho, Syowa, and Dome Fuji. Asuka Station (71° 31′34 ″S 24° 8′ 17″E) is an unmanned year-round station in Queen Maud Land. Mizuho Station (70° 41′ 53″S 44° 19′ 54″E) was officially closed in 1987 but does have scientists conducting science periodically. Syowa Station (69° S 39° 35′E) is located on East Ongul Island in Queen Maud Land. It is Japan's largest research station and operates year-round. Dome Fuji Station (77° 19′S 39° 42′E) was established in 1995 by JARE. It is located about 620 miles (1,000 km) inland from the JARE Syowa Station.

Korea (South) Antarctic Program

The South Korea Antarctic Program was established in 1987 by the polar research institute called the "Korea Ocean Research and Development Institute" (KORDI) along with the Korean National Committee on Antarctic Research. Under the KORDI, there is another institute called the Korea Polar Research Institute, which is focused on facilitating the research activities and operation of South Korea's two Antarctica research stations. The two South Korean stations are the King Sejong Antarctic Station (62° 13′ 24″S 58° 47′ 21″W) located on King George Island and the under-construction Jang Bogo Station (74° 36′ 55″S 164° 12′3″E) in Terra Nova Bay. Jang Bogo Station is scheduled to be completed in 2014.

The Netherlands Antarctic Program

The Netherlands polar research activities (Arctic and Antarctic) are coordinated by the Netherlands Polar Programme (NPP), which was established in 2002. The NPP is governed by the Earth and Life sciences division of the Netherlands Organization for Scientific Research (NWO). The research station of the government of the Netherlands is a joint venture between the British Antarctic Survey (BAS) and the NWO called the "Dirck Gerritsz Laboratory." The Dirck Gerritsz Lab is housed in the BAS Rothera Research Station and was opened on February 25, 2013.

New Zealand Antarctic Program

The New Zealand Antarctic Program is called the "Antarctica New Zealand." Antarctica New Zealand is under the New Zealand Ministry of Foreign Affairs and reports to their Antarctic Policy Unit. New Zealand operates one Antarctica Station called "Scott Base" (77° 51′S 166° 45′E) on the southern part of Ross Island.

Norwegian Antarctica Program

Norway's Antarctic Program is called the "Norwegian Polar Institute," which was established in 1928. The Norwegian Polar Institute covers both the Arctic and Antarctica regions and has offices in Svalbard (Longyearbyen and Ny-Ålesund) and South Africa (Cape Town). The Norwegian Polar Institute has two Antarctic stations on the Princess Martha Coast of Queen Maud Land, which are the year-round Troll Station (72° S 2° 32′E) and the seasonal Tor station (71° 53′ 20″S 5° 9′ 30″E).

Pakistan Antarctic Program

The Pakistan Antarctic Program is called the Pakistan Antarctic Programme (PAP). The PAP is governed by the Pakistan Ministry of Science and Technology. PAP maintains one seasonal station called the Jinnah Antarctic Station (JAS). The JAS (70° 24′S 25° 45′E) is located near the Sør Rondane Mountains in Queen Maud Land.

Poland Antarctica Program

Started in 2012, Poland's Antarctic Program is called the "Polish National Antarctic Program." The Polish National Antarctic Program is under the direction of the Department of Antarctic Biology of the Institute of Biochemistry and Biophysics, Polish Academy of Science. The research station of the Polish National Antarctic Program is the Henryk Arctowski Polish Antarctic Station (62° 9′S 58° 28′W) on King George Island.

Romania Antarctic Program

The Romanian Antarctic Program is a private venture supported financially by the Romanian Antarctic Foundation via the Romanian Institute of Polar Research. The Romanian Institute of Polar Research maintains one seasonal station called the Law-Racoviță Station (69° 23′S 76° 23′E) located on the Larsemann Hills of Princess Elizabeth Land.

Russian Federation Antarctic Program

The Union of Soviet Socialist Republic (USSR), now the Russian Federation, established an Antarctica program in 1920 that in 1958 was formerly named the Arctic and Antarctic Research Institute (AARI). The AARI maintains a number of year-round and seasonal research stations, such as Mirny (66° 33′ 7″S 93° E) in the Davis Sea; Vostok (78° 28′S 106° 48′E) on the EAIS; Novolazarevskaya (70° 46′ 37″S 11° 49′ 26″E) on the Schirmacher Oasis of Queen Maud Land; Molodezhnaya (67° 40′S 45° 50′E), an unmanned station in the Thala Hills of Enderby Land; Bellingshausen (62° 11′S 58° 57′W) on King George Island; Leningradskaya (69° 30′S 159° 23′E) on the Oates Coast in Victoria Land; Russkaya (74° 46′S 136° 52′W) on the Ruppert Coast of Marie Byrd Land; and Progress (69° 22′ 44″S 76° 23′ 13″E) located on the Larsemann Hills of Princess Elizabeth Land.

South Africa Antarctic Program

The South Africa Antarctic Program is called the “South African National Antarctic Programme” (SANAP). SANAP is governed by the Department of Environmental Affairs. South Africa operates one Antarctica Station in Antarctica called “SANAE IV” (South African National Antarctic Expedition) (71° 40′25′S 2° 49′44′E) on the nunatak called Vesleskarvet in Queen Maud Land.

Spain Antarctic Program

Spain’s Antarctic Program is called the “Spanish Polar Committee or the Comite Polar Espanol” (CPE), in Spanish. The CPE seasonal bases are Juan Carlos I Antarctic Base (62° 39′S 60° 23′W) at South Bay on Livingston Island and Gabriel de Castilla (62° 58′ 40″S 60° 40′ 30″W) on Deception Island in the South Shetland Islands.

Sweden Antarctic Program

The Swedish Antarctic Program is operated by the Swedish Polar Research Secretariat. Since 1984, the Swedish Polar Research Secretariat is governed by the Swedish Ministry of Education and Research. Sweden maintains two seasonal research stations, called the Svea Research Station (74° 35′S 11° 13′W) and the Wasa Research Station (73° 3′S 13° 25′W). Both are located in Queen Maud Land.

Ukraine Antarctic Program

The Ukraine Antarctic Program is the National Antarctic Scientific Center established in 1993. Ukraine purchased the UK Faraday Station for 1 pound in 1996. This purchased station was renamed Akademik Vernadsky Station (65° 14′ 43″S 64° 15′ 24″W) and is located on Marina Point on Galindez Island in the Argentine Islands.

United Kingdom Antarctic Program

The United Kingdom Antarctic Program is called the "British Antarctic Survey" (BAS) and was established in 1962. The BAS operates three permanent stations: the Rothera Research Station (67° 34′S 68° 7′W) at Rothera Point on Adelaide Island; the Halley Research Station (75° 34′ 54″S 26° 32′ 28″W) on the Brunt Ice Shelf on Coats Land; and Fossil Bluff (71° 20′S 68° 17′W) located on Fossil Bluff of Alexander I Island. Fossil Bluff is operated by the Rothera Research Station and is largely a support facility. The BAS seasonal station is the Signy Research Station (60° 43′S 45° 36′W) on Signy Island.

United States Antarctic Program

The United States Antarctic Program (USAP) is known by the same name and was established in 1956. The USAP is governed by the U.S. National Science Foundation (NSF), Division of Polar Programs. The USAP maintains four permanent Antarctic research stations, which are Amundsen–Scott South Pole, Palmer, McMurdo, and Siple stations. The Amundsen–Scott South Pole station (90° S 0° E) is located near the geographical South Pole. The Palmer Station (64° 46′S 64° 3′W) is located on Anvers Island. The McMurdo Station was established in 1955 as a USAP support and logistics center. Presently, it has around 100 buildings and is capable of supporting more than 1,200 people. It is the largest community in Antarctica. The Siple Station (75° 55′S 83° 55′W) was established in 1973 by Stanford's STAR Lab. The USAP maintains two seasonal research stations, which are the Byrd (80° S 119° W) and the West Antarctic Ice Sheet (WAIS) Divide. The WAIS divide is an ice core drilling site. The USAP also has various summer field camps around Antarctica for scientific research studies.

Uruguay Antarctic Program

The Uruguayan Antarctic Program is called the "Uruguayan Antarctic Institute" (in Spanish, *Instituto Antártico Uruguayo*) and is governed by the Uruguay's

Ministries of Defense, Foreign Affairs, and Education. The permanent research station of Uruguay is Artigas Base (62° 11′S 58° 54′W) that is located on King George Island. The seasonal station is called "Estación Científica Antártica Ruperto Elichiribehety" or ECARE (63° 24´ 8″S 56° 58´ 23″W) in Hut Cove of Hope Bay.

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See also: Alfred Wegener Institute (AWI); Amundsen–Scott South Pole Station; Arctic and Antarctic Research Institute (AARI); Belgrano II Antarctic Station; Bharati Research Station; Dirck Gerritsz Laboratory, the Netherlands; Georg von Neumayer Station, Neumayer Station, Neumayer III Station; King Sejong Antarctic Station; Nuclear Power in the Arctic; Troll Station; Vostok Station; Weddell #1 Antarctic Drifting Station; Zackenberg Research Station; Zhongshan (Sun Yat-sen) Station

Further Reading

Council of Managers of National Antarctic Programs (COMNAP) Website. https://www.comnap.aq/SitePages/Home.aspx. Accessed January 7, 2014.

National Science Foundation. "Polar Programs." http://www.nsf.gov/div/index.jsp?div=plr. Accessed January 7, 2014.

Antarctic Research Stations/Bases. *See* Antarctic Programs and Research Stations/Bases

Antarctic Territorial Claims

Officially, there are eight territorial or sector claims to the Antarctica south of the 60° S. These claims were made by seven nations before 1960. The seven nations are the Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom. Presently, the claims to the Antarctic are recognized only by the seven participating nations. The scientific, research, and exploratory activities of the seven nations are generally limited to their respective territories. The United States and the Soviet Union (now the Russian Federation) reserved the right to make future claims to Antarctica. Brazil may make a claim for the territory between 53° W and 28° W, which would overlap the Argentinean and United Kingdom's claim. There is also a large unclaimed land in the Marie Byrd Land region from the South Pole (0° S) running along the 90° W and 150° W longitudes.

The United Kingdom officially claimed the British Antarctic Territory in 1962 but argues its original claim dates back to 1908. The British Antarctic Territory is from the South Pole (0° S) to 60° S running along the 20° W and 80° W longitudes. The territory resembles a slice of pie covering an area of 660,000 square miles (1,709,400 sq. km). The British Antarctic Territory is overlapped by the Argentina and Chile Antarctic claims. The overlapping sector claimed by Argentina is called

"Argentine Antarctica" and is a wedge shape from the South Pole (0° S) to 60° S running along the 25° W and 74° W longitudes. Argentine Antarctica is located entirely within the British Antarctic Territory and was claimed in 1942. The overlapping sector claimed by Chile is called "Chilean Antarctic Territory" and was claimed in 1940. It is wedge shaped from the South Pole (0° S) to 60° S running along the 53° W and 90° W longitudes. The Chilean Antarctic Territory covers an area of 480,000 square miles (1,250,000 sq. km).

The New Zealand claim is called "Ross Dependency" and was claimed in 1923. Like the other claims, Ross Dependency is wedge shape originating at the South Pole (0° S) to 60° S running along the 150° W and 160° E longitudes. It covers an area of 174,000 square miles (450,000 sq. km). The only claim that is not within a sector is Peter I Island (68° 51′S 90° 35′W) in the Bellingshausen Sea. This island is one of two claims made by Norway. Peter I Island (68° 51′S, 90° 35′W) is a volcanic island approximately 250 miles (400 km) off the Antarctic coast. It is about 11 miles (18 km) long and around 5 miles (8 km) wide. Norway claimed the island in 1929. Peter I Island is the only claim within the unclaimed Marie Byrd Land region (90° W and 150° W).

The Australian claim is called the "Australian Antarctic Territory," but was originally a claim made by the United Kingdom. The United Kingdom passed the territorial authority to Australia in 1933. The Australian Antarctic Territory is the largest claim in Antarctica covering an area of 2,276,651 square miles (5,896,500 sq. km). There are two parts to the Australian Antarctic Territory. The first is wedge shaped starting at the South Pole (0° S) to 60° S running along the 160° E and 136° 11′E longitudes. The second part starts at the South Pole (0° S) to 60° S running along the 142.2° E and 44° 38′E longitudes. The small area in between Australian Antarctic Territories is the French claim of Adélie Land. The Adélie Land claim was made in 1840 and covers an area of 166,796 square miles (432,000 sq. km). The territory starts at the South Pole (0° S) to 60° S running along the 142.2° E and 136° 11′E longitudes.

The second claim of Norway is Queen Maud Land with an area covering 1,042,476 square miles (2,700,000 sq. km). The territory is wedge shaped starting at the South Pole (0° S) running along the 20° W and 45° E longitudes. Other sector territorial claims' latitudinal limit is 60° S, but the Queen Maud Land limit was never established.

After the passage of the Antarctic Treaty in 1959 (put in force in 1961), most countries did not recognize the Antarctic Territorial Claims. The basis for countries not recognizing the territorial claim is Article 1 of the Antarctic Treaty, which made Antarctica a distinct territory. Others claim Article 2 is contradictory and reaffirms territorial claims. There is one defunct claim in Antarctica. In 1939, Nazi Germany claimed the Antarctic area, called New Swabia, that starts from South Pole (0° S) and runs along the 20° E and 10° E longitudes. New Swabia has been subject to conspiracy theories ranging from a UFO base to a hideout for exile Nazis after World War II. The claim to New Swabia was dropped after World War II.

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See also: Antarctic Treaty System (ATS)

Further Reading

Beck, P. *The International Politics of Antarctica.* London: Croom Helm, 1986.

Burton, Steven J. "New Stresses on the Antarctic Treaty: Toward International Legal Institutions Governing Antarctic Resources." *Virginia Law Review* (1979): 425–33.

Dodds, K. "The Great Game in Antarctica: Britain and the 1959 Antarctic Treaty." *Contemporary British History* 22, no. 1 (2007): 43–66.

Antarctic Treaty System (ATS)

The Antarctic Treaty System (ATS) is represented by the Antarctic Treaty of 1959, Measures adopted in furtherance of the principles and objectives of the Treaty and agreements and acts, associated with it constitute a farsighted system of international cooperation, which promotes international peace and security, scientific knowledge and environmental protection (Recommendation XII-6, 1983).

The ATS operates as a mechanism of foreseeing, revealing, and addressing new issues and demonstrated its ability to meet new challenges and attract new participants of the Antarctic community. The ATS presents a flexible and dynamic complex, which can be adapted to changes in the modern world.

The Antarctic Treaty is the main ATS document. It was signed on December 1, 1959, in Washington by the delegations of the governments of Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the USSR, the United Kingdom, and the United States, which participated in the Antarctic studies under the program of the International Geophysical Year (IGY) 1957–1958. This international law act has become a universal tool for the successful management of activity in the earth's South Polar region.

The treaty provisions on the use of Antarctica exclusively for peaceful purposes, its nonmilitarization and neutralization, freedom of scientific investigation, declaring the Antarctic as a nuclear-free zone, and cooperation of countries for these purposes comprise the basic elements of the international legal regime of the region.

In spite of significant disagreements on defining the legal status of the Antarctic and a large number of theoretical publications on this issue, standing up for the political positions of their countries, participants to the Washington Conference in 1959 were able to reach a consensus in addressing this most complicated international law issue. This has created conditions for the neutralization of the international tension sources in the Antarctic.

Article IV of the treaty on holding all territorial claims in the Antarctic in abeyance does not maintain but, on the contrary, eliminates the probability of conflicts over territorial sovereignty of different Antarctic regions. A balance of interests arrived at in the treaty serves as a guarantor of stability in the region. This basic provision of the treaty allows legal practice participants to assume common obligations and jointly govern the activity in the Antarctic without impairing their principal national positions in respect to the status of the Antarctic territories.

Participation in the IGY was open for any nation, and participants of the conference in Washington were the countries that took active practical participation in the study of the Antarctic region. This approach allowed implementing in the future one of the basic organizational principles of the ATS, which was formalized to a notion of the Antarctic Treaty Consultative Party. A country, which carries out significant scientific investigation in the Antarctic on a permanent basis, has this status. The agreed decisions are adopted only by those parties, which have permanently operating national Antarctic programs and research stations. This restricts politicization of discussions between the treaty's parties (Article IX, paragraph 2). As of the beginning of 2013, the status of the Consultative Parties was, in addition to the aforesaid countries, given to Bulgaria, Brazil, China, Ecuador, Finland, Germany, India, Italy, Republic of Korea, the Netherlands, Peru, Poland, Spain, Swede, Ukraine, and Uruguay.

All decisions in the ATS are adopted by consensus. This procedural rule does not permit adoption of decision by voting with a principle of using any numeric quota of votes. Even in the event of the overwhelming majority of the parties to the treaty supporting any draft decision, it can be adopted only after it is finally approved by all Consultative Parties. This approach does not allow adopting a discriminatory decision with respect to the other participants to the treaty whatever difficult and prolonged the process of its discussion and agreement might be. Article XIII determined the character of its openness for acceding of any nation, which is a UN member. As of the beginning of 2013, in addition to the aforementioned 28 Consultative Parties, the governments of Austria, Belarus, Czech Republic, Denmark, Estonia, Guatemala, Greece, Hungary, Canada, Democratic People's Republic of Korea, Columbia, Cuba, Malaysia, Monaco, Pakistan, Papua New Guinea, Portugal, Romania, Slovakia, Switzerland, Turkey, and Venezuela acceded the Antarctic Treaty. These countries have the status of the Non-Consultative Parties, which participate in the work of the highest governing body of the Antarctic Treaty—Antarctic Treaty Consultative Meetings (ATCM), but do not make decisions.

From the time the Antarctic Treaty was signed, participants to the ATCM have developed a wide range of measures, contributing to achieving the goals and principles of the treaty and expanding different types of activity in the region. The ATCM Recommendations (until 1995) and Measures (after 1995), after they are approved by the governments of the Consultative Parties, acquire a binding force.

It indicates the existence of an effective multilevel system of control for the decisions of political–economical character adopted in the ATS.

In addition to the Antarctic Treaty and the ATCM Recommendations and Measures, the following documents came into force in the ATS: 1978—Convention for the Conservation of Antarctic Seals, 1982—Convention on the Conservation of Antarctic Marine Living Resources, 1998—Protocol on Environmental Protection to the Antarctic Treaty, 2004—Agreement on the Conservation of Albatrosses and Petrels. This international law acts constitute the ATS legal basis. The Protocol on Environmental Protection to the Antarctic Treaty (Protocol) designated Antarctica as an international reserve devoted to peace and science. In compliance with its Article 7, any activity relating to mineral resources, other than scientific research, shall be prohibited. All participants to the Protocol were to undertake practical actions through the mechanisms stipulated in its six annexes to define national procedures for different types of activity in the Antarctic by their citizens, and governmental and nongovernmental organizations. Any type of claimed activity was to be based on prior assessment of the impact of this activity on the Antarctic environment. The Protocol formulates special rules for the conservation of Antarctic flora and fauna, and the management of human waste disposal and measures for control and prevention of pollution of the marine environment of the region. The Protocol extended its application to the principles of establishment and control of different types of activity in the Antarctic Specially Managed and Antarctic Specially Protected Areas, including designation of Historic Sites and Monuments and measures of liability for environmental damage in cases of emergency accidents.

The ATCM governing bodies include ATCM—held annually by the Consultative Parties in the Latin alphabet order; Commission for the Conservation of Antarctic Marine Living Resources (Hobart, Australia) regulates fishery in Antarctic waters based on research; Committee for Environmental Protection, established in 1998, which acts within the ATCM framework and develops recommendations to the parties related to the implementation of the Protocol and its annexes; Antarctic Treaty Secretariat in Buenos Aires (Argentina)—functions from 2004—which provides activity between the ATCM, disseminates information to the treaty parties about the ongoing Antarctic events and makes preparations for the next ATCM; SCAR in Cambridge (Great Britain), established in 1961, which is intended for coordination of scientific activity in the Antarctic between the treaty parties; and Council of Managers of National Antarctic Programs in Christchurch (New Zealand), created in 1989, intended for holding forums and consultations and for cooperation between the national Antarctic programs.

Valery Lukin

See also: Antarctic Territorial Claims

Further Reading

Frakes, J. "The Common Heritage of Mankind Principle and the Deep Seabed, Outer Space, and Antarctica: Will Developed and Developing Nations Reach a Compromise?" *Wisconsin International Law Journal* 21, no. 409 (2003).

United States Department of State. *Handbook of the Antarctic Treaty System.* 2002. http://www.state.gov/documents/organization/15272.pdf. Accessed January 7, 2014.

Arctic, Definitions of

There are various ways to define the Arctic. The Arctic is commonly viewed as the region surrounding the North Pole (90° N) that includes the Arctic Ocean, its marginal seas, and the coastal areas of Alaska (United States), Canada, Denmark (Greenland), Finland, Iceland (Grímsey Island), Norway, Sweden, and Russia. Three commonly used and more precise definitions of the Arctic include (1) latitude; (2) temperature; and (3) tree line.

Arctic Defined by Latitude

In a strict definition, the Arctic Circle is the area north of 66° 33′ 44″ latitude. A defining characteristic of the Arctic Circle is that all locations above 66° 33′ 44″N experience a 24-hour period of sunlight on the summer solstice (around June 21) as well as 24 hours of darkness during the winter solstice (around December 21). The 66° 33′ 44″N latitude is considered the southernmost boundary of the Arctic Circle. The Arctic Circle is not a fixed position and is contingent on the Earth's axial tilt, which fluctuates within a margin of 2 percent over a period of 40,000 years. This fluctuation is due primarily to the orbit of the Moon and its influence on the Earth's tidal forces. The Arctic Circle is currently migrating north at around 50 ft. (15 m) per year.

Arctic Defined by Temperature

The 10°C (50°F) isotherm is a common temperature definition of the Arctic. This isotherm is determined by the average temperature in July. The area with the same temperature of 10°C (50°F) creates an irregular line that circumnavigates the northern region. Sometimes, the 10°C (50°F) July isotherm line is located within the Arctic Circle (66° 33′N) and sometimes south of the Arctic Circle. The 10°C (50°F) July isotherm is close to northern tree growth limit.

Arctic Defined by Tree Line

Another definition for the Arctic is the northern limit of tree growth. The tree line is more similar to the 10°C (50°F) July isotherm than the Arctic Circle (66° 33′N) latitude line. Tree line is commonly defined as the farthest north trees can grow.

Above the tree line, the cold temperatures and permafrost inhibit trees from growing. The tree line is the definitional boundary between the boreal forest and the tundra. The tree line is considered the southern edge of the Arctic. The tree line is as far south as 56° N in Labrador Peninsula of Canada and as far north as 72° N in the Central Siberian Plateau of Russia.

Andrew J. Hund

See also: Arctic Circle

Further Reading

Serreze, M., M. Holland, and J. Stroeve. "Perspectives on the Arctic's Shrinking Sea-Ice Cover." *Science* 315, no. 5818 (2007): 1533–36.

Sperry, A. *All about the Arctic and Antarctic.* New York: Random House, 1957.

Arctic Air Pollution

Air pollution is commonly defined as an atmospheric condition where chemical or particulate concentrations are higher than normal, which lead to negative environmental health effects. The atmosphere is divided into different zones; however, air pollution is categorized as tropospheric or stratospheric. Arctic air pollutants are gases, liquids, or solids emitted from both stationary and mobile sources and are suspended in the atmosphere. Arctic air pollution transfers or delivers contaminants from lower latitudes to the Arctic high trophic air masses commonly referred to as transboundary pollution. These brownish pollutants move from industrial northern Europe across the North Pole creating what is called "Arctic haze."

Arctic air pollution has both local and global contexts in its source, such as anthropogenic or natural, local or global, and indoor or outdoor. Similar to other regions, natural air pollution in the Arctic comes from forest fires, volcanoes, and sandstorms from temperate deserts. Industrial and agricultural chemicals, as well as urban air pollution, migrate northward in what is often described as the grasshopper effect. Air pollution in the Arctic is influenced by unique chemistry, climate change, melting permafrost, and indoor housing conditions.

Local air pollution in the Arctic is often related to energy development and heat production, which release a set of criteria pollutants: nitrogen (N) and sulfur oxide (SO_x); ozone (O_3); particulates along with mercury (Hg), lead (Pb), cadmium (Cd), and other metals; and volatile organic compounds (VOCs). Local topography and air patterns, including wind, impact the buildup and distribution of these gases. Even at low concentrations, most criteria air pollutants are harmful, especially to pregnant women, children, and the elderly. A significant difference between Arctic air pollution and air pollution at lower latitudes is that the source of the pollution is rarely generated by the small human population in the Arctic. Instead, it is transported in a northerly direction by air currents. However, recent market conditions have led to an increase in local coal and wood combustion resulting in increased atmosphere particulate matter.

Air pollution risk assessment is the process of evaluating scientific data, usually exposure monitoring and concentration-dependent health effects, to make predictions about the probabilities of an outcome. The risk is a function of toxicity, the intrinsic health hazard of substance to a person or/and animal model, and exposure, the amount and bioavailability of a substance. Lead and mercury risk assessment are two common examples. There can also be social and cultural impacts in addition to the usual physiological health impacts. The Arctic population is affected by a greater health risk, but generally receives reduced economic benefits from the industrial activity at the lower latitudes.

The Arctic has a sparse historical record of the ambient air concentrations for many air pollutants that adversely affect humans. Pollution in the Arctic has a unique impact on health because of its effect on the food system. With a large percentage of Arctic residents living a subsistence lifestyle, air pollutants eventually enter the water system and food-related pathways. Recent Arctic Monitoring and Assessment Program (AMAP) monitoring activity has increased in the eight Arctic nations, but coverage remains sparse. The common outdoor air pollutants monitored are the primary pollutant gases NO_x, SO_x, CO, Rn, and the secondary pollutant, ozone. Particulate matter from combustion, and natural and industrial VOCs are monitored in some regions. AMAP also monitors metals like lead and mercury, which can impact ecosystem services by biomagnification up the food chain. The unique chemical reaction slinking atmospheric mercury deposition in the spring and ozone destruction instigated by the presence of halogens, such as bromine, provide a new pathway for mercury's introduction into the Arctic food system.

Transboundary air pollutants, including the common gases of nitrous oxide (N_2O) and methane (CH_4), can impact the Arctic by leading to global warming and loss of physical environment such as sea ice and glaciers, and erosion of the coastline. Melting permafrost can also release methane, radon, and other gases. As Northern development increases and permafrost melts, local air pollution sources are expected to increase, directly impacting health and indirectly increasing social and cultural stress.

Indoor air pollution is an important concern in the Arctic due to the construction of energy-tight buildings. Indoor air contains hundreds of substances at low levels. Gas molecules such as ozone, formaldehyde, and carbon monoxide are not trapped by most ventilation systems now installed in Arctic housing. Indoors levels of air pollutants may even exceed the outside ambient air. In the Arctic, most buildings are constructed to increase energy efficiency to lower heating costs, but an airtight building without an adequate fresh air intake can lead to unhealthy levels of pollutants. High levels of VOC off-gassing from synthetic building materials can lead to a hazardous condition termed "sick building syndrome." Tobacco smoke, incense, coalescents in paints, antifreeze, radon, and even candles can build up in modern Arctic housing.

In the Arctic, a relatively common climatological condition called "ice fog" can affect the level of air pollution. Ice fog forms when the very cold winter air cannot hold water vapor. As the air temperatures decrease, water in combustion gases from homes and cars crystallizes in particulate form and disperse light. Depending on the topography of the area, cold air is trapped in an inversion, and ice fog builds up at ground level. SO_x pollution is exacerbated by its interaction with ice fog, but carbon monoxide (CO) is not.

Lawrence K. Duffy

See also: Arctic Haze; Arctic Observatories; Geospace; Grasshopper Effect

Further Reading

Arctic Monitoring and Assessment Programme (AMAP). http://www.amap.no/. Accessed January 7, 2014.

Isbell, M., M. Gordian, and L. Duffy. "Winter Indoor Air Pollution in Alaska: Identifying a Myth." *Environmental Pollution* 117, no. 1 (2002): 69–75.

Philander, S., ed. *Encyclopedia of Global Warming and Climate Change.* Los Angeles: Sage, 2008.

Stonehouse, B. *Arctic Air Pollution.* Cambridge: Cambridge University Press, 1986.

Arctic and Antarctic Research Institute (AARI)

The Arctic and Antarctic Research Institute (AARI) was established by the decision of the Union of Soviet Socialist Republics (USSR) government in 1920. It received its present name in 1958 as the first 38 years of its existence were related exclusively to the Arctic studies. The institute was until May 18, 1963, in the structure of the Main Administration of the Northern Sea Route (Glavsevmorput) of the USSR Ministry of Marine Fleet. After this date, the institute was transferred to the Hydrometeorological Service of the USSR, now the Russian Federation.

In the first years of its existence, the Arctic Research Institute (ARI) organized and carried out the following unique studies in the Arctic Ocean and at its Soviet (Russian) coast:

- First through voyage onboard the icebreaker *Sibiryakov* along the Northern Sea Route in one summer navigation season in 1932
- First research drifting North Pole station in 1937–1938

Russian scientists' drill site at Lake Vostok, Antarctica. (Arctic and Antarctic Research Institute Press Service, Pavel Teterev/AP Photo)

- First high-latitudinal airborne expedition to the area of the relative inaccessibility pole onboard aircraft *H-169* in spring 1941
- High-latitudinal airborne expeditions in the Arctic Basin in 1947–1956
- Organization of scientific observatories on the coasts and islands of the Arctic Ocean (Barentsburg on Spitsbergen, Dickson in the Kara Sea, Tiksi in the Laptev Sea, and Pevek in the East Siberian Sea) in the 1950s

Based on the results of these expeditions:

- Detailed charts of seabed relief of the Arctic Basin were issued.
- Main regularities of its ice and water circulation were determined, and main features of the formation of variability of the hydrological regime and structure of water masses in the Arctic Ocean and the Siberian shelf seas were revealed.
- Methodologies of meteorological, ice, and hydrological forecasts for the different navigation variants of the Northern Sea Route were developed and put into practice.

In July 1955, the USSR organized the Complex Antarctic Expedition (CAE) of the USSR Academy of Science. Specialists of Glavsevmorput and AARI representatives were made responsible for the logistic and much of the hydrometeorological support for the activities of this expedition. The first CAE was under the leadership of Dr. Mikhail Somov, the ARI deputy director, who after his return from the expedition headed the new Department of Antarctic Studies. In 1958, the CAE was transferred from the USSR Academy of Science to the structure of Glavsevmorput, which commissioned the AARI with the functions of preparing, organizing, and carrying out the next USSR Antarctic expeditions. After the AARI transfer to the structure of the Hydrometeorological Service, these expeditions were named the Soviet Antarctic Expeditions (SAE). In spite of preserving the status of the Complex Interagency and National Antarctic Expedition, the AARI was responsible for organizing and providing logistic support for SAE activity, which was renamed on August 7, 1992, to the Russian Antarctic Expedition (RAE). Due to the institute's efforts in the 1970s–1980s, the modern infrastructure of the Russian (Soviet) Antarctic scientific stations, which are situated over the entire perimeter of Antarctica and its inland regions, was created.

In the 1960s–1980s, the AARI specialists continued active Arctic studies. They participated in the trials of the first Soviet atomic icebreakers *Lenin* and *Arktika*; in conducting studies during the unique cruise of the atomic icebreakers the *Arktika* and *Sibir* to the North Geographical Pole in 1977 and in 1987, respectively; in organizing and carrying out research at the drifting North Pole stations. Research also included airborne high-latitudinal Sever expeditions; assessments of the transfer of water from the Iberian rivers to Middle Asia; circulation models of the ocean and the atmosphere in the Arctic and the Antarctic; and the physical and mechanical impact of sea ice on shore structures. Research investigated the ship hulls and engineering designs in the open sea and in introduced construction technologies of runways in Antarctica on compacted snow. The institute prepared and published the "Atlas of the Antarctic" (1966 and 1969) in two volumes, "Atlas of the Oceans: Arctic Ocean" (1980), "Atlas of the Arctic" (1985), "Atlas of the Oceans: Antarctica" (2005), and a large number of monographs, scientific articles, and methodological aids.

During the Soviet period of its activity, the AARI built two research expedition vessels for support of SAE (RAE) operations—the *Mikhail Somov* (1975) and the *Akademik Fedorov* (1987)—and in late 2012, the new vessel, the *Akademik Tryoshnikov*, was added to this flotilla. Many of the institute's staff were awarded with the state decorations of the USSR and the Russian Federation, and became laureates of the USSR State Prize and the Prize of the Government of the Russian Federation.

On June 5, 1994, the AARI was assigned the status of the State Research Center of the Russian Federation. The AARI carries out, at present, scientific studies in the following directions, which include meteorology and climatology; sea–air interaction; oceanography; sea ice; ice and ocean physics; hydrology of the mouth areas of rivers; engineering oceanography and ice research during operations in the offshore areas of the ice-covered seas; polar geography, paleogeography and glaciology of ice caps; polar medicine; polar ecology; and ice properties of ships with the test ice tank.

Besides, the institute's structure includes the Center of Ice and Hydrometeorological Information with a technical group for data transmission, Center of Geophysical Information, Department of the Expedition Fleet, the Logistical Center of the Russian Antarctic Expedition, the International Sea Ice Data Bank, the Russian-German "Otto Schmidt" Laboratory, the Russian-Norwegian "Fram" Laboratory, Laboratory of Climate and Environment Variability, and Department for Training of Young Specialists and the Post-Graduate Courses. On October 8, 2012, the Government of the Russian Federation assigned the status of the state operator in the Antarctic to the AARI.

Valery Lukin

See also: Alfred Wegener Institute (AWI); Antarctic Programs and Research Stations/Bases

Further Reading

Arctic and Antarctic Research Institute (AARI) Website. http://www.aari.nw.ru/index_en.html. Accessed January 7, 2014.

Arctic Basin

The oceanic basin in the Arctic Ocean is the Arctic Basin. It consists of two major basins: the Eurasian Basin and Amerasian Basin. The Eurasian Basin is smaller and geologically younger than the Amerasian Basin. These basins are bisected by the Lomonosov Ridge. The Lomonosov Ridge is an unusual geologic structure that is around 35–200 miles (60–200 km) wide and stretches around 1,100 miles (1,800 km) running roughly from Ellesmere Island of the Canadian Arctic Archipelago to the New Siberian Islands in Russia.

The Eurasian Basin and Amerasian Basin are surrounded by a number of continental shelves. In North America, the continental shelves average about 340 miles (540 km) offshore and include the Beaufort and Chukchi shelves. The continental shelf of Greenland is the Lincoln Shelf and includes two rift basins, which are the East Greenland Rift Basin and the West Greenland Rift Basin. In Eurasia, the continental shelves stretch over 900 miles (1,500 km) and includes the Barents, East Siberian, Kara, and Laptev shelves.

The Eurasian Basin (sometimes referred to as the Norwegian Basin) consists of two basins: the Nansen Basin and the Amundsen Basin (sometimes referred to as the Fram Basin). The Nansen Basin is an abyssal plain and is located between the Barents Sea continental shelf and the Gakkel Ridge. The depth of the Nansen Basin is around 9,800 ft. (3,000 m) below the ocean surface. The Amundsen Basin is located in between the Gakkel Ridge and the Lomonosov Ridge. Amundsen Basin is a linear basin about 1,200 miles (2,000 km) long and has a width up to 250 miles (400 km). The Eurasian Basin has the lowest point in the Arctic Ocean at 17,881 ft. (5,450 m) below the sea level.

The Amerasian Basin (sometimes referred to as the North American Basin) consists of Canada and Makarov Basins. The Canada and the Makarov Basins are divided by the Alpha-Mendeleev Ridge. The Canada Basin is the largest subbasin in the Arctic Ocean and is located between Alaska/Canada and the Alpha Ridge. The Canadian Basin has three abyssal plains, which are the Canadian, Chukchi, and

Mendeleev. The Canadian Abyssal Plain is the deepest area in Amerasian Basin side of the Arctic Ocean at more than 12,000 ft. (3,850 m) below the ocean surface. The Chukchi Abyssal Plain is about 7,200 ft. (2,200 m) below the ocean surface and covers an area of 1,900 square miles (5,000 sq. km). The Mendeleev Abyssal Plain is a little more than 9,500 ft. (2,900 m) below sea level. The Makarov Basin is located between the Alpha Ridge and Lomonosov Ridge. The Makarov Basin has two abyssal plains, which are the Wrangel and Siberian Abyssal Plains. The Siberia Abyssal Plain occupies almost half of the northern part of the Siberia Basin and is about 13,000 ft. (4,000 m) under the sea.

There are four main abyssal plains on the Arctic Ocean seafloor. On the Eurasian Basin, they are the Barents and Pole Abyssal Plains, which are separated by the Nansen Gakkel Ridge. On the Amerasian Basin, there are the Canadian and the Fletcher Abyssal Plains, which are separated by the Alpha-Mendeleev Ridge. The Arctic seafloor is subdivided by three great ridges, which are the Nansen-Gakkel Ridge (Arctic Mid-Ocean Ridge), Lomonosov Ridge, and the Alpha-Mendeleev Ridge. The Nansen-Gakkel Ridge is an active divergent tectonic plate stretching approximately 1,100 miles (1,800 km) from northern Greenland in the direction of Siberia. The Lomonosov Ridge rises about 10,000–12,000 ft. (3,300–3,700 m) above the seafloor. The Lomonosov Ridge at its most shallow area or the closest it comes to the ocean surface is around 3,000 ft. (950 m). The Canadian Basin and the Makarov Basin are divided by the Alpha-Mendeleev Ridge. In the Arctic Ocean, the Alpha-Mendeleev Ridge is the largest single submarine canyon with a width ranging from about 150 to 500 miles (250–800 km).

Andrew J. Hund

See also: Arctic Ocean; Beaufort Sea Dispute; Continental Shelf Claims in the Arctic; Lomonosov Ridge Claims; Northwest Passage Claims and Disputes

Further Reading

Bogdanov, N. "Tectonics of the Arctic Ocean." *Geotektonika* No. 3 (2004): 17–30.

Franke, D., K. Hintz, and C. Reichert. "Geology of the East Siberian Sea, Russian Arctic, from Seismic Images: Structures, Evolution, and Implications for the Evolutions of the Arctic Ocean Basin." *Journal of Geophysical Research: Solid Earth* 109, no. 7 (2004): 1–19.

Gurevich, N., S. Mashchenkov, O. Bychkova, and A. Abel'skaya. "New Data on Evolution of Amerasian Basin: Arctic Ocean and the Results of Preliminary Identification of Magnetic Abnormalities." *Rossiiskii Geofizicheskii Zhurnal* (*Journal of Geophysics*) Nos. 31–32 (2003): 37–45.

Arctic Botany

Arctic botany collectively includes the vascular and nonvascular plant species growing within the tundra climate region north of the coniferous forest tree line.

Arctic flora includes moss, lichens, fungi, algae, liverworts (collectively known as cryptogams), forbs (herbaceous flowering plants), dwarf shrubs, shrubs, and small trees. Species diversity and biomass are low. Arctic botanical habitats include wet tundra (tussock tundra, wet meadows, and bogs), dry tundra (dryas and dwarf shrub tundra), and shrub tundra (mainly drainages). Arctic flora is determined by overall climate and microclimate factors including water availability, soil type, nutrient supply, and snow cover. Arctic plants have specific adaptations for the climate and microclimate conditions. Botanical surveys both historical and current have contributed to understanding vegetation and distribution patterns across the Arctic.

Arctic Botanical Habitats

A prevalent wet tundra habitat type is wet tussock tundra, comprising tussock cotton grass (*Eriophorum vaginatum* L.) and Bigelow's sedge (*Carex bigelowii* Torr. ex Schwein.). Low shrub species may be present, including dwarf birch and resin birch (*Betula nana* L., B. *glandulosa* Michx.), marsh Labrador tea (*Ledum palustre* L. ssp. *decumbens* [Aiton] Hultén), lingonberry, and bog blueberry (*Vaccinium vitis-idaea* L., *V. uliginosum* L.). Common mosses include splendid feather moss (*Hylocomium splendens* [Hedw.] Schimp.), red stem moss (*Pleurozium schreberi* [Brid.] Mitt.), and sphagnum moss (*Sphagnum* L. spp.). Common lichens include reindeer lichen (*Cladina rangiferina* [L.] Nyl.), flavocetraria (*Flavocetraria* Karnefelt and A. Thell spp.), and cup fungi (*Cladonia* P. Browne spp.).

Wet meadow habitats are dominated by cotton grasses (*Eriophorum* L.), sedges (*Carex* L. spp.), and bulrushes (*Trichophorum* L. spp.). Forbs vary and may include purple marsh locks (*Comarum palustre* L.), coltsfoot (*Petasites frigida* [L.] Fr.), or others. Graminoid meadows contain only cotton grass and sedges such as water sedge (*Carex aquatilis* Wahlenb.). Wet bog habitats also may contain ericaceous shrubs like dwarf birch, lingonberry, Labrador tea, and bog blueberry, with a variety of graminoids, some forbs, and sphagnum moss.

Dry tundra habitats include vast reaches of dryas tundra habitat, dominated by dryas or mountains-avens (*Dryas* L. spp.). White Arctic mountain heather (*Cassiope tetragona* [L.] D. Don), netleaf willow (*Salix reticulata* L.), and alpine and red-fruit bearberry (*Arctostaphylos alpina* [L.] Spreng., *A. rubra*) can also be plentiful. Important lichen species include flavocetraria species, snow lichen (*Stereocaulon tomentosum* Fr.), cup fungi species, and white worm lichen (*Thamnolia vermicularis* [Sw.] Ach. ex Schaerer.).

Dwarf shrub tundra habitats may also include willows such as skeleton-leaf willow (*Salix phlebophylla* Andersson) and ericaceous shrubs like dwarf birch, marsh Labrador tea, lingonberry, bog blueberry, and crowberry (*Empetrum nigrum* L.).

Forb presence may include dense sweetvetch and locoweed cover (*Hedysarum* L. spp., *Oxytropis* L. spp.) Non-sphagnum mosses like splendid feather moss and sickleleaf moss (*Tomentypnum falcifolium*) are common. Sedge-dryas habitats occur on moister sites, dominated by sedges like water sedge (*Carex aquatilis* Wahlenb.) or Bigelow's sedge, and sometimes including non-tussock cotton grasses (such as tall cotton grass, *Eriophorum angustifolium* Honck.).

Taller shrub communities occur in drainages and valleys with sufficient water to support larger growth forms. Tall shrubs are mainly willows, including feltleaf willow (*S. alaxensis* [Andersson] Coville), diamond leaf willow (*S. planifolia* Pursh), Richardson's willow (*S. richardsonii* Hook.), Barclay's willow (*S. barclayi* Andersson), and others. Alder (*Alnus viridis* [Chaix] DC. ssp. *crispa* [Aiton] Turrill, *A. viridis* ssp. *fruticosa*) can occur alone or with willows.

Other minor types occur in aquatic, exposed, alpine, coastal, or riparian habitats. Forb marshes and submerged aquatic species are found in ponds, sloughs, and oxbow lakes. Lichen-dominated types occur on dry, windblown, rocky, or high alpine sites. Halophytic graminoid or forb meadows form in coastal areas. Alpine forb-sedge types occur in late-lying, well-irrigated snowbeds, and contain a variety of non-shrub species. Riparian, or streamside, habitats support graminoid or forb communities. Forest types do not occur, although individuals or islands of stunted trees, including black and Siberian spruce (*Picea mariana* [Mill., *P. obovata* Ledeb.] Britton, Sterns, and Poggenb.), tamarack and larch (*Larix laricina* and *L. sibirica* Ledeb.), paper and silver birch (*Betula papyrifera* Marshall, *B. pendula* Roth), and cottonwood species (*Populus* L. spp.), are scattered in moister locations.

Arctic Climate

Arctic tundra has a short growing season (50–90 days), low precipitation (6–10 in. (15–25 cm)), and frequent high winds (30–60 mph [40–100 km/h]). Midsummer temperatures reach 86ºF (30ºC) while winter temperatures are lower than −58ºF (−50ºC). Average temperature is often less than 50ºF (10ºC) in July, and snow can occur at any time. Ice remains through May on water bodies, and autumn colors appear in August. In winter, darkness is continual for around 45 days at 70º N latitude and 120 days at 80º N, with the opposite in continual daylight in summer.

Water access is limited. Permafrost, permanently frozen soil, occurs in most of the region. The thin surface-active layer thaws and refreezes each year, providing some water to roots. Local persistent snowbeds provide water later in the growing season. In poor drainage areas, deep organic soil mats (histosols) can form. Nitrogen and other nutrients are limited, and decomposition, with subsequent soil formation, is extremely slow.

Arctic Plant Adaptations

Arctic plants tolerate limited water conditions and frost with low growth forms and shallow root systems. Fuzzy, hairlike structures protect from wind and snow damage, and reduced leaf size minimizes water loss to wind. Some lichens can dry entirely, transported by wind to rehydrate later. Plants are slow-growing, perennial, evergreen, and long lived, maximizing metabolic activity over many growing seasons.

Vegetative reproductive reduces energy cost of producing flowers, seeds, or other reproductive structures, although long hours of sunlight allow quick development of flowers and seeds. Growth capacity starts immediately after snowmelt, with advanced, preformed buds from the prior season ready for rapid leaf expansion. Snow accumulation provides an insulating layer to plants at the ground surface. Trees are generally unable to establish in permafrost areas. Surviving trees are stunted, with basal rosettes of layering branches or flagged branches.

Botanical Survey

Estimates from botanical surveys indicate that more than 1,700 plant species occur, of which 400 are flowering plants. Improved modern genetic testing has detected higher diversity in certain plant families and genera. Government agencies, private companies, and academic institutions have conducted botanical surveys in the Arctic, to enhance herbarium collections, to monitor plant population trends, and to conduct research.

Early botanical surveys in the Arctic were often part of large multipurpose exploration parties. Some notable historical figures of Arctic botanical survey include Georg Stellar, naturalist, for the Bering expedition from Russia to Alaska in 1740–1741. Stellar spent 10 hours onshore at Kayak Island (near present-day Cordova, Alaska), as the first European naturalist to describe the flora and fauna of Alaska. Further exploration took place on what is now Bering Island after the expedition shipwrecked there. The Western Union Telegraph Exploration, 1865–1867, employed the naturalist Robert Kennicott to explore flora and fauna of Alaska. Botanical discoveries were heralded as partial justification for maligned U.S. purchase of Alaska from Russia. Robert E. Peary's fourth trip to Greenland in 1896 included several botany students from Cornell University who collected more than 135 species of plants from the Island of Baffin, the Labrador coast, and around the Nugsuak Peninsula. The Harriman Expedition around the coast of Alaska in 1899 included an entourage of scientists, artists, photographers, and naturalists, including the principal botanist Frederick Vernon Coville. More than 240 new species were collected, including marine algae, fungi, lichens, moss, liverworts, hornworts, ferns, and vascular plants.

More recent botanical explorers have included Danish biologist Alf Erlin Porsild, collecting more than 25,000 specimens and curating the National Museum of

Canada's herbarium. He worked with William Cody to produce various floras for Canada. Nicholas Polunin, part of the Canadian Arctic Survey, explored and collected many botanical specimens throughout the Canadian Arctic. Eric Hultén, a Swedish botanist, published the most comprehensive Alaskan flora to date in 1968.

Modern botanical surveys continue through international efforts including the Circumpolar Arctic Vegetation Mapping Project using satellite data; the Pan Arctic Flora Project, producing a unified list of accepted names for Arctic vascular plants; the International Tundra Experiment, coordinating climate change studies; and the Circumpolar Biodiversity Monitoring Program, the main program of the Conservation of Arctic Flora and Fauna of the Arctic Council. The Canadian Museum of Nature has undertaken a multiple-year Arctic Flora Project for North American Arctic plants, with more than 900 species cataloged.

Herbarium Collections

Herbarium collections serve as archival records, genetic material, and teaching and research tools. Geographic locations allow estimates of population range across the Arctic and specific habitat locations, and provide a long-term record of change in populations dynamics, of particular importance in a changing climate.

Specimens from a number of Arctic expeditions are housed in the U.S. National Herbarium, Smithsonian National Museum of Natural History. Other Arctic collections are located at the University of Alaska Museum Herbarium (ALA) at the Museum of the North, University of Alaska, Fairbanks; the National Herbarium of Canada (CAN), Canadian Museum of Nature; the University Museum of Bergen, Norway (BG); and the Herbarium (UME) at Umeå University in Sweden.

Elizabeth Bella

See also: Arctic Shrub Range Expansion; Climate Change and Invasive Species in the Arctic; Tundra

Further Reading

Aiken, S., et al. "Flora of the Canadian Arctic Archipelago: Descriptions, Illustrations, Identification, and Information Retrieval." Ottawa: NRC Research Press, National Research Council of Canada, 2007.

Billings, W., and H. Mooney. "The Ecology of Arctic and Alpine Plants." *Biological Review* 43 (1968): 481–529.

Cody, W. *Flora of the Yukon Territory.* 2nd ed. Ottawa: National Research Council of Canada, 2000.

Hultén, E. *Flora of Alaska and Neighboring Territories: A Manual of the Vascular Plants.* Stanford, CA: Stanford University Press, 1968.

Porsild, A., and W. Cody. *Vascular Plants of Continental Northwest Territories.* Ottawa: National Museum of Natural Sciences, National Museums of Canada, 1980.

Arctic Camel

The first discovery of a camel in Canada's High Arctic was made in 2006 by Dr. Natalia Rybczynski, a Canadian Museum of Nature (CMN) paleobiologist at the Fyles Leaf Bed Site on Ellesmere Island, NU. Identified using morphology and collagen fingerprinting of a fragmentary fossil limb bone, this is the most northerly camel found to date, 1200 km north of the remains of the giant Yukon Camel, first found in 1913.

The fossil, collected over three field seasons, consists of about 30 bone fragments, which together form part of a limb bone of a Pliocene camel. This is the first evidence of camels living in a High Arctic, boreal-type forest. The fossil record from this locality shows the camel lived about 3.5 mya during the Pliocene. During this time, the planet was in a warm phase, similar to predicted global warming.

The exceptional preservation of the fossil fragments, helped by the Arctic environment, allowed for the use of a new technique called "collagen fingerprinting." It shows that the fossil's collagen, the primary protein in bone, is most similar to that of modern camels, particularly the dromedary or one-humped camel.

The fragments were also surface-scanned and then assembled using digital technology. Although only a partial limb bone was recovered, there was sufficient anatomical evidence to suggest that these were the remains of a giant camel.

Camels originated about 45 mya during the mid-Eocene in North America. They dispersed to Eurasia 7 mya using the Bering land bridge. Fossil remains of camels have been found in Spain, Africa, China, Eastern Europe, and North America.

During the Pleistocene, there were two kinds of Arctic camels. Most fossil camel remains discovered in the Arctic are *Camelops*, also called the "western camel." They are a distant relative of llamas.

The second camel, the Yukon giant camel, is larger than *Camelops.* This is a true camel and a close relative of the fossil genus *Paracamelus*, a lineage that gave rise to modern camels. Collagen fingerprinting also shows that the High Arctic camel is a close relative of the Yukon giant camel.

It is possible that the High Arctic of North America represents the original adaptive environment for this lineage. Perhaps some of the specializations seen in camels today are adaptations to a polar Arctic environment.

When the High Arctic camel lived on Ellesmere Island, the channels of the Arctic Archipelago would have been infilled, allowing camel populations to move freely through areas that are islands today. Plant fossil evidence indicates that a boreal-type forest extended to the Arctic Ocean.

The Pliocene climate in the region would have been warmer than it is today, but the winters would have still been cold and snowy. The High Arctic camel would probably have grown a thick winter coat, similar to that of the modern Bactrian or two-humped camels. Camel humps, which serve as fat storage, would have helped the camel survive long cold winters when food sources would have been scarce.

This camel was likely a browser, like moose today, and would have relied more heavily on woody material in the winter. Modern camels are herbivores and are called "mixed feeders" because they can eat grasses and browse on leaves and twigs.

Other traits seen in modern camels that may have benefited the High Arctic camel include the wide flat feet, which are useful for walking on soft surfaces or snow. Their large eyes may have also been helpful for foraging in the winter during periods of lengthy Arctic darkness.

Natalia Rybczynski and Martin Lipman

See also: Dinosaurs of Antarctica; Mesozoic Marine Reptiles of Antarctica; Paleoecology of Antarctica; Pliocene Arctic Fossils; Woolly Mammoths; Woolly Mammoths, Baby; Yukaghir Mammoth

Further Reading

Csank, A., W. Patterson, B. Eglington, N. Rybczynski, and J. Basinger. "Climate Variability in the Early Pliocene Arctic: Annually Resolved Evidence from Stable Isotope Values of Sub-Fossil Wood, Ellesmere Island, Canada." *Palaeogeography Palaeoclimatology Palaeoecology* 308, nos. 3–4 (2011): 339–49.

Rybczynski, N., J. Gosse, C. Harington, R. Wogelius, J. Hidy, and M. Buckley. "Mid-Pliocene Warm-Period Deposits in the High Arctic Yield Insight into Camel Evolution." *Nature Communications* 4 (2013): 1550.

Arctic Circle

The Arctic Circle is predominately an ocean that is surrounded by continents and covers roughly 6 percent or 5.5 million square miles (14.2 million sq. km) of the earth. The area is mostly covered by ice. As of 2012, the Arctic ice cover was 1.82 million square miles (4.72 million sq. km). In a strict definition, the Arctic Circle is the area of 66° 33′ 44″N and includes the Arctic Ocean, Greenland, and northern parts of European, Asian, and North American continents. Around half of the Arctic coastline is on Russian soil. The Arctic Circle crosses eight countries, which are United States (Alaska), Russia, Finland, Sweden, Norway, Denmark (Greenland), Canada, and Iceland (Grímsey Island). All eight countries are signatories to the multilateral, nonbinding agreements of Arctic Environmental Protection Strategy and the Declaration on Arctic Environmental Protection ("Rovaniemi Declaration") of 1991.

Beyond what is indicated on maps, the Arctic Circle is not an actual line or specific place. The Arctic Circle is one of five imaginary circles indicated on maps of the earth, representing major lines of latitude (e.g., Tropic of Cancer [23° 26′ 16″N],

Midnight sun in the Arctic. (Andrew J. Hund)

Equator [0°], Tropic of Capricorn [23° 26′ 16″S], and the Antarctic Circle [66° 33′ 44″S]). The distance from the Arctic Circle to the Antarctic Circle is about 9,300 miles (15,000 km). Both poles are of the same distance from the equator (0° to 66.5° N or S). The Arctic Circle is not a fixed position and is contingent on the Earth's axial tilt, which fluctuates within a margin of 2 percent over a period of

GRÍMSEY, NORTHERN ICELAND

Grímsey (66° 33´N 18° W) is Iceland's fourth largest island. The island lies about 25 miles (41 km) off Iceland's northern coastline and extends from north northwest to south southeast. It has an area of 2 square miles (5.3 sq. km) and is 3.2 miles (5.5 km) in length. The island's rock base, formed during the late ice age, is mostly dolerite. Columnar basalt widely occurs in sea cliffs, the highest of which are situated along the eastern shoreline, some rising to around 345 ft. (105 m) above sea level. The harbor and village lie in the island's lower western area. The Icelandic sagas refer to Grímsey's utilities around the year 1000, such as driftwood and harbor facilities. By 1200, the island appears to have been permanently settled, but at the end of the eighteenth century, lobar pneumonia and tragedies at sea almost wiped out the entire male population. In the late nineteenth century, the American Willard Fiske presented the islanders with chess sets, a library, and a sum of money. Iceland's northernmost settlement, Grímsey, today has around 100 inhabitants whose livelihood is based mostly on fishing, seabirds, and their eggs. The Arctic Circle straddles the island. Communications are by regular ferry service from Dalvík and flights from Akureyri. Since 2000, Grímsey has been part of Akureyri municipality.

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40,000 years. This fluctuation is due primarily to the orbit of the Moon and its influence on Earth's tidal forces. The Arctic Circle is currently migrating north at around 50 ft. (15 m) per year.

The 66.5° N latitude is considered the southernmost boundary of the Arctic Circle. A defining characteristic of the Arctic Circle is that all locations above 66.5° N latitude experience a 24-hour period of sunlight on the summer solstice (around June 21) as well as 24 hours of darkness during the winter solstice (around December 21). The summer solstice is commonly called the "Midnight Sun," while the winter solstice is called "Polar Night." The seasons of the Northern Hemisphere are opposite to that of the Southern Hemisphere.

The Arctic Circle ecosystem is commonly referred to as tundra, but many scientists subdivide the Arctic region into two biogeographic zones: the High and Low Arctic zones. The High Arctic zone is the area from 80° N to 88° N, while the Low Arctic zone is between 68° N up to 80° N. The Low Arctic zone is commonly covered with knee-high plants and bushes, while the High Arctic zone is limited to ankle-high plants. Much of the High Arctic zone is desert with limited precipitation, and even though being further north, the High Arctic zone receives less snow. For example, the southern region of Greenland receives more than 100 times more snowfalls than northern Greenland. The zone just south of the Arctic Circle is called the Northern Temperate zone.

APATITY, RUSSIA

Apatity, Russia (67° 34′N 33° 24′E) is a town of about 60,000 people. The town was established in 1930 and officially gained town status in 1966. The town is located in the Russian administrative division of Murmansk Oblast. The town name is derived from the local group of phosphate minerals referred to as "apatite." These phosphorus minerals are used in the production of fertilizers. The Murman railway that runs from St. Petersburg to Murmansk travels through the town of Apatity. Apatity is located between the Khibinsky Mountains and Lake Imandra. The town is near the eastern shore of Lake Imandra. To the west of Apatity is Kirovsk (about 14 miles [23 km]) and 115 miles south (185 km) is Murmansk. The largest employer for Apatity is the Joint-Stock Company (JSC) Apatit. Apatit is the largest mining and concentrating venture in Russia and Europe. There are several museums in the town operated by the Kola Science Centre, Russian Academy of Sciences (KSC-RAS), such as the Museum of Investigation and Development History of the European North of Russia (operated by the International Cultural Center of KSC-RAS); the Geological museum; and the Mineralogical museum (operated by the Institute of Geology KSC RAS).

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MIDNIGHT SUN

The Midnight Sun is when the sun stays above the horizon for more than 24 hours. This occurs only in the polar circle regions (i.e., above 66.5° N or 66.5° S). The 24 hours of light corresponds with the summer solstices in each of the Antarctica and Arctic Circles. In Latin, the term "solstice" means standstill. All locations in the Northern Hemisphere experience longer periods of daylight and locations north of the Arctic Circle (66.5° N) experience a 24-hour period of sunlight on the summer solstice. During the summer solstice, in the Northern Hemisphere, the North Pole (location 90° N) is tilted toward the sun (around June 21) and directly over the Tropic of Cancer. The Northern Hemisphere, during the summer solstice, is positioned to receive extended periods of sunlight due to its position relative to the sun. The extended periods of sunlight coupled with shorter periods of darkness at night result in increased temperatures in the Northern Hemisphere of the earth. The summer solstice in the Southern Hemisphere occurs during wintertime in the Northern Hemisphere. The Midnight Sun occurs in Antarctica (66.5° S) around December 21.

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There are only a few large settlements of people north of the Arctic Circle. The largest cities are found in Russia and Norway, such as Kirovsk, Russia (also called "Khibinogorsk") (67°37′N 33°39′E) (pop. 28,625); Kandalaksha, Russia (67° 9′N 32° 24′E) (pop. 35,654); Monchegorsk, Russia (67° 56′N 32° 55′E) (pop. 45,361); Bodø, Norway (67° 18′ 20″N 14° 32′ 57″E) (pop. 47,847); Severomorsk, Russia (69° 4′N 33° 25′E) (pop. 50,060); Apatity, Russia (67° 34′N 33° 24′E) (pop. 59,672); Tromsø, Norway (69° 40′ 58″N 18° 56′ 34″E) (pop. 72,116); Vorkuta, Russia (67° 30′N 64° 2′E) (pop. 70,548); Norilsk, Russia (69° 20′N 88° 13′E) (pop. 175,365); and Murmansk, Russia (68° 58′N 33° 5′E) (pop. 307,257). In Greenland, the most populated Arctic town is Sisimiut (66° 56′ 20″N 53° 40′ 20″W) and in Alaska is Barrow (71° 17′ 44″N 156° 45′59″W) with a population of more than 4,000.

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See also: Arctic, Definitions of; Arctic Ocean; South Pole; Three-Pole Concept

Further Reading

National Snow and Ice Data Center. "What Is the Arctic?" http://nsidc.org/cryosphere/arctic-meteorology/arctic.html. Accessed January 7, 2014.

Wheeler, Sara. *The Magnetic North: Notes for the Arctic Circle.* New York: Farrar, Straus and Giroux, 2011.

Arctic Council

The Arctic Council (AC) is a high-level intergovernmental forum, established for international cooperation of panarctic states. Establishment of this forum became possible only during the period of relaxation of international tension after the end of the Cold War, when the Arctic region was considered as a prospective theater of war operations between the NATO and USSR countries.

In August 1993, the International Conference of Arctic Parliamentarians was organized in Reykjavik (Iceland). Similar Conferences were held every two years on a regular basis. As proposed by Finland in Rovaniemi in September 1996, the representatives of the governments of the subarctic states with participation of different associations of the indigenous peoples of the Far North decided to establish the AC.

The Declaration on the Establishment of the AC was signed in Ottawa (Canada) on September 19, 1996, by eight Arctic states: Denmark including Greenland, Iceland, Canada, Norway, Russia, the United States, Finland, and Sweden.

The council was created to promote cooperation of the Arctic states, coordinate their actions to serve the interests of sustainable development of the region, environmental protection and conservation of culture, and traditions and languages of the indigenous peoples of the North. The Declaration specially stipulates that the AC is not involved in the issues of military security.

The highest body of the council is a ministerial session, which is held every two years. The Chair of the Council is elected for two years, successively representing all member-countries of the council. The AC working body is the Committee of Senior Arctic Officials dealing with the current activity of the council, holding its meetings not less than twice a year.

To provide active participation of the representatives of the Arctic indigenous peoples in the AC activity, the permanent participant status (participation in the discussion of all issues but without the voting right) was assigned to the Inuit Circumpolar Council; the Aleut International Association; the Saami Council; the Association of Indigenous Peoples of the North, Siberia, and Far East of the Russian Federation; and the Arctic Athabaskan Council and the Gwich'in Council International. The permanent participant category is equally open for all Arctic organizations of the indigenous peoples, in which the Arctic peoples prevail.

As declared in the Constituent Declaration of the Arctic Council and regulated by its Rules of Procedure, the observer's status in the AC is open for the non-Arctic states, intergovernmental and inter-parliamentary organizations (both global and regional), and nongovernmental organizations, which according to the decision of the council are capable to make input into its work. As of 2012, the United Kingdom, the Netherlands, Poland, Germany, the Standing Committee of the Parliamentarians of the Arctic Region, the United Nations Environment Program, the Nordic

Council, the Northern Forum, the World Wild-Life Fund, the International Arctic Science Committee, the International Union for Circumpolar Health, the Advisory Committee on Protection of the Sea, and so on, had the observer's status in the AC. From 2007, the observer's status in the AC was given on a one-time basis to China and Italy, and the European Commission and South Korea. The European Union Commission, China, Japan, South Korea, and Italy have interest in receiving the observer's status in the AC.

Granting the observer's status is a prerogative of the AC Ministerial Meeting. Criteria for the compliance of the candidate for the observer's status in the AC include support of the AC goals, confirmed in the Ottawa Declaration; acknowledgment of sovereignty of the Arctic states; their sovereign rights and jurisdiction in the Arctic; recognition of the guiding legal principle of activity in the Arctic Ocean—the international Law of the Sea; consideration for the values, interests, culture, and traditions of the indigenous peoples and other population of the Arctic; demonstration of political will and financial ability to contribute to the work of the permanent participants and other indigenous Arctic peoples; and knowledge and experience of activity in the Arctic.

The AC began its activity with implementing programs in the framework of the so-called Rovaniemi process—international cooperation on the Arctic Environmental Protection Strategy. Sustainable development issues were added to the AC terms of reference later. There are six Task Forces in the AC: Arctic Monitoring and Assessment Program, Emergency Prevention, Preparedness and Response, Conservation of Arctic flora and fauna, Protection of the Arctic Marine Environment, Sustainable Development in the Arctic, and Arctic Contaminants Action Program.

Reports on the State of the Arctic Environment and the Arctic Marine Shipping Assessment were prepared in the AC framework and contained the first assessments of the possible scenarios in the case of a continued tendency for a rapid ice cover decrease in the Arctic Ocean.

In 2008–2009, in the framework of the activity of the Task Forces, the Draft Agreement on Cooperation on Aeronautical and Marine Search and Rescue in the Arctic was developed and was signed by the Ministers of Foreign Affairs of the AC member-countries in May 2011 in Nuuk, Greenland. This document was the first panarctic agreement. At the present time, the second agreement of such format on the Arctic marine oil pollution preparedness and response is being prepared.

There are more than 70 ongoing AC projects in the field of climate change, ecology, economics, culture and health, prevention of emergencies, and protection of the interests of the indigenous peoples of the North.

The intergovernmental cooperation in the Arctic differs significantly from the principles of international cooperation in the Antarctic (see the entry "Antarctic Treaty System (ATS)"). If the AC membership is strictly restricted to the states in the Arctic region, the Antarctic Treaty is open for accession to any UN member-countries. Unlike the Antarctic Treaty, the AC is not involved in the political–legal regulation issues and any restrictions of military presence in the region. At the same time, the AC is open to the states that show interest in the Arctic granting them the observer's status.

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See also: Antarctic Territorial Claims; Antarctic Treaty System (ATS); Arctic Territorial Claims and Disputes; Barents Euro-Arctic Council (BEAC)

Further Reading

Axworthy, T., T. Koivurova, and W. Hasanat. *The Arctic Council: Its Place in the Future of Arctic Governance*. Toronto: Munk-Gordon Arctic Security Program, 2012.

Ronson, A. "Political Climate Change: The Evolving Role of the Arctic Council." *The Northern Review* 33 (Spring 2011): 95–111.

Turunen, Minna, and Paula Kankaanpää. "The Visibility of the Arctic Council—Results of a Background Study." Arctic Centre Report, vol. 37. Rovaniemi, Finland, 2002. http://arcticcentre.ulapland.fi/docs/ArcticCouncil-raportti2002.pdf Accessed January 7, 2014.

Vasiliev, A. "Russian Policy in the Arctic and the Arctic Council." 5th NRF Open Assembly, Anchorage, Alaska, September 24–27, 2008. http://nrf.is/images/stories/pdf/anchorage_2008/proceedings/plenary_papers/5th_nrf_anc_2008_vasiliev_russian_arctic_policies.pdf. Accessed January 7, 2014.

Arctic Fox

The Arctic fox (*Alopex lagopus*) is a charismatic native inhabitant of the Arctic region. This small mammalian land-dwelling predator has an average weight of 6.5–17 lbs (3–8 kg). The Arctic fox has a length of approximately 18–26.75 in. (46–68 cm) head and body, and their tail can be up to 13.75 in. (35 cm) long. The Arctic fox is well adapted to extreme cold. Arctic foxes have two color morphs: their fur is snow white in winter and brown-yellowish in summer, or can be dark blue year-round. This species occurs in the entire Arctic and can be found in Eurasian and North American Arctic tundras. Some populations like in Fennoscandia are drastically reduced but still present.

The Arctic fox is adapted to harsh conditions of the Arctic environment having rounded ears and body, short muzzle and legs, and a fur coat with one of the best insulating capacities known among any terrestrial mammal. The pads of their feet have a rete of capillaries that minimize heat loss. Studies have shown that temperatures can get below −40°C before the Arctic fox needs to increase metabolic rate to maintain normal body temperature. They are also able to survive without food for extended periods of time. The Arctic foxes' cold climate adaptations have made it possible for them to endure and survive the Arctic climate for many thousand years.

Arctic foxes enjoying the sun. (Falk Huettmann)

Coastal foxes rely primarily on a diet of birds, eggs, and carrion, while tundra foxes have small mammal (microtine) diet. Traditionally, a fluctuation of many Arctic fox populations in tundra is correlated with rodent population fluctuations. As the vole and lemming populations are cyclic, so are the foxes. During microtine peaks, they have a very high reproduction potential. Between these peaks, large portion of the foxes won't breed at all and can even die due to starvation. It is known that foxes get far out onto the sea ice in search for food. Carcasses of marine mammals from polar bear strikes are the main food source for Arctic foxes there. First telemetry studies have shown that Arctic foxes can spend at least 150 consecutive days on the ice and move across huge distances (>2,700 km).

Conservation Status

The Arctic fox is listed as least concern on the IUCN Red List and is not protected in its range, except for populations in Norway, Finland, and Sweden, where this animal is considered critically endangered. Arctic fox trapping is somewhat limited and licensed in Svalbard (Norway), Greenland, Canada, Russian Federation, and Alaska (where Arctic foxes are trapped as part of a statewide predator control program). The role of industrial activities in Arctic regions is noteworthy because it can attract as well as kill foxes, and bring in invasive species detrimental for Arctic foxes. Foxes have declined on the Pribilof Islands (Alaska). The isolated Arctic fox population (*Alopex lagopus semenovi*) of Medniy Island (Commander Islands) is included in the Red Book of Russia. Presently, there are no legislations that deal with climate change and Arctic foxes nor violations widely enforced or prosecuted.

The Changing Climate and Red Fox Invasion

While the climate is changing, entire ecosystems are migrating northward, favoring invasive species such as the red fox (*Vulpes vulpes*) and invasive diseases, for example, rabies. The red fox is native to the boreal forests of the Northern Hemisphere. The red fox distribution is now expanding northward. In Fennoscandia, the red fox is increasingly inhabiting the alpine regions, and at human development and at industrial sites on the tundra of Northern America and Russia. The red fox is undoubtedly the superior species; it tends to be 60 percent heavier and 25 percent larger in linear dimension than the Arctic fox. It is known to overtake entire Arctic fox dens and even kill Arctic foxes. With climate change, introducing species like the red fox to the Arctic, and a threatened sea ice, which is an important feeding habitat, the Arctic fox is most likely facing a future of drastic declines and possibly even extinctions, taking a similar fate to the polar bear (to be assumed extinct in 100 years, or less).

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See also: Arctic Ground Squirrel; Arctic Hare; Arctic Seabirds; Arctic Wolf; Caribou; Dogs in the Arctic; Lemmings; Musk Oxen; Polar Bear; Wolverine

Further Reading

Angerbjoern, A. M. Tannerfeldt, and S. Erlinge. "Predator-Prey Relationships: Arctic Foxes and Lemmings." *Journal of Animal Ecology* 68 (1999): 34–49.

Linell, J., O. Strand, and A. Landa. "Use of Dens by Red Vulpes Vulpes and Arctic Alopex Lagopus Foxes in Alpine Environments: Can Interspecific Competition Explain the Non-Recovery of Norwegian Arctic Fox Populations?" *Wildlife Biology* 5 (1999): 167–76.

Pamperin, N., E. Follmann, and B. Person. "Sea-Ice Use by Arctic Foxes in Northern Alaska." *Polar Biology* 31 (2008): 1421–26.

Prestrud, P. "Adaptations by the Arctic Fox (*Alopex lagopus*) to the Polar Winter." *Arctic* 44, no. 2 (1991): 132–38.

Arctic Ground Squirrel

The Arctic ground squirrel (*Spermophilus parryii*) is a hibernating rodent native to the Holarctic ecozone. It is a species of the ground squirrel that live individually in tunnels or burrows. During the warmer month, the squirrel is diurnal or active during the day. These squirrels are omnivorous. Their range stretches from Siberia, to Alaska, to Hudson Bay, Canada, and as far south as the northern part of British Colombia. Archaeologist found a mummified Arctic ground squirrel that dates back to about 20,000 years ago.

Adult Arctic ground squirrels average about 16 in. (39 cm) in length with a range of 14–18 in. (35–46 cm) from head to end of tail. Their tails range between 3 and 5 in. (7–13 cm). The squirrels weigh around two pounds. Male Arctic ground squirrels are slightly heavier than females (about 3.5 ounces [100 g]). The physical appearance of the Arctic ground squirrel is a grayish tan and gray in the upper backside and rusty to tan on the belly side. They have a rusty-tan-colored nose, head, and legs. Their legs are short and stubby, and they have flat tail that is fairly bushy. There are four toes on their feet. The squirrel walks on all four legs but can sit up on two legs to survey the immediate landscape. They have round heads with a short face with a blunt nose, small rounded ears, and white markings around their eyes. Overall, their body shape is oval. Their coat changes from summer to winter. In the summer, their coat is red/yellow in color alongside their cheeks and sides. In the fall, these red/yellow patches turn silvery in color.

There are eight recognized subspecies of Arctic ground squirrels, which are the *Spermophilus parryii-nebulicola*; *-ablusus*; *-leucostictus*; *-osgoodi*; *-parryii*; *-plesius*; *-stejnegeri*; *-kodiacensis* (Kodiak ground squirrel); *parryii kennicottii* (Barrow ground squirrel); and *-lyratus* (St. Lawrence Island Ground Squirrel). These subspecies differ by location as well as slight variation in the color of their coat and shape of the skull.

The primary source of food is seeds, insects, grasses, flowers, sedges, bog rushes, bilberries, roots, leaves, lichen, berries, nuts, and mushrooms. They also eat bird eggs and occasionally eat the young of other Arctic ground squirrels. The squirrels will sometimes carry food in their cheeks to store in the burrow or eat the food as they find it.

The Arctic ground squirrel hibernates over the winter from around August to late April for females and late September to the beginning of April for males. The squirrels line and insulate their burrow with leaves, lichens, and musk ox hair. In preparation of hibernation, in the late summer, the male Arctic ground squirrel will stock up food in its burrow for spring upon waking up from hibernation when new vegetation is limited. During hibernation, the body temperature of the squirrel lowers to 99°F (37°C) and can lower down to 27°F (−3°C). Its brain temperature lowers to just above freezing, and its heart rate declines to approximately 1 beat per minute.

The mating season for squirrels is shortly after hibernation, which is roughly mid-April and mid-May, but those in higher latitudes can be later. During mating season, males are aggressive and compete with other males for the females. The paternity of most offspring is from the dominant male; however, a female litter is usually sired by multiple males. Pregnancy for the female lasts around 25 days with most litters consisting of 5–10 pups and sometimes more than a dozen. The pups are breast-fed for around six weeks, then leave the burrow after weaning.

Arctic ground squirrels communicate with each other through physical and vocal modes. They greet each other by nose-to-nose contact or by pressing various body parts together. When a predator or threat is observed, a squirrel will make different vocalizations, such as screeching and rattling to warn others of the danger. These calls vary based on the type of predator, such as a shrill whistle sound for an aerial threat and a deep sound for a land threat. Common predators of the Arctic ground squirrel are foxes (red and Arctic), wolverine, brown bears, lynx, ermine, hawks, owls, falcons, and eagles.

The Inuit call the squirrel "sik sik" based on the sound it makes. The Unangax or Aleut call the squirrel "parka," which is generally thought to be because their fur or pelt can be used to edge hoods on parkas. The Arctic ground squirrels' fur is used by various people in the Arctic for clothing.

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See also: Arctic Fox; Arctic Hare; Arctic Seabirds; Arctic Wolf; Caribou; Dogs in the Arctic; Lemmings; Musk Oxen; Polar Bear; Wolverine

Further Reading

Barker, O., and A. Derocher. "Habitat Selection by Arctic Ground Squirrels (*Spermophilus parryii*)." *Journal of Mammology* 91, no. 5 (2010): 1251–60.

Buck, C., A. Breton, F. Kohl, O. Toien, and B. Barnes. "Overwinter Body Temperature Patterns in Free-Living Arctic Ground Squirrels (*Spermophilus parryii*)." In B.G. Lovegrove and A.E. McKechnie, eds. *Hypometabolism in Animals: Hibernation, Torpor and Cryobiology.* Pietermaritzburg, South Africa: University of KwaZulu-Natal, 2008, pp. 317–26.

Sheriff, M., G. Kenagy, M. Richter, T. Lee, O. Toien, F. Kohl, C. Buck, and B. Barnes. "Phenological Variation in Annual Timing of Hibernation and Breeding in Nearby Populations of Arctic Ground Squirrels." *Proceedings of the Royal Society: Biological Sciences* 278 (2011): 2369–75.

Arctic Hare

The Arctic hare (*Lepus arcticus*) is one of the largest hares and the northernmost hare species. They are characterized by their molting or seasonally changing coat, especially the southern Arctic species. Their range stretches from Greenland across northern Canada to Alaska. In these ranges, the Arctic hares live on treeless hillsides and rocky areas of the tundra. They live above ground, but have been known to create dens or use natural shelter as the cold Arctic weather necessitates. In the winter, they sometimes relocate to the forest. The hares are opportunistic omnivore feeders that have a diet composed of a variety of tundra vegetation, such as grasses, shrubs, lichens, twigs, herbs, crowberries, buds, and woody plants (Arctic willow). Arctic hares will also feed on small animals and seaweed, as well as scavenge feed on dead animals (carrion). There are nine subspecies (*Lepus arcticus-andersoni*, *-arcticus*, *-bangsii*, *-banksicola*, *-groenlandicus*, *-hubbardi*, *-labradorius*, *-monstrabilis*, and *-porsildi)*, which are differentiated by the hares' range, molting behavior, and physical appearance.

Adult Arctic hares average about 22 in. (56 cm), with a range of 17–28 in. (43–71 cm) in length. The hares' weight ranges from 6 to 15 pounds (2.5–7 kg). Female hares are slightly heavier than males. They have very thick fur, a compact body, and powerful legs. The hares are highly adapted to the cold Arctic weather. For example, they have small front feet, tails, and ears that help reduce heat loss. Their paws are thickly padded with course fur along with their large back feet that act like snow shoes, which enables them to walk on the snow surface without sinking. Arctic hares have an acute sense of smell that allows them to find food under the snow. Their ears have black tips, and their eyes are located on the sides of their head, which provide them with a 360° viewing angle without moving their head. The hares' locomotion is primarily by their front feet, which can move separately, while their hind legs step in unison. The hares' front feet are equipped with long claws that facilitate digging in snow to acquire food. They also use their incisor teeth to dig in the snow for food.

The hares' coat changes from summer to winter. In spring, the amount of daylight triggers a release of hormones that causes the hares to molt. The southern hares' white winter coat is replaced with shorter fur that is brown-gray in color. The northern Arctic hare also molts into shorter fur but maintains the white coloration year-round. The changing coat helps the hares to adapt to the warmer days, and the changing color aids the southern hare with camouflage for the seasons.

The Arctic hare's body is built for speed with low body fat and long powerful hind legs resulting in the hare being able to bound up almost 7 ft. (2.1 m). They are able to run up to 37 mph (60 km/h) and maneuver in erratic patterns to escape predators. Common predators are humans, Arctic wolves, Arctic foxes, ermines, gyrfalcons, peregrines, and snowy owls.

Although Arctic hares are mostly solitary, in the winter, they are known to gather in large groups in what is called "flocking." This unique flocking behavior is believed to be for protection from predators. The flocks can be up to several 1,000 hares. A unique feature of the flock is that when disturbed or spooked, the hares run and change direction in unison. Communication of the Arctic hares is limited vocalizations. They are known to emit a distress call when captured by a predator. Arctic hares mostly communicate by secreting a scent from the glands under their chin and groin.

The mating season for hares begins in April or May, but those in higher latitudes may be later. The courtship behavior of the male is to follow the female around biting her on the neck, which commonly results in drawing blood. Pregnancy lasts around 50 days with most litters consisting of 2–8 leverets in June or July. The leverets are born in a small depression in the ground, which is commonly bedded with grass, moss, and fur or can be sheltered under or near rocks. The leverets are born with a fur coat and with their eyes open. The hares' mother returns to the nest about every 18 hours to breast-feed the young. The leverets are breast-fed for around eight or nine weeks, then weaned and left to fend for themselves.

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See also: Arctic Fox; Arctic Ground Squirrel; Arctic Seabirds; Arctic Wolf; Arctic Woolly Bear Caterpillar/Moth; Caribou; Dogs in the Arctic; Lemmings; Musk Oxen; Polar Bear; Wolverine

Further Reading

Angerbjörn, A. "Hares and Rabbits: Leporidae." In *Grzimek's Animal Life Encyclopedia.* 2nd ed. Vol. 16. Farmington Hills, MI: Thomas Gale, 2004, pp. 505–16.

Best, T., and T. Henry. "*Lepus arcticus.*" *Mammalian Species* 457 (1994): 1–9.

Gray, D. "Behavioral Adaptations to Arctic Winter: Shelter Seeking by Arctic Hare (*Lepus arcticus*)." *Arctic* 46, no. 4 (1993): 340–453.

Arctic Haze

Arctic haze or "poo-jok" is observed as an unnatural reddish-brown phenomenon in the Arctic sky especially during warmer months. Arctic haze is primarily produced when an accumulation of unnatural particulate matter builds up in the atmosphere and obscures the clarity of the Arctic sky. Arctic haze is considered a form of environmental pollution, and it is caused primarily by industry related human activities and other activities related to modernization and the burning of fossil fuels (e.g., coal and petroleum). Natural sources of haze-producing particles are wildfires and volcanoes, but they are not major sources of Arctic haze. Observation of Arctic haze is known to be directly correlated with the industrial revolution and modernization and has impacted human health and the health of our planet.

The term "haze" was developed by the World Meteorological Organization as part of a classification system of horizontal sky obscuration categories that include phenomena such as fog, mist, and snow. Haze usually appears reddish-brown in color, but can appear bluish depending on the angle viewed relative to the sun. The particular shade of reddish-brown color of Arctic haze is related to the presence of various concentrations of gaseous nitrogen dioxide (NO_2) compounds trapped in the atmosphere. Haze particulates are produced in dry air, but liquid droplets (e.g., water, sulfuric acid or nitric acid) can form on haze particulates (e.g., silicon and lead) and produce mist droplets and a wet haze observed in the Arctic sky, which is the Arctic haze or poo-jok. Limited production of turbulent atmospheric activity (e.g., wind, rain, and snow) that could displace haze particles from polar air masses, especially in the spring and summer months, leads to the persistence of Arctic haze for extended periods of time. Conglomerates of Arctic haze and other haze can last longer than one month. Haze that has formed in different regions of the world can drift and join other haze conglomerates resulting in larger Arctic haze polar air masses.

At first, native persons and early explorers could not figure out where the reddish-brown poo-jok was coming from, but later its appearance seemed to directly coincide with the industrial revolution resulting from other human beings' influence on nature. Analysis of Arctic haze by scientific methods (i.e., wet chemistry and particle-induced X-ray emission studies) beginning in the 1970s revealed a variety of major ions and metals present in the haze (e.g., sodium, magnesium, silicon, sulfur, calcium, iron, zinc, and lead) and supported the hypothesis that Arctic winter aerosol is heavily influenced by well-aged continental aerosol originating from midlatitude regions where they were first produced.

Arctic haze aerosols arise from complex chemical reactions as sulfur dioxide (SO_2) gases emitted from the burning of fossil fuels are converted into sulfuric acid (H_2SO_4) especially in the presence of NO_2. Sulfuric acid and nitric acid are known to be the major contributors to acid rain and important contributors to the liquid droplets that form on dry particulate matter and form reddish-brown Arctic haze. Metallic particulate matter of haze has the ability to act as catalyst, speeding up the chemical reactions that produce acid rain contributing to Arctic haze production.

Mined coal and petroleum often contain sulfur compounds, unless the sulfur compounds are removed prior to burning them. SO_2 emissions are a precursor to haze particulate matter. Both of these scientific facts are cause for concern, especially when considering the environmental impacts. A number of amendments to the clean air act have been made to measure environmental impact, alter industrial processes, and fuel emissions in an attempt to slow down the production of Arctic haze particulates and acid rain as well as their precursors. The European Union seems to have had the greatest success in reducing the percentage of SO_2 emissions. Large areas of haze covering many thousands of kilometers are being produced each year, especially under warmer atmospheric conditions where Arctic haze is known to persist. Many people fear that as the threat of rising global temperature increases (i.e., global warming) so too will the production and amount of Arctic haze in the atmosphere. Arctic haze obscures the clarity and beauty of earth.

Karen Knaus

See also: Arctic Air Pollution; Climate Change and Invasive Species in the Arctic; Climate Change and Permafrost; Climate Change in the Arctic

Further Reading

Berresheim, H., P. Wine, and D. Davies. "Sulfur in the Atmosphere." In B. Singh, ed. *Composition, Chemistry and Climate of the Atmosphere.* New York: H. Van Nostrand Rheingold, 1995.

Garrett, T. *Pollutant Haze Is Heating Up the Arctic.* Greenbelt, MD: Earth Observatory of the EOS Project Science Office, NASA Goddard Space Flight Center, 2006.

Heintzenberg, J., H. -C. Hansson, and H. Lannefors. "The Chemical Composition of Arctic Haze at Ny-Ålesund, Spitsbergen." *Tellus* 33 (1981): 161–71, Munksgaard, Copenhagen.

Arctic Loon

The Arctic loon (*Gavia arctica*) also known as the black-throated diver (as a middle way, the neologism black-throated loon has been suggested by ornithologists) breeds in oligotrophic lakes in the northern temperate zone, in the tundra, and the taiga of Eurasia, from Scotland, Scandinavian Peninsula, Finland, the Baltic States, Belarus, Russia, and east toward Kazakhstan, northern Mongolia, Siberia, Kamchatka, and northern Sakhalin. It is also considered to be a rare breeder on the northwest coast of Alaska, from Cape Krusenstern south to Seward Peninsula.

The world population is estimated at 280,000 to 1.5 million individuals, although the overall population trend is decreasing. The population of Russia has been estimated at almost 10,000 breeding pairs and in Alaska 100 breeding pairs. Two subspecies are recognized by taxonomists. The nominal subspecies lives in western Eurasia east toward Lena River and winters off the coasts of Europe, North Africa, and Southwest Asia. East of Lena River (including Alaska), the subspecies *Gavia arctica viridigularis* is found. It winters in China, Japan, and Korea. A closely related and very similar taxon is the Pacific loon, *Gavia pacifica*, a breeding bird in Alaska, northern Canada, and adjacent areas of northeastern Asia, especially in Kamchatka, Chukotka, and the Kolyma Peninsula.

Arctic loons occupying southern regions begin their breeding season in April–May, or later in the north, depending on the onset of spring. Upon nest completion, the female will lay two eggs. Its diet consists predominantly of fish. The Arctic loon has longevity of about 28 years.

Folk Knowledge and Myths

While the common loon, *Gavia immer*, has played an important role in the folk ornithology and mythology among North American Indians, Inuit, Greenlanders, and West Nordic people of Iceland, the Faroes, and northern Norway, the Arctic loon replaces it in the traditional north Eurasian folk knowledge and was an important part of local lore and economy among various peoples in the north.

A well-known legend known from northern Scandinavia, Finland, the Baltic States, and Russia that God first created it without legs, but became sensible of the mistake and flung a pair of legs after it, hence the early English *arse foot* and Livonian *peržjālga* (arse foot) as folk names for it. Among the Siberian Kets and various Ugrian peoples, the Arctic loon acted as assistant sprits of shamans traveling to the lower world or was associated with evil power. It is a common view in Eurasia and North America that the call of loons can be interpreted as ominous. Also their flight can be read as a kind of weather forecast. This species makes a great noise against rain. Hence, Scandinavian peasants thought it was impious to kill it.

Its eggs have been gathered and used as food in northern Eurasia, and also the meat has sometimes been exploited as human food. The use of loon skin for making cloth, caps, bags, and other items are well known from the circumpolar area. The utilization of Arctic loon skin is mentioned from the Sámi area already by Olaus Magnus in 1555, and it has been used until today. Also the peasantry of northern Sweden and the indigenous peoples of northern Russia and Siberia have made use of Arctic loon skin.

Ingvar Svanberg

See also: Arctic Redpoll; Arctic Seabirds; Arctic Skua; Arctic Tern; Gyrfalcon; Lapland Longspur; Red-Throated Loon; Rock Ptarmigan; Snow Bunting; Snow Goose; Snowy Owl

Further Reading

Eriksson, M. "Loons/Divers: Names, Myths, Scandinavian Perspective." *Newsletter of the Diver/Loon Specialist Group of Wetland International* 3 (2000): 5.

Russell, R. "Arctic Loon *(Gavia arctica).*" In A. Poole and F. Gil, eds. *The Birds of North America.* Philadelphia: Cornell Lab or Ornithology, 2002, no. 657.

Sjölander, S. "Reproductive Behavior of the Black-Throated Diver *Gavia arctica.*" *Ornis Scandinavica* 9 (1978): 51–65.

Svanberg, I., and S. Ægisson. "Great Northern Diver (*Gavia immer*) in Circumpolar Folk Ornithology. Fróðskaparrit: Annales Societatis Scientiarum." *Færoensis* 53 (2006): 51–66.

Arctic National Wildlife Refuge (ANWR)

The Arctic National Wildlife Refuge (ANWR) is located on Alaska's North Slope, in the northeastern corner of the state. It is bounded on the north by the Beaufort Sea and on the east by Canada. At 30,135 square miles (78,051 sq. km), it is the largest national wildlife refuge in the United States.

ANWR is home to some of the most diverse wildlife in the Arctic. There are 42 fish species, 37 land mammals, 8 marine mammals, and more than 200 migratory and resident bird species. ANWR is home to black bear, grizzly bear, and polar bear, and has three resident caribou herds. It includes five distinct ecological

Arctic National Wildlife Refuge in Alaska. To compensate for a decline in domestic oil production since the late twentieth century, plans have been proposed to exploit the reserves within the United States, most notably in the ANWR. Such steps have proven controversial because of the potential for disturbing wildlife and marring an unspoiled part of the country. (U.S. Fish and Wildlife Service)

regions including the coastal marine areas; coastal plain tundra; alpine tundra of the Brooks Range; the forest–tundra transition south of the mountains; and tall spruce, birch, and aspen of the boreal forest.

The history of government protection of the land that would become ANWR began in 1960, one year after Alaska achieved statehood. U.S. secretary of the interior Frederick A. Seaton established the Arctic National Wildlife Range for the purposes of "preserving unique wildlife, wilderness and recreational values."

In December 1980, in one of his lasts official acts as president, Jimmy Carter signed the Alaska National Interest Lands Conservation Act (ANILCA), which renamed the area the Alaska National Wildlife Refuge and doubled its size to 19.3 million acres (7.8 million hectares). The new law also identified four new purposes of ANWR, which were to preserve wildlife including caribou, bears, migratory birds, and other species; to fulfill international fish and wildlife treaty obligations of the United States; to provide continuing opportunities for subsistence use by local residents; and to protect water supplies.

In addition to preserving wilderness and indigenous interests, Congress also recognized the economic value of ANWR. While ANILCA confirmed the wilderness designation of the original 8.9 million acres set aside in 1960, Section 1002 of ANILCA deferred decision on oil and gas exploration and development in 1.5 million acres of ANWR protected in 1980, along the coastal plain of Alaska. This area, referred to as the "1002 Area," has been a focus of intense debate since 1980, as preservationists have battled interests' intent of developing oil and gas production.

The U.S. Energy Information Administration has estimated that oil production resulting from the opening of ANWR could produce between 2 and 4 billion barrels of oil over a 12-year period, reducing the United States' dependency on foreign oil. On the other hand, the environmental value of ANWR, including the 1002 Area, is widely regarded as unparalleled. The U.S. Fish and Wildlife Service views ANWR as: "America's finest example of an intact, naturally functioning community of Arctic/subarctic ecosystems. Such a broad spectrum of diverse habitats occurring within a single protected unit is unparalleled in North America, and perhaps in the entire circumpolar north."

Owing to its remoteness, ANWR is one of the least visited destinations in the national wildlife refuge system, with only about 1,000 visitors per year. Most visitors enjoy ANWR for recreational purposes, although hunters also take advantage of its plentiful wildlife. While it is possible to reach ANWR overland via the Dalton Highway (the only road reaching the area), most visitors travel to ANWR by air.

Bruce Taterka

See also: Climate Change and Permafrost; Colville River; Continental Shelf Claims in the Arctic; Economic Growth in the Changing Arctic; Environmental Concerns, Arctic Mining Operations

Further Reading

Kaye, Roger. *The Last Great Wilderness: The Campaign to Establish the Arctic National Wildlife Refuge*. Fairbanks: University of Alaska Press, 2006.

U.S. Energy Information Administration. "Analysis of Crude Oil Production in the Arctic National Wildlife Refuge." May 2008. http://www.eia.gov/oiaf/servicerpt/anwr/. Accessed January 7, 2014.

U.S. Fish and Wildlife Service. *Arctic National Wildlife Refuge*. Public Use Summary, 2009. http://arctic.fws.gov/pdf/pureportap2010.pdf. Accessed January 7, 2014.

Arctic Observatories

The high latitudes offer ideal locations to observe space weather from the ground, without the use of expensive satellites. There are several large observatories in the

Arctic with instruments that are suitable for space weather observations. The most obvious instrument would be a camera to look at the aurora. More refined would be instruments that separate the colors of the auroral light, like spectrometers. One of the oldest methods of observing the processes in the near-Earth space is by recording changes in the magnetic field. Magnetometers are very sensitive instruments and can see the smallest variations. Some of these variations are due to electric currents that flow in and near the aurora. Radio waves are also a good method to learn about processes that take place in the upper atmosphere and space. Radio wave observations can be made with antennas that listen to naturally occurring radio emissions, or they can be made by sending a radio signal and then listening to the echo, as with radar.

All-sky cameras and magnetometers are relatively cheap instruments, and they can be distributed to hundreds of sites to paint a global picture. Spectrometers tend to be more difficult to operate and more expensive to build, and they are concentrated at a few sites throughout the Arctic and Antarctic. The large radars are few in number and require large observatories.

One type of radar uses high-frequency radio waves. Antennas for sending and receiving these radio waves are a series of short towers and are set up throughout the Arctic and Antarctic. This is the SuperDARN (Super Dual Auroral Radar Network). This radar looks obliquely into the upper atmosphere and gets return signals scattered off of meter-sized irregularities in the charged ionosphere. From the Doppler-shifted return signal, one can obtain the line-of-sight velocity of the irregularities. By setting up radar sites in pairs that look at the same volume from different angles, actual drift velocities can be obtained.

There is almost global coverage from this radar network to give global pictures of the plasma drift and electric field in the ionosphere. The large observatories are Poker Flat Research Range (PFRR) in Alaska near Fairbanks, the European Incoherent Scatter Radar facility (EISCAT) in Norway and Svalbard, the Polar Cap Observatory (PCO) in Resolute Bay in Canada, and the Sondrestrøm Radar in Greenland. There are similar radars outside of Arctic latitudes, at Millstone Hill in Massachusetts and Arecibo on Puerto Rico. All these house incoherent scatter radars, which require either very large dish antennas (EISCAT and Sondrestrøm) or large arrays of antennas (PFRR, PCO). The large observatories also have many additional instruments. Typically, these are spectrometers, interferometers, and various cameras. Spectrometers separate the colors of aurora or airglow, which gives some information on chemical processes that go on at high altitude. Interferometers usually look at only one emission feature in extremely high resolution. It is possible to measure the velocity of the emitting atoms and molecules from the Doppler shift of the emission and thus obtain wind measurements at high altitude. Imaging cameras can be used to image the entire sky (all-sky camera) or with the use of a telescope look at the details in auroral curtains.

INCOHERENT SCATTER RADAR

Radar works by sending out a radio signal and then listening for the echo. The radio wave in an airport radar is reflected by the metal skin of airplanes. Weather radar makes use of the reflection of radio waves from raindrops. There are no objects like that in the upper atmosphere, aurora, or ionosphere. The radar used for these purposes is called incoherent scatter radar (ISR). The radio waves are tuned to be reflected off of individual electrons. The scattered signal is extremely weak and detectable only because there are so many electrons in the ionosphere and because the radars use very large antennas and strong radio signals. The antennas used for this are either large dishes or phased arrays. The dish antennas are parabolic dishes with 32–40 m (100–120 ft.) of diameter. The largest and first ISR was built with a dish lying flat in an extinct volcano in Puerto Rico. That dish is 305 m (1,000 ft.) in diameter. The newest ISRs employ phased array antennas. These are football-sized arrays of dipole antennas. While the dishes need to be physically moved and pointed to scan over different areas of the sky, a phased array can point its sensitivity in any direction by manipulating the timing of the receiver for each dipole antenna. This is done in software and makes the pointing of these antennas very agile. Much information can be extracted from the scattered signal from an ISR. The total return power gives the density of the plasma at a given altitude, but the shape, shifts in frequency, and other parameters of the scattered signal also contain information. Thus, one can deduce plasma drift, electric fields, temperature, and, with a few assumptions, even the composition of the plasma.

Dirk Lummerzheim

Cameras often have filters to concentrate on a single emission feature. It is often useful to combine observations from many different instruments and instruments in many different locations to obtain a better understanding of phenomena. The multitude of observatories and additional smaller observation sites makes this difficult. Every site will have data in different formats or different time or spatial resolution. To make it easier to combine data from many different sites and instruments, virtual observatories have been set up. These are, as the name implies, not physically located anywhere, but live in cyberspace. An example of a virtual observatory was developed mainly at the University of Calgary and is hosted on computers in Canada, United Kingdom, Scandinavia, and China: Global Auroral Imaging Access, GAIA.

Dirk Lummerzheim

See also: Arctic Haze; Aurora Australis; Aurora Borealis; Auroral Substorm; Geospace; Ionosphere, Polar; Rocket Ranges in the Arctic; Space Weather

Further Reading

European Incoherent Scatter Scientific Association (EISCAT). http://www.eiscat.com/. Accessed January 7, 2014.

Geophysical Institute Poker Flat Research Range. http://www.pfrr.alaska.edu/. Accessed January 7, 2014.

Global Auroral Imaging Access (GAIA). http://gaia-vxo.org/. Accessed January 7, 2014.

The Resolute Bay Observatory, SRI International. http://isr.sri.com/iono/epco/epco.html. Accessed January 7, 2014.

Sondrestrøm Research Facility, SRI International and the National Science Foundation. http://isr.sri.com/. Accessed January 7, 2014.

Arctic Ocean

The Arctic Ocean is the world's smallest ocean. It is the predominant feature of the Arctic region covering an area of 5.4 million square miles (14.06 million sq. km). Baffin and Hudson Bay are major features of the Arctic Ocean. The deepest point of the Arctic Ocean is around 17,850 ft. (5,440 m) with an average depth of around 12,000 ft. (3,658 m). During the winter, the Arctic Ocean is covered by an ice pack of 5–10 ft. deep, while in the summer, the outside edges are ice free. Over the past 50 years, scientists have noted a persistent loss in Arctic Sea ice.

The Arctic Ocean is bordered by Russia, Alaska, Canada, Greenland, and Norway, and is ringed by various seas, such as the East Siberian, Laptev, and Kara Seas of Russia; the Chukchi Sea located between Alaska and Russia; Beaufort Sea, which has a shared coastline by Alaska and Canada; and the Barents Sea that borders both Russia and Norway. The two international outlets are located between Greenland and the Spitsbergen Islands of Norway (called the "Fram Strait") and between Alaska and Russia (called the "Bering Strait"). The Fram and Bering Straits are used for shipping lanes and are also the main routes for surface water exchange. Another significant strait is Hudson Strait, which is located between the northern coast of Quebec and Baffin Island. Navigating the Arctic Ocean is precarious due to frequent encounters with icebergs and ice islands.

The Arctic Ocean supports a small but complex web of life, which flourish with the change of seasons. On top of the ice, the seasonal melting ice creates pools of water that enable the development of various biological communities. Brine channels (tunnels in the sea ice) become home to various bacteria and algae, which are a food source for flatworms and other tunnel-type creatures. During the melting of ice, these organisms and nutrients are released into the water, which promotes the growth of algae under the ice. Zooplankton feed on the algae, and the zooplanktons are a food source for aquatic and marine mammals such as fish, squid, sea lions, walruses, seals, and whales. Beneath the ice, various creatures live, reproduce, and die. These creatures' bodies drop to the ocean floor, where they become food (nutrients) for various benthic animals, such as sponges, crustaceans, mollusks, and other ocean floor–dwelling creatures. This food sources help the ocean floor creatures to thrive, and in turn, they become food for larger creatures such as fish, squid, sea lions, walruses, seals, and whales. These aquatic and marine mammals are preyed upon by larger mammals that live on the ice, such as polar bears.

Most major rivers flowing into the Arctic Ocean are found in Russia, with the exceptions being the Mackenzie River in Canada and the Colville River in Alaska. The major Russian rivers flowing into the Arctic adjacent seas and into the Arctic Ocean from Russia are Khatanga and Lena Rivers flowing into the Laptev Sea; the

ILULISSAT DECLARATION (2008)

The Ilulissat Declaration was announced on May 28, 2008, at the Arctic Ocean Conference. The Arctic Ocean Conference was held from May 27 to 29, 2008, in Ilulissat, Greenland. The five Arctic coastal countries of Canada, Denmark (Greenland), Norway, the Russian Federation, and the United States (Alaska) were participants in the conference. The three other Arctic Nations of Finland, Iceland, and Sweden were not asked to participate because they are not a coastal country of the Arctic Ocean. The Arctic Council, Barents Euro-Arctic Council, and the Arctic indigenous peoples were also not participants in the discussions.

Foreign ministers from each of the five coastal countries formally meet to discuss Arctic sovereignty (border disputes, demarcation issues, continental shelf limits, etc.), sovereign right, and jurisdiction authority over their sovereign areas. The declaration also focused on climate change effect on the livelihood of Arctic indigenous people, the Arctic ecosystems, and environmental protection for flora, fauna, and ice-covered areas. A major issue discussed was the opening of the Northwest Passage with regard to international shipping routes and emergency response capabilities.

The Arctic Ocean Conference was hosted by the foreign minister of Denmark, Per Stig Moller, and the prime minister of Greenland, Hans Enoksen. The invited ministerial-level participants were Gary Lunn (minister for Natural Resources of Canada), Sergey Lavrov (minister for Foreign Affairs of the Russian Federation), Jonas Gahr Støre (minister for Foreign Affairs of Norway), and John Negroponte (deputy secretary of State of the United States of America). The Ilulissat Declaration was a formal acknowledgment of the immediate and long-term priorities of the Arctic coastal countries for the sustainability of the Arctic Ocean region.

Andrew J. Hund

Indigirka and Kolyma rivers flowing into the East Siberian Sea; and the Pechora, Ob, and Yenisey Rivers flowing into the Kara Sea.

Over the years, the rivers and seas flowing into the Arctic Ocean have been polluted to various degrees. For example, the discharge of liquid waste (effluents) from the Mayak and Tomsk nuclear fuel reprocessing plants are released into the Ob River, and those from Krasnoyarsk nuclear fuel reprocessing plant flow into the Yenisey River. The various areas of the Pechora River are severely polluted. From 1960 to 1991, low-level radioactive waste was dumped in the Barents Sea and Kara Sea by the Soviet military. High-level radioactive waste was also dumped into the shallow fjords of the Kara Sea near the Novaya Zemlya Archipelago. Nuclear waste was also dumped in the Novaya Zemlya Trough that has depths up to 1,250 ft. (380 m). The Soviet military also dumped radioactive waste in the east coast of Kamchatka and in the Sea of Japan.

The introduction of pollution to the ecosystem can have significant and lasting effects on the already stressed ecosystem. Arctic ecosystems are highly sensitive to environmental degradation due to the persistent low temperatures, short growing season, and significant changes to sea ice and permafrost. The food chain of the Arctic Ocean is based on a few species, and as a result, slight man-made or natural changes can have significant effects on the fragile ecosystem. The Arctic waters and sea ice are sinks for pollutants.

There are a number of ports in the Arctic. Some Canadian ports are Inuvik (68° 21′N 133° 43′W) and Tuktoyaktuk (69° 26′N 133° 1′W) in the Northwest Territories and Nanisivik (73° 2′N 84° 32′W) in Nunavut. Arctic ports for the United States include Barrow (71° 17′N 156° 45′W) and Prudhoe (70° 19′N 148° 42′W) in Alaska. Norway ports include Kirkenes (69° 43′N 30° 3′E) and Vardø (70° 22′N 31° 6′E). The island of Svalbard has a port at Longyearbyen (78° 13′N 15° 39′E). Russian port in the Barents Sea is Murmansk (68° 58′N 33° 5′E), Arkhangelsk (64° 32′N 40° 32′E) is a port of the White Sea, Tiksi (71° 38′N 128° 52′E) is the port of the Laptev Sea, and Pevek (69° 42′N 170° 17′E) is the port of the East Siberian Sea. Ports of the Kara Sea include Dikson (73° 30′N 80° 31′E), Dudinka (69° 24′N 86° 11′E), Igarka (67° 28′N 86° 35′E), Labytnangi (66° 39′N 66° 25′E), and Salekhard (66° 32′N 66° 36′E).

Andrew J. Hund

See also: Arctic Basin; Arctic Shipping; Barents Sea; Beaufort Sea; Beaufort Sea Dispute; Chukchi Sea; Coastal Erosion; Continental Shelf Claims in the Arctic; Drifting Research Stations in the Arctic Ocean; East Siberian Sea; Greenland Sea; Kara Sea; Laptev Sea; Northeast Passage; Northwest Passage; Northwest Passage Claims and Disputes

Further Reading

Berkman, P., A. Vylegzhanin, eds. *Environmental Security in the Arctic Ocean.* NATO Science for Peace and Security Series C: Environmental Security, 2013.

Arctic Redpoll

The Arctic redpoll (*Carduelis hornemanni*) is a member of the finch family. It is sometimes called the "hoary redpoll." There are two subspecies: the Coues's Arctic redpoll or the Scandinavian Arctic redpoll (*Carduelis hornemanni exilipes*) and the Hornemann's Arctic redpoll or Greenland Arctic redpoll (*Carduelis hornemanni hornemanni*). The Coues's Arctic redpoll is found in Scandinavian countries and Canada, and breeds in Alaska, Canada, and Eurasia. It is slightly darker and leaner than the Greenland Arctic redpoll. The Greenland Arctic redpoll is found mostly in Greenland and breeds in Greenland and Canada on Ellesmere and Baffin Islands. It differs significantly from the Coues's Arctic redpoll and is more pale and has a white rump.

Arctic redpolls are very social and lively birds that travel in flocks. In the winter, they will travel in mixed flocks with other finches. They forge and glean feed on bushes and trees, and scratch the ground eating mostly seeds and insects. Redpolls frequently hang upside down while feeding in bushes and trees and use their feet to grasp food items.

Redpolls' weight ranges between 0.4 and 0.7 ounces (11–20 g). The length of adult redpoll ranges between 4.5 and 5.5 in. (11–14 cm), with a wingspan of about 9 in. (23 cm). A main characteristic of the redpoll is the red crown on its head. There are slight color and marking differences between males and females. Females lack the pink on the breast and have more streaks in the belly area.

The preferred habitat of redpolls is open tundra and woodland areas. In the winter, redpolls live in open woodland spaces in urban and suburban locales. They nest and breed in open subarctic coniferous forest, scattered brushy scrub, and near sheltered water banks. Some redpolls live year-round across the Arctic, from Alaska to Russia. Other redpolls will migrate between further north in the summer and winter in the Taiga latitudes in Canada, Alaska, and northern Europe. If there is a significant increase in the population, the range can extend further south into the middle part of the United States and Europe.

Redpoll pairs bond and are monogamous couples. Typically, with their social nature, they nest in colonies. The female uses various grass and twigs to fashion a cup-shaped nest near the ground surrounded by rocks or bushes. The female lays one to six eggs and can have up to two broods a year. The female sits on the eggs between 9 and 12 days. The chicks are born featherless, requiring warmth and care for an additional 9–15 days, after which the young are able to leave the nest and forage with the flock.

Andrew J. Hund

See also: Gyrfalcon; Lapland Longspur; Rock Ptarmigan; Snow Bunting; Snow Goose; Snowy Owl

Further Reading

Cramp, S., and C. Perrins. *Handbook of the Birds of Europe, the Middle East and Africa. The Birds of the Western Palearctic.* Oxford: Oxford University Press, 1977–1994.

Knox, A., and P. Lowther. "Hoary Redpoll (*Carduelis hornemanni*)." In A. Poole and F. Gill, eds. *The Birds of North America*. No. 544. Philadelphia: The Birds of North America, Inc., 2000.

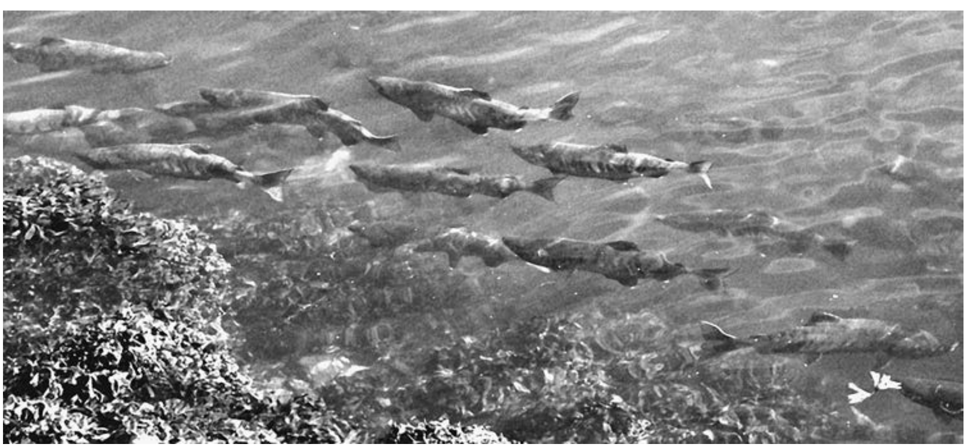
Arctic Salmon

Salmon and trout are the name given to a number of fish in the Salmonidae family. The basic distinction between trout and salmon is that salmon are anadromous (born in freshwater, travel to the ocean for several years, then return to their freshwater birthplace to spawn) and spawn once, while trout are residents and spawn several times. There are also landlocked salmon, which are similar to trout. There are eight Arctic salmon, which belong to two groups. The two groups are the Pacific and the Atlantic.

The one member of the Atlantic group is the Atlantic salmon, while there are seven species in the Pacific salmon group (chinook, chum, coho, masu, pink, steelhead, and sockeye). A key difference between the Pacific and the Atlantic salmon is the oceans where they live. Another difference is that Pacific Salmon are semelparous (spawn only once), while some Atlantics are iteroparous, meaning they can migrate up a river and spawn and then can return to the ocean and spawn again.

Atlantic

Natural stocks of Atlantic salmon (*Salmo salar*) inhabit the Atlantic Ocean and spawn in the northern rivers of Greenland, Iceland, and Norway as far south as



Chum (or dog) salmon. (Andrew J. Hund)

Portugal on the European side of the Atlantic. On the North American side of the Atlantic, these salmon inhabit the East Coast Rivers of New England northward to the Canada Arctic region. They have also been found in Alaska and British Columbia Rivers as an invasive species. These salmon have escaped British Columbia aquaculture farms. They are also farmed in many other countries, such as Norway and Chile.

Atlantic salmon that are landlocked are not a different species but have evolved into a nonmigratory species. Landlocked Atlantic salmon (*Salmo salar m. sebago*) inhabit numerous lakes in eastern parts of North America and northern Europe. The maximum length of an Atlantic salmon is around 59 in. (150 cm) with the average length being between 28 and 30 in. (71–76 cm). A typical adult Atlantic salmon weighs between 8 and 12 pounds (3.6–5.4 kg), with some nearing 30 pounds (13.6 kg). The life span is estimated to be up to 13 years.

Pacific

The chinook salmon (*Oncorhynchus tshawytscha*) is the largest of the Pacific salmon species. They are a powerful salmon that is capable of traveling more than 1,200 miles (2,000 km) up the Yukon River to spawn. Chinook salmon are also called "king salmon" in the United States and "spring salmon" in British Columbia. Chinook salmon originate both in Asia and in North America, and their range is from mid-California to the Mackenzie River and Kugluktuk of Canada.

The maximum length of a chinook salmon is around 59 in. (150 cm) with the average length being about 28 in. (70 cm). A typical adult chinook salmon weighs between 10 and 50 pounds (4.5–23 kg). The maximum weight of chinook is estimated at 135 pounds (62 kg). The largest sport king salmon ever caught was more than 5 ft. in length weighing 97 pounds and was caught by Les Anderson in 1985 on the Kenai River. Bigger king salmon have been caught in fish weirs and on commercial fishing vessels. All chinook salmon are semelparous (die after spawning). The life span is estimated to be up to nine years.

The chum salmon (*Oncorhynchus keta*) is the second most abundant salmon species and has the largest natural range of all Pacific salmon species. Like the king salmon, they are capable of traveling more than 1,200 miles (2,000 km) up the Yukon River to spawn. Chum salmon are also called "calico," "dog," or "keta salmon." Their range is from mid-California to the southernmost island of Kyushu, Japan, north to the Lena River of Russia and east to the Mackenzie River of Canada. Chum salmon are found across the Pacific Ocean and in the waters of the Bering, Laptev, and Beaufort Seas as well as the Sea of Japan and Sea of Okhotsk.

The maximum length of a chum salmon is around 45 in. (115 cm) with the average length being about 24 in. (60 cm). A typical adult chum salmon weighs between 10 and 22 pounds (4.5–10 kg). The maximum weight of chum is estimated at 45 pounds (20 kg). The largest sport chum salmon ever caught was 44 in. (112 cm)

Editor Andrew J. Hund with a king salmon. (Andrew J. Hund)

in length weighing 42 pounds and was caught in British Columbia. Chum salmon spawn in rivers and streams, and their offspring (fry) make the journey to the ocean soon after birth. They return to their natal river or streams after three to six years in the ocean. The estimated life span of the chum salmon is up to seven years.

The coho salmon (*Oncorhynchus kisutch*) natural stocks are found in Asia and North America from mid-California to the coastal waters near Point Hope, Alaska, west to the Anadyr River in Russia, and south to Hokkaido, Japan. Coho salmon are also called "silver salmon" or just silvers. The maximum length of a coho salmon is around 43 in. (108 cm) with the average length being about 28 in. (71 cm). An average coho salmon adult weighs about eight pounds (3.6 kg), with the maximum weight being estimated up to 35 pounds (16 kg). The coho fry remain their natal river for one to two years, migrate to the ocean for around 18 months, and then return to the natal river or stream to spawn and die (semelparous). The estimated life span of the coho is up to five years.

The Masu salmon (*Oncorhynchus masou*) is a small salmon that spawns in rivers of Western Kamchatka and lives in the Western Pacific waters of Japan, Korea, and Russia. Masu salmon are also called "cherry salmon." There are a couple of subspecies, such as the Biwa trout (*Oncorhynchus masou rhodurus*), the red-spotted masu (*Oncorhynchus masou macrostomus*), and the landlocked Taiwanese masu (*Oncorhynchus masou formosanus*). The maximum length of a Masu salmon is around 27 in. (70 cm), with the average Masu being around 20 in. (50 cm). A typical adult Masu salmon weighs between 4.5 and 5.5 pounds (2–2.5 kg). The maximum weight of Masu is estimated at 19 pounds (9 kg). Cherry salmon resemble coho salmon. Masu spend at least one year in the ocean, reach maturity around three to four years of age, and die after spawning (semelparous). From March to May, Masu return to natal rivers, where they spend the summer, then spawn in the fall. The estimated life span of the Masu salmon is up to four years of age.

The pink salmon (*Oncorhynchus gorbuscha*) are the most abundant of the salmon species. They originate in both Asia and North America and are found from northern California to Korea and north from the Mackenzie River to the Lena River in Russia. Pink salmon are also called "humpies." They are the smallest of the salmon species, with adults weighing between 2 and 5.5 pounds (1–2.5 kg). The maximum length of a pink salmon is around 30 in. (76 cm), with the average pink being around 20 in. (50 cm). The estimated maximum weight of pink salmon is about 15 pounds (6.8 kg). Humpies spawn in rivers and streams, and their offspring (fry) make the journey to the ocean soon after birth. The majority of pink salmon spend 18 months in the ocean, return to their natal rivers and streams after two years, and die after spawning (semelparous). The estimated life span of the pink salmon is up to three years.

The steelhead trout (*Oncorhynchus mykiss*) is the anadromous variety of the rainbow trout. The length of an adult steelhead typically ranges between 19 and 23 in. (50–58 cm). Steelhead weigh between 3 and 15 pounds (1.4–6.8 kg). Like the other salmon species, the steelhead makes the ocean journey and returns to its natal river or stream. Typically, steelhead stay in freshwater for two to three years and then spend another two to three years in the ocean, before returning to the natal river to spawn. Some steelhead die after spawning (semelparous), while others spawn more than once (iteroparous). The estimated life span of the steelhead is up to 11 years.

The sockeye salmon (*Oncorhynchus nerka*) is the third most plentiful salmon of the Pacific salmon species. Unlike other salmon species, the sockeye salmon does not spawn in rivers or streams. Instead, they spawn in lakes generally at the end of stream or river. Sockeye salmon range is from the Klamath River in California west across the Pacific Ocean to Hokkaidō, Japan, north to the Anadyr River in Russia, and east to Bathurst Inlet in Canada. The landlocked sockeye salmon is called "Kokanee salmon."

The maximum length of a sockeye salmon is around 33 in. (84 cm), with an average range being from 17 to 20 in. (45–60 cm). Sockeye weight ranges from

3.5 to 7 pounds (1.6–3.2 kg). Red salmon spawn primarily in lakes (some use rivers and streams, although rare), and their offspring (fry) can grow in the lake for one to three years before make their journey to the ocean. Sockeye remain in the ocean for one to four years before returning to the natal lakes and die after spawning (semelparous). The estimated life span of the sockeye salmon is up to eight years.

Andrew J. Hund

See also: Beluga Whale; Orca; Pacific Sleeper Shark; Salmon Shark; Walrus

Further Reading

Krkošek, M., et al. Report: "Declining Wild Salmon Populations in Relation to Parasites from Farm Salmon." *Science* 318, no. 5857 (December 14, 2007): 1772–75.

Montgomery, David. *King of Fish: The Thousand-Year Run of Salmon.* Boulder, CO: Westview Press, 2003.

Arctic Seabirds

Seabirds are birds that derive their primary source of energy from oceans. Some seabirds are a rather ancient species group, and they exist in every ocean in the world; it includes four orders, 15 families, and 298 species from the Class Aves. The latitudinal Arctic (66° 33′N and higher) provides breeding grounds for 44 of these species (approximately 15% of all seabird species). These include birds from the loons (Gaviidae), petrels (Procellariidae), cormorants (Phalacrocoracidae), gannets (Sulidae), skuas (Stercorariidae), gulls (Laridae), and auks (Alcidae). Of these families, the one petrel (Northern Fulmar, *Fulmarus glacialis*), the terns, five species of gulls, the auks, loons, and the four skuas are endemic to the Arctic and subarctic. The highest species diversity is found in the Chukchi Sea (28 species), followed by the Davis Strait/Baffin Bay, Greenland, Norwegian, and Barents Seas (22–26 species). Modeled species distributions show that these areas of high species diversity also coincide with areas of high densities of seabirds (i.e., high likelihood of finding a seabird within a certain area). These areas have high numbers of seabirds because these are also the areas where most colonies are found. Over the last thousand years, humans have often settled near such colonies for collecting food, because such areas can be very productive for fish, marine mammals, and other resources, too.

Many Arctic seabird species are colonial (i.e., most auks, gannets, cormorants, the Northern Fulmar, terns, and some gulls). Arctic seabird colonies are often located on islands around the Arctic, as well as on the mainland of Greenland, and Iceland. The majority of the colonies are concentrated on the larger islands (e.g., Novaya Zemlya, Baffin Island, and Svalbard), but some species will nest on small offshore rocks as well (e.g., common murre; *Uria aalge*; thick-billed murre, *U. lomvia*; and Northern

Gannets, *Morus bassanus*). The colonial species usually nest along the shoreline, while the noncolonial species (i.e., loons, skuas, and some gulls) tend to nest on the open tundra (loons nest on lakes and ponds, skuas nest in grasses, while gulls nest in a variety of places from the coastline to open grassy areas).

With the exception of residential pigeon guillemot (*Cepphus columba*), virtually all of the mentioned families migrate to the Arctic for the breeding season primarily because of the highly productive waters that are opened up as sea-ice melts (e.g., the Arctic tern; *Sterna paradisaea* will do a global migration of 80,000 km to return to the Arctic to breed). The cold Arctic waters, mixing with warmer waters (e.g., from the Gulf Stream), create a productive environment for seabirds to raise their chicks. The breeding season extends from June to late September in the Arctic, but breeding strategies can differ greatly between species. Common murre and thick-billed murre, cormorants, Northern Gannets, and the Northern Fulmar nest along the coastline, usually on cliffs. They raise one to two chicks in the nest until fledging when the young are led to sea by the adults. Small alcids like crested and least auklet nest in crevices in rock taluses, raising one chick per year. Skuas and most gulls nest in open tundra and raise one to three chicks per year, feeding the chicks in the vicinity of the nest. Loons nest on open tundra lakes, but can raise two to three precocial chicks per year that spend the first two weeks of their lives on the backs of the adults to conserve heat and avoid predators.

Seabirds of the Arctic forage on a variety of food sources, but most are primarily piscivorous (fish feeders). Piscivorous seabirds include the larger auks (murres and guillemots), dovekie, gannets, terns, cormorants, and loons. These birds feed on a variety of small fish including capelin (*Mallotus villosus*) and sand lance (*Ammodytes* spp.). The small alcids are primarily planktivorous feeders, eating large copepods, amphipods, and other large zooplankton. Most of the gulls and the Northern Fulmar are opportunistic feeders and will feed on carrion, fish, squid, and waste products. Some species of gulls (e.g., glaucous, herring, and great black-backed) will take advantage of garbage dumps or human scraps in towns or cities. Many of the larger gulls show individual culture and will engage in predatory behavior, killing chicks or adults, and stealing eggs from nests, which has implications in species management and population trends and when endangered species, for instance, get preyed upon.

Due to the difficulty and expense of performing a census in the Arctic, the exact number of individual seabirds that breed is unknown; however, it is generally estimated that all but two species of seabirds (ivory gull and Thayer's gull) have populations greater than 100,000 individuals. It is also difficult to estimate population trends in most Arctic species, and sometimes the widely dispersed nonbreeders can make up of more than 40 percent of the species overall. But studies on common and thick-billed murres have shown substantial population decreases in some colonies, for example, in eastern Canada. Despite having estimated population sizes of 10 million birds, numbers of both species around West and East Greenland have diminished due to drowning in gill nets (most recently), harvesting by humans (historically and ongoing) or other reasons (chronic oil spills, climate change). Northern Fulmar and black-legged kittiwake (*Rissa tridactyla*) have also recently shown decreases in population size. The most dramatic losses to seabirds have been seen in the ivory and Thayer's gulls, which are now listed on the IUCN red list as near threatened. The Kittlitz's murrelet is also discussed as a species for the U.S. Endangered Species Act. It is unlikely that these losses are due to a single cause as it is clear that there are multiple stressors on seabirds in the Arctic ecosystem overall. For example, declines in ivory gull populations could be due to hunting in Greenland, high levels of mercury in eggs, loss of sea ice, or a combination of these three or more factors. Other additional threats to seabirds in the Arctic include climate change, pollution, and oil/gas exploration, planned drilling, and shipping routes.

Arctic seabirds have evolved in the presence of seasonal sea ice, which controls the balance of the ecosystem, and the world climate even. The inevitable loss of the summer sea ice will invariably affect the ecosystem, seabirds, and the world. Dovekies have been speculated to buffer some of the effects of sea-ice loss by adapting foraging strategies within their ecological niche. However, further degradation of their foraging areas (decreased productivity, overfishing, or increased sea-surface temperature) will certainly cause declines in their population, metapopulations, and subsequent genetic makeup. It is unknown how other species will react to climate change; however, current data suggest negative consequences for all Arctic seabirds. Other negative consequences also occur when seabirds are subjected to pollution such as plastic, which have been recently found to be increasing in concentration in the Arctic basin, as worldwide. Seabirds will swallow plastics or feed them to their chicks causing death. Deaths also occur after a bird has been oiled, which comes from spills caused by drilling or spills from ships. Increases in drilling or oil/gas exploration as well as increased shipping will likely lead to spilled oil in the Arctic, which will invariably kill seabirds. This is primarily due to the fact that the oil and gas exploration sites occur in seas and shelf areas where high numbers of seabirds are found (i.e., the Norwegian Sea, Barents Sea, Beaufort Sea, and Chukchi Sea).

Many Arctic seabirds have already disappeared in their southern ranges, for example, Dovekies in Iceland, tufted puffins in Japan and California. Subtropical birds like gannets are now found nesting in Arctic regions, for example, White Sea. The future of seabirds in the Arctic is uncertain as one school of thought is that as summer sea ice retreats, seabirds will be able to adapt and change foraging strategies. The other more widely accepted school of thought is that the Arctic ecosystem will change so drastically that all seabirds will suffer and cannot withstand prey loss and stress brought by invasive species. It is clear that much more research is required to conserve all Arctic seabird species and that an efficient management model is to be found still to achieve.

Grant Humphries and Falk Huettmann

See also: Agreement on the Conservation of Albatrosses and Petrels (ACAP); Arctic Botany; Arctic Loon; Arctic Redpoll; Arctic Skua; Arctic Tern; Common Raven; Great Auk; Gyrfalcon; Lapland Longspur; Little Auk; Red-Throated Loon; Rock Ptarmigan; Snow Bunting; Snow Goose; Snowy Owl; Sooty Albatross; Wandering Albatross

Further Reading

Gaston, T. "Arctic Seabirds: Diversity, Populations, Trends and Causes." In Rick Watson, et al., eds. *Gyrfalcons and Ptarmigan in a Changing World.* Vol. 1. Boise, ID: The Peregrine Fund, 2011.

Humphries, G., and F. Huettmann. "Predictions of 27 Arctic Pelagic Seabird Distributions Using Public Environmental Variables, Assessed with Colony Data: A First Digital IPY and GBIF Open Access Synthesis Platform." *Marine Biodiversity* 41 (2011): 141–79.

Zoeckler, C. "Status, Threat and Protection of Arctic Waterbirds." In Falk Huettmann, ed. *Protection of the Three Poles.* Tokyo: Springer, 2012, pp. 203–216.

Arctic Shipping

Arctic shipping significantly changes how business is done, worldwide. The impacts cover the many aspects of globalization. As a matter of fact, Arctic shipping routes have already been prepared and explored for many years, even dating as far back the fifteenth century. The tragic Franklin Expedition (search for Northwest Passage) became infamous, but numerous other explorations were done too, for example, along the Russian coast and carried out by many nations.

Arctic shipping lanes are assumed to be equal in impact to the Panama Canal. At minimum, they connect the major Atlantic ports and markets with the Asian markets and with the Pacific Rim (this includes global cargo hot spots such as Singapore, Shanghai, Taiwan, Tokyo, and even Australia, Indonesia, Malaysia, and India). The geopolitical relevance of the Arctic shipping lanes is appreciated when knowing the large historical efforts that were undertaken to establish global shipping routes in the first place, such as with the Suez Canal, and alternative routes to the Panama Canal through the San Juan River and Nicaragua, or that Taiwan and the United States are so heavily invested with the current Atlantic–Pacific connection: the Panama Canal.

While Canada was not especially an international leader in Arctic marine or in any shipping issues so far, the upcoming Arctic shipping lanes have put a new emphasis on this part of the world. Presently, Russia is vying to be a global leader for Arctic shipping. The recent Russian claim of the North Pole signals such a role. Consequently, the impacts on small nations like Norway or Iceland will also be dramatic with the rise of Arctic shipping. That is because many hubs (e.g., airports, administration) and deep harbors are required to cater all the traffic, for maintenance, and spill preparedness (many types of spills can be expected, e.g., oil spills, broken ships, so-called rat-spills, and ballast water and chronic oil pollution). Arctic shipping will become a major conduit for introducing invasive species. But also impacts on land will occur via infrastructure, such as support lines for ports, the construction of hubs, and roads that connect the worldwide supply arteries. Arguably, Arctic shipping will indeed create its own air traffic and shipping (e.g., increased coast guard efforts). However, a coherent network of protected areas on land and at sea hardly exists nor are they being addressed.

All of this is directly linked with the human population growth, as well as with peak oil, species well-being, the consumption of goods, and, first and foremost, with climate change. There is hardly a better confirmation that climate change is for real than the topic of Arctic shipping in itself: while many climate facts were denied for years by political administrations such as with President George W. Bush, many of those governments then happily signed on to support the preparation and planning of Arctic shipping routes due to the retreating sea ice in a warming atmosphere.

Opening the Arctic, such as through shipping and resource extraction, will have to fit one way or another into such a new world that it creates and contributes to. From the track record, it is easy to comprehend that population centers, industrial production facilities, and farming (food production) will adjust to Arctic shipping (e.g., by moving as close to the market arteries as possible and getting connected).

Arguably, the geopolitical aspect of Arctic shipping is hardly touched upon yet, nor are most people aware. The present revival of Arctic shipping is also linked with the fall of the iron curtain, and many new powers and nontraditional Arctic nations want to be involved, such as South Korea, China, India, and the Mediterranean nations (e.g., Malta and Greece as major stakeholders in world shipping). Arctic shipping will require a world police to watch and regulate this development and such shipping routes. The situation in Somalia with pirates on the rise makes that clearer than ever. There are voices that state that the cold war will start all over again centered on the question of who dominates Arctic shipping.

Presently, the international seas are still free and belong to the global public. However, the Arctic shipping lanes mostly cross national waters and Exclusive Economic Zones, such as Canada, United States, Norway, Iceland, and Russia. The United Nations Convention of the Laws of the Sea (UNCLOS) was supposed to deal with this situation in a progressive fashion. But it is already delayed for more than 20 years and is still not signed by the United States and other nations. While UNCLOS keeps delaying further, it becomes clear that the open and international seas like the Arctic Ocean are already heavily overcommitted. These regions are neither free, nor really available to all citizens (think of the property structure in Arctic fisheries, seafloor mining, and offshore oil and gas development). Some of these are among the remotest operating industries to date as well. It is unlikely that Arctic shipping plans will end any time soon. While complexities are rising dramatically in most dimensions, even the most basic issues like oil spill avoidance and impacts on biodiversity remain not assessed sufficiently, and there is no sign that this failure will be resolved any time soon and in relevant means.

Falk Huettmann

See also: Arctic Territorial Claims and Disputes; Continental Shelf Claims in the Arctic; Sector Principle in the Arctic; United Nations Convention on the Law of the Sea (UNCLOS)

Further Reading

Kaluza, P., A. Koelsch, T. Gastnerm, and B. Blasius. "The Complex Network of Global Ship Movements." *Journal of the Royal Society Interface* 7 (2010): 1093–1103.

Krupnik, I., and D. Jolly, eds. *The Earth Is Faster Now: Indigenous Observations of Arctic Environmental Change.* Fairbanks, AK: The Arctic Research Consortium of the United States (ARCUS), 2002.

Spiridonov, V., M. Gavrilo, Y. Krasnov, A. Mararov, N. Nikolaeva, L. Sergienko, A. Popov, and E. Krasnova. "Toward the New Role of Marine and Coastal Protected Areas in the Arctic: The Russian Case." In F. Huettmann, ed. *Protection of the Three Poles.* Tokyo: Springer, 2012, pp. 171–202.

Arctic Shrub Range Expansion

Climate warming is contributing to large-scale productivity and vegetation changes in the Arctic. One expected response to climate change is an increase in shrubs in tundra areas. A growing number of observations indicate that abundance of willow, alder, and dwarf birch is increasing in Alaska, Canada, Scandinavia, and Russia due to a warming climate and feedback systems. Shrub expansion is not uniform, with greatest increases by deciduous tall shrubs in drainages, valleys, and disturbance areas with higher moisture and nutrient availability. Tundra shrub conversion will have two main global effects: changes in the surface energy budget and decreased carbon storage. Increases in the shrub cover change surface reflectivity (albedo), causing further warming patterns, which further increases vegetation change potential. Transitions from tundra to shrub land release soil carbon into the atmosphere, increasing global temperatures.

Arctic regions have experienced a one-third relative increase in shrub coverage since the 1950s. The increasing shrub species include alder, willow, and dwarf birch, the three most abundant tall shrubs north of the continental tree line. Species include dwarf and resin birch (*Betula nana* L., *B. glandulosa* Michx.); feltleaf, diamond leaf, and gray leaf willow (*Salix alaxensis* [Andersson] Coville, *S. pulchra*

Cham., *S. glauca* L.); and green alder (*Alnus viridis* [Chaix] DC. ssp. *crispa* [Aiton] Turrill, *A. viridis* ssp. *fruticosa*). Growth of other tundra plant types including graminoids and forbs is also increasing, while growth of mosses and lichens is decreasing.

Satellite observations (normalized difference vegetation index) of greening in the tundra biome depict increases in photosynthetic biomass, leaf area, and shrub biomass, findings collaborated by field studies. A comparison study examined more than 200 photos of northern Alaskan landscapes to assess the landscape for changes in shrub density and size. New photographs taken between 1999 and 2003 were compared with photos from the 1950s. Increases in shrub cover are most detectable on hill slopes, valley bottoms, river terraces, and floodplains. Smaller shrubs also increased in locations between valleys.

Some shrub communities are expanding while others remain stable. Tall and low-growing deciduous shrubs have increased in abundance, while dwarf or evergreen shrubs have not. Low shrub thickets have increased in height over time, and bare ground areas have decreased in shrub expansion areas. Most shrub expansions occur in geomorphic locations with highest disturbance, such as channel margins, floodplains, stream corridors, terraces, and drainages. Nutrients are most available in these disturbance areas, through higher temperatures, greater moisture availability, and increased microbial activity. Warming temperatures may also cause changes in nutrient availability through nitrogen mineralization. Shrubs can more efficiently use available nutrients compared to many other tundra plants. As shrubs grow and expand their coverage, they further alter soil thermal, biotic, and moisture properties at a community scale.

Grazing may have a significant influence on reducing shrub cover expansion in some areas. Excluding grazing by caribou, reindeer, or musk oxen resulted in dramatic increases in shrub cover, leaf area, photosynthesis, and net carbon uptake. In areas where grazing intensity is low, shrubs have tended to increase both in height and cover faster than in the surrounding grazed areas. Shifts in phenology such as earlier budbreak or timing mismatches with pollinators may also limit shrub expansion. Early budbreak, caused by earlier warm temperatures, may lead to frost damage if temperatures fluctuate in early spring. Insect pollination may be disrupted if insect emergence is offset from flower production, although alder, willow, and dwarf birch can effectively reproduce vegetatively.

Increased shrub abundance results from warming temperatures and may further contribute to Arctic warming in a feedback loop. An increase in the abundance and height of shrubs changes the low albedo of snow-covered tundra to a higher albedo of exposed darker-colored shrubs. Taller shrubs reduce wind speed and protrude from the snow, compared with small thin-stemmed shrubs, resulting in even higher albedo. Higher albedo results in faster rates of snowmelt, warmer near-surface temperatures, and a deeper soil active layer. Tundra to shrub transition produces a net increase in summer heating, completing a positive feedback mechanism with global warming trends.

Carbon budget alteration also results from tundra to shrub conversion. The Arctic contains approximately 40 percent of the world's soil carbon. Shrubs store carbon in woody stems with longer turnover times compared with annual plant roots and graminoid biomass. The soil carbon pool loses carbon when the aboveground biomass of shrubs increases, resulting in a net loss of carbon from the ecosystem. Permafrost thaw will also make new carbon pools accessible for microbial respiration and increased vegetation productivity. Higher rates and size of wildfire in the tundra, due to warmer temperatures and increased lightning strikes, release large pools of carbon, and may result in shrub conversion in postburn locations. Overall tundra vegetation composition changes may lead to modified litter quality, carbon storage changes, and nutrient alternations, contributing to feedbacks with climate and biogeochemical cycles.

Elizabeth Bella

See also: Arctic Botany; Climate Change and Invasive Species in the Arctic; Human Impacts and the Antarctic Wilderness; Protocol on Environmental Protection to the Antarctic Treaty; Tundra

Further Reading

Bhatt, U., D. Walker, M. Raynolds, J. Comiso, H. Epstein, G. Jia, R. Gens, J. Pinzon, C. Tucker, C. Tweedie, and P. Webber. "Circumpolar Arctic Tundra Vegetation Change Is Linked to Sea Ice Decline." *Earth Interactions* 14, no. 8 (2010): 1–20.

Elmendorf, S., H. Gregory, R. Hollister, R. Bjork, N. Boulanger-Lapointe, E. Cooper, J. Cornelissen, T. Day, et al. "Plot-Scale Evidence of Tundra Vegetation Change and Links to Recent Summer Warming." *Nature Climate Change* 2 (2012): 453–57.

Loranty, M., and S. Goetz. "Shrub Expansion and Climate Feedbacks in Arctic Tundra." *Environmental Research Letters* 7 (2012): 1–3.

Sturm, M., and C. Racine. *A Half-Century of Change in Arctic Alaskan Shrubs: A Photographic-Based Assessment.* Boulder, CO: National Snow and Ice Data Center, 2005.

Tape, K., M. Sturm, and C. Racine. "The Evidence for Shrub Expansion in Northern Alaska and the Pan-Arctic." *Global Change Biology* 12 (2006): 686–702.

Arctic Skua

The Arctic skua (*Stercorarius parasiticus*) is a fast acrobatic flying avian pirate resembling a gull. It is cleptoparasitisic in its behavior and commonly obtains food by pursuing and harassing other birds, generally terns, puffins, and gulls, forcing them to drop their recent catch. The other common name of the Arctic skua is parasitic jaeger. The Arctic skua's superior flight abilities resulted in the British

Armed Forces, Royal Air Force, naming the first naval dive bomber the "Blackburn Skua." It is a transequatorial migrant that breeds in the Arctic northern coasts in North America and Eurasia and wintering in the southern regions of Australia, Africa (South Africa and Angola), South America (Argentina and Peru), and New Zealand. Its life span is about 12 years.

In comparison with other skuas, the Arctic skua is fairly small in size. The Arctic skua is commonly mistaken for the Pomarine skua (*Stercorarius pomarinus*) or the long-tailed skua (*Stercorarius longicaudus*). The Arctic skua ranges from 16 to 19 in. (41–48 cm) in length, with its tail streamer adding about 3 in. (7 cm) to its overall length. Its wingspan is between 42 and 49 in. (107–125 cm). The weight of the Arctic skua is between 0.66 and 1.5 pounds (300–650 g). Adult Arctic skuas have two morphs, which are light or pale and dark. In the light or pale morph phase, it has a dark brown or almost black crown and upper head, with the sides of the head and neck being yellowish-white. The throat, breast, and under-tail areas are grayish-brown, while the belly area is white. The adults in the dark morph phase are commonly dark or sooty brown all over and have a black crown and pale-colored cheek. Some will include a third morph phase, which is an intermediate between the light or pale and dark phases. During the intermediate morph phase, the Arctic skuas have a light-colored or pale underbelly, head, and neck. In all morph phases, they have a white flash on their wings.

The preferred habitat of the Arctic skua is coastal marine and tundra areas. Arctic skua reaches sexual maturity around four years of age. Breeding of the Arctic skua is in May or June depending on the location with northern breeding areas being later in the season. They breed in both isolated tundra location and in a colony's coastal location. In the tundra breeding locations, the Arctic skua will be more defensive and territorial of their nesting area. The nesting site is selected by the male. The female constructs the shallow nest out of the grass, twigs, moss, or lichen. The nest is located on the ground or a built-up rocky depression. The couple will generally return to the same location every year. Typically, two eggs are laid, and the male and female incubate the eggs for around 25−28 days. After hatching, the chicks leave the nest. Both parents feed and tend to the hatchlings until they are able to fly (fledge) when they are about 25−30 days old. The Arctic skua's diet consists of other birds' catch. It also eats insects, bird eggs, young birds, small mammals (e.g., rodents), and berries.

Andrew J. Hund

See also: Arctic Seabirds; Arctic Tern

Further Reading

BirdLife International. *Stercorarius parasiticus.* In International Union for Conservation of Nature (IUCN) 2013. IUCN Red List of Threatened Species. Version 2013.1. www.iucnredlist.org. Accessed January 8, 2014.

Arctic Tern

The Arctic Tern (*Sterna paradisaea*) is one of very few animals whose travels take it to both the Arctic and Antarctic regions. A member of the tern family Sternidae, Arctic terns migrate between 36,000 and 49,000 miles/year. It is a medium-sized tern, with a length ranging from 11 to 15.5 in. (28–39 cm), a wingspan of 25.5−30 in. (65–76 cm), and a weight of 3.5−4.5 ounces (99–128 g). As with many species that breed in polar regions, the tern is stocky with short legs. It is white below and gray above, with a black cap, bright orange bills and feet, and a deeply forked tail.

The species breeds across the circumpolar region, from islands of the Arctic south to Massachusetts, Wales, and Brittany. When not breeding, terns spend much of the year commuting to and from their wintering grounds in the Antarctic, where they feed along the edge of pack ice in the Atlantic sector of the Southern Ocean, particularly in the Weddell Sea. The species is highly pelagic, with migration routes in every single ocean usually well offshore. While at sea, the tern spends all of its time in the air, including the time it sleeps. Upon reaching its wintering grounds, terns undergo a molt that, for a brief period of time, leaves them stranded on the edge of the pack ice.

Due to its impressive migration, the Arctic tern has been well studied by ornithologists, who have collected much data due to bird banding and geo-location. The average southbound migration, during which birds take a more circuitous route to the Antarctic, is 93 days. In the spring, the breeding imperative results in a more direct northbound flight averaging 40 days. Like other longitudinal migrant seabirds, the tern takes advantage of prevailing wind systems—clockwise in the Arctic, counterclockwise in the Antarctic—to maximize the distance traveled. During their northbound migration, some birds have been recorded covering 400 miles in a 24-hour period. The oldest recorded age is 34 years. Although an average age is not known, it is not a stretch to imagine that birds surviving to adulthood fly more than 1 million miles during their lifetime, akin to two round-trips between the earth and the moon.

Sexual maturity is achieved in the third or fourth year. Nests consist of a shallow scrape in open gravel or grassy areas, with clutch sizes ranging from one to three eggs. Adult terns will protect their nest and hatchlings by aggressively dive bombing predators, which include herring gulls and, in their southern colonies, cats, rats, and even hedgehogs. The terns feed on small fish, sand eels, krill, and, on breeding grounds, insects. Populations declined in the late nineteenth and early twentieth centuries due to fashion trends, which incorporated tern feathers in women's hats. Colonies rebounded well, however, and it is now considered a species of least concern with more than 1 million birds, although southern populations are declining due to pressure from human populations.

Andrew J. Howe

See also: Arctic Seabirds; Arctic Skua

Further Reading

Cabot, D. and I. Nisbet. *Terns.* London: Collins, 2013.

Hatch, J. "Arctic Tern (*Sterna paradisaea*)." In A. Poole and F. Gill, eds. *The Birds of North America, No. 707*. Philadelphia: The Birds of North America, Inc., 2002.

Arctic Territorial Claims and Disputes

No country owns the North Pole or the Arctic Ocean region. The five coastal states of Canada, Denmark (Greenland), Norway, the Russian Federation, and the United States (Alaska) have been granted the management, jurisdiction, and governance over Arctic Ocean under the United Nations Convention on the Law of the Sea (UNCLOS). This international agreement establishes exclusive economic zones (EFZs) that grants natural resources development rights over all territorial waters out to 200 nautical miles (230 miles; 370 km) and the continental shelf as a natural prolongation or seabed that extends beyond the 200 nautical miles, but not further than 350 nautical miles (400 miles; 650 km).

This provision allows the coastal states to have exclusive rights to and the harvesting of mineral resources to the end of the natural prolongation, but not exclusive rights over living resources beyond the EEZ. The UNCLOS does not establish ownership of North Pole or the Arctic Ocean region, just jurisdiction authority over coastal states above and mineral resources under the continental shelf. Four of the Arctic Ocean coastal states have ratified the UNCLOS with the United States holding out. Members of the U.S. Congress are reluctant to ratify the treaty because Part XI is viewed as being against national security interests and is economically disadvantageous to U.S. companies. The coastal countries' territorial sovereignty claims over the Arctic and the seafloor have not been resolved. Under UNCLOS, there are several disputes, which include the sector principle, Continental Shelf Claims, Northwest Passage, Hans Island, and the Beaufort Sea Dispute.

Sector Principle

The sector principle is the way in which the territorial claims or boundaries are made in the Arctic. National claims to the Arctic region were recognized under International Law when the nation-state could prove physical occupation of an area. Claims to Arctic sovereignty are based on the sector principle, which is a version of the geographic doctrine. The geographic doctrine is also called "doctrine of contiguity, propinquity, hinterland, and continuity." Under the geographic doctrine, if a government occupies and/or exercises state functions over the territory, the government can be granted title to the area. The sector principle at its basic definition is simply drawing a line out from the coastal country's borders along longitudinal parallels to the North Pole. The longitudinal lines result in sectors for establishing the coastal countries' territory from the neighboring countries. Historically, claims based exclusively on the sector principle have been rejected by most nation-states. The general consensus in the international community is that for a country to establish sovereignty over a territory, it must be accepted under international law and the country must exercise governmental functions over the territory. Presently, there is an increased interest in mineral rights and strategic military positioning in the Arctic. The sector principle is the way in which the territorial claims or boundaries are made. National claims of sovereignty to the Arctic region can be recognized under international law providing the nation-state can prove physical occupation or sufficiently exercise state functions over the area.

Continental Shelf Claims

The continental shelf claims are a current dispute between the coastal countries. The issue is over who has owned the natural prolongation and gaps in the ocean boundaries. A claim to a continental shelf off a coastal country can be included if it is a natural prolongation or seabed that extends beyond the 200 nautical miles, but not further than 350 nautical miles (400 miles; 650 km). This provision allows the coastal states to have exclusive rights to and the harvesting of mineral resources to the end of the natural prolongation, but not exclusive rights over living resources beyond the EEZ 200 nautical miles limit.

Presently, Canada has not made an official claim with the UNCLOS to extend its continental shelf. The Canadian government contends that the Lomonosov Ridge is an extension of Ellesmere Island of the Canadian Arctic Archipelago. The Denmark government contends that the Lomonosov Ridge is an extension of Greenland. In their UNCLOS continental shelf claim, the Russian Federation argued that the Lomonosov and Mendeleev Ridges were an extension of the Eurasian continent, thus an extension of the Russian territory. The Russian Federation claim only extends to the North Pole. The United Nations (UN) has not ruled in favor or oppositions to the Russian Federal continental shelf claim proposal. The UN requested more research on the matter before deeming the claim valid or invalid. Norway seeks to resolve continental shelf issues in three areas, which are in the Barents Sea called the "Loophole," the Norwegian Sea called the "Banana Hole," and the Western Nansen Basin in the Arctic Ocean. Each of these are gaps in the coverage of the EEZ 200 nautical mile limit resulting in fisheries being not under any country's jurisdiction or management.

Northwest Passage

Certain parts of the waters of the Arctic are in dispute. In general, Canada, Denmark, Norway, the Russian Federation, and the United States regard most of the Arctic waters as territorial waters out to 12 nautical miles (14 miles; 22 km) and allowed the coastal states four specific areas of regulation enforcement, which are taxation, customs, immigration, and pollution. The disputes arise as to what constitutes internal waters. The Northwest Passage is one such dispute between the United States and Canada. The United States along with most maritime nations acknowledges that Canada owns the Northwest Passage; however, the dispute is over whether the Northwest Passage is Canadian internal waters or an international strait. Classifying the Northwest Passage as an international strait allows for the free passage without Canadian consent for all international maritime vessels. Canada claims that the Northwest Passage is part of their internal waters and not international waters as specified under UNCLOS. Thus, the Canadians claim the Northwest Passage is under their sole jurisdiction, and they have the right to enforce their own navigable and shipping laws regarding fishing, vessel safety, and illegal transportation of goods or persons. Another concern of wanting to maintain the Northwest Passage as an international strait is that Canadian environmental regulations over internal waters are stricter than the UNCLOS. The Canadian government does not claim to have the right to close the passage, just to have jurisdictional authority over enforcement and regulation.

Hans Island Dispute

The Hans Island (80° 49′N 66° 27′W) dispute is between Canada and Denmark over the ownership of a small area in the Nares Strait, which includes Hans Island. At dispute are claims to the fishing areas, management, and jurisdiction over the Northwest Passage. Hans Island is a barren uninhabited knoll measuring 0.5 square mile (1.3 sq. km) in area and is 0.8 mile (1,290 m) long by 0.75 mile (1,200 m) wide. Hans Island is positioned in the center of the Kennedy Channel of the Nares Strait (sometimes called "Robson Channel"). The Nares Strait connects Baffin Bay to the Lincoln Sea and separates Ellesmere Island, Nunavut, Canada, and northern Greenland (owned by Denmark). Hans Island is roughly in between the territory of Canada and Greenland (Denmark). The island was named for Native Greenlander and Arctic explorer Hans Hendrik (1834–1889).

Beaufort Sea Dispute

The Beaufort Sea dispute is a disagreement over the maritime boundary between the United States and Canada. The dispute centers on the exact location of the Beaufort Sea international boundary between Alaska and the Yukon. The Canadians claim the boundary should run along 141st meridian west. The basis for the Canadian government's claim is the Treaty of Saint Petersburg of 1825. This treaty was signed by the Russian Empire and the United Kingdom. Canada, being the successor to the United Kingdom, argues that the Treaty of Saint Petersburg establishes their claim to the Beaufort Sea. The United States rejects the 141st meridian west boundary line. The United States maintains that the boundary runs straight out conforming to an equidistance line from the Alaska coast. The difference between the two countries' assumed boundaries resembles a wedge and is an area just under 8,300 square miles (21,000 sq. km).

Andrew J. Hund

See also: Antarctic Territorial Claims; Arctic Territorial Claims and Disputes; Beaufort Sea Dispute; Continental Shelf Claims in the Arctic

Further Reading

"Convention between Great Britain and Russia concerning the Limits of their Respective Possessions on the North-West Coast of America and the Navigation of the Pacific Ocean, 16 February 1825: Article 3." 75 Consolidated Treaty Series (CTS), 95.

Griffiths, F. "The Arctic as an International Political Region." In Kari Möttölä, ed. *The Arctic Challenge: Nordic and Canadian Approaches to Security and Cooperation in an Emerging International Region.* London: Westview Press, 1988.

McKitterick, T. "The Validity of Territorial and Other Claims in Polar Regions." *Journal of Comparative Legislation and International Law* 3rd Ser., 21, no. 1 (1939): 89–97.

Arctic Wolf

The Arctic wolf (*Canis lupus arctos*) is a subspecies of the gray wolf and lives north of 70° latitude, inhabiting the Canadian High Arctic, Alaska, Greenland, Iceland, and Northern Europe. The Arctic wolf is called the "white wolf" or "polar wolf." Arctic wolves are versatile animals that have adapted to year-round subzero temperatures and five months of total darkness. Their harsh and remote habitat has protected them.

Description and Adaptations

Some wolf species have a little white coloring, but the Arctic wolf is the only one that is almost completely white. The Arctic wolves are generally smaller than gray wolves, but have bulkier bodies and are the only subspecies of wolf that is not threatened as a result of human contact and still inhabits their original range. Arctic wolves can range in size from 3 to 5 ft. in length from head to tail, 25 to 31 in. (63–79 cm) at the shoulder, and weigh between 100 and 175 pounds (45–80 kg). Males are bigger and heavier than females. Arctic wolves have 42 very sharp teeth and powerful jaws.

The Arctic wolves are adapted to bitterly cold environment of the Arctic having a compact body to retain heat, smaller ears, and a shorter muzzle than other members of the canid family. These features reduce the surface area that releases body heat. While sleeping, Arctic wolves curl up and cover their muzzles with their tails to avoid frostbite on their noses or mouths. Arctic wolves have two thick layers of fur. The thinner undercoat forms a waterproof barrier for the skin, and a heavier outer layer of fur gets even thicker as winter approaches. Both help insulate the animal and keep their body temperature steady despite the bitter cold. Unique padded paws give them a firm grip on the permanently frozen ground. Game is limited and widespread in the High Arctic. As a result, the Arctic wolf has evolved to survive on fat stores in their bodies when prey is scarce. The low density of prey also results in a wolf's territory ranging up to 1,000 square miles (2,600 sq. km).

Diet

Arctic wolves travel in packs that range from 2 to 20. Like any other wolf species, they hunt in groups to bring down large animals such as caribou or musk oxen when available, but frequently hunt small mammals alone, such as Arctic hares, lemmings, seals, and various rodents. When a hunt is successful, a large animal will keep the pack in the severe cold and feed for several days. Pack members take turns feeding and protecting the carcass from other animals. They also remove chunks of flesh and sneak off to cache them, in case future hunts are less successful. They waste no part of the kill and even consume the bones and fur. Arctic wolves can eat up to 20 pounds (9 kg) of meat at a time.

Reproduction

Each pack is led by an alpha male and female who are mates. The pair are the only ones to breed. Breeding season begins in March, and the female delivers the pups after about 63 days of gestation. The average litter size is two or three pups, which is about half the size of gray wolf litters.

When a female is pregnant, she seeks a secure place to give birth. In the Arctic, it is impossible for wolves to dig a den as other species do, because the ground never thaws. Arctic wolves use caves or crevices in rock outcrops for shelter. If none are available, a sheltered depression in the ground is used. The mother stays with her pups for the first three weeks to protect and care for them. Wolf pups weigh less than a pound at birth and are blind and deaf. They are completely dependent on their mother for food and warmth. The alpha wolf brings food to the female during this time, and the rest of the pack helps protect the den. When the pups are about five weeks old, they are weaned and are fed with regurgitated meat provided by all the adults in the pack. They become independent hunters when they are one year old.

Young males reach sexual maturity at two and may decide to leave the pack and become a lone wolf in search of a mate and territory of his own. Once unclaimed land is found, the wolf marks the boundary with his scent and starts the cycle of life again.

Jill M. Church

See also: Arctic Fox; Arctic Ground Squirrel; Arctic Hare; Arctic Seabirds; Caribou; Dogs in the Arctic; Lemmings; Musk Oxen; Polar Bear; Wolverine

Further Reading

Brandenberg, Jim. *White Wolf: Living with an Arctic Legend.* Minnetonka, MN: Northword Press, Inc., 1998.

International Wolf Center. *Wolves of the High Arctic.* Stillwater, MN: Voyager Press, Inc., 1992.

Mech, L. David. *The Arctic Wolf: Ten Years with the Pack.* Stillwater, MN: Voyager Press, Inc., 1997.

Arctic Woolly Bear Caterpillar/Moth

The Arctic Woolly Bear caterpillar (of the moth species *Gynaephora groenlandica*) is the larval form of the Arctic Woolly Bear moth. These moths are found above the Arctic Circle in Canada and Greenland. The life cycle of all butterflies and moths is in four stages, which are the egg, larva, pupa, and adult. Due to the Arctic growing season and temperatures, the Arctic Woolly Bear moth's life cycle is extended. The majority of this moth's life cycle is in the larva or caterpillar stage as a means to adapt to the Arctic climate.

The Arctic Woolly Bear caterpillar spends around 90 percent of its life frozen. The other 10 percent is divided among feeding on the tundra (5%) and summer hibernation (5%). The Arctic Woolly Bear moths in the caterpillar stage have an extended life span lasting at least 7 years to as long as 14 years before developing into the pupa stage. Butterflies and moths feed during the larva or caterpillar stage, and once they have eaten enough food, they become a pupa and entomb themselves in a silk cocoon. After a certain amount of time, the butterfly or moth emerges from the cocoon as an adult.

The summer feeding time is limited in the Arctic; thus, the Arctic Woolly Bear caterpillars' feeding window is limited. The caterpillar feeds in June. This feeding time corresponds to the nutritional peak of its primary food source, the Arctic willow. The caterpillar does not feed the entire time it is active; instead it spends time basking in the sun (thermoregulating) in between feedings.

Since the Arctic Woolly Bear caterpillar cannot eat enough food to advance to the pupa stage during a single summer, it has to feed over multiple summers (up to 14 summers). If the caterpillar has not eaten enough food to advance to the pupa stage, it seeks refuge, spins hibernacula, and overwinters. The hibernacula offer the Arctic Woolly Bear caterpillar protection (by avoidance) from its two main predators (parasitoids), the ichneumonid wasp and the tachinid fly.

Inside the hibernacula, the caterpillar is inactive until it freezes at around 15.8°F (−9°C) in late summer. During this period, the caterpillar undergoes a mitochondrial degradation (cellular breakdown) resulting in an abnormally low metabolic rate (hypometabolism) and an increase in the production of cryoprotective compounds (mainly glycerol). The cryoprotective compounds or antifreeze enables the caterpillar to tolerate temperatures as low as −94°F (−70°C) during the winter.

In the spring, the mitochondria are rapidly resynthesized, and the caterpillar emerges from the hibernacula and returns to feeding in an attempt to eat enough food to advance to the pupa stage. Once the caterpillar has acquired enough food, it becomes a pupa, spins a cocoon, then emerges as an Arctic Woolly Bear moth after a certain period of time. After emerging from cocoon, the moth lives only a few days. The male Arctic Woolly Bear moth dies after mating, and the female moth dies after laying her eggs. Neither the male or female Arctic Woolly Bear moth feeds during their short life.

Andrew J. Hund

See also: Canadian Arctic Archipelago; Greenland

Further Reading

Bennett, V., R. Lee, J. Nauman, and O. Kukal. "Selection of Overwintering Microhabitats Used by the Arctic Woollybear Caterpillar, *Gynaephora groenlandica*." *CryoLetters* 24, no. 3 (2003): 191–200.

Kukal, O., J. Duman, and A. Serianni. "Glycerol Metabolism in a Freeze-Tolerant Arctic Insect: An In Vivo 13-C NMR Study." *Journal of Comparative Physiology B* 158 (1988): 175–83.

Arktisk Station

Arktisk Station (65° 15′N 53° 31′W) is located east of the town Qeqertarsuaq/Godhavn (69° 14′N 53° 32′W) on the Disko Island, West Greenland. The station was established in 1906 by the Danish botanist Morten Porsild (1872–1956). He collaborated with the famous polar researcher Knud Rasmussen (1879–1933), when helped to fund the establishment a permanent research station. The location of the station was probably determined by the nearby location of warm wells that provided favorable living condition for plants and insects.

The station consists of a main building, the old station building that was completely restored in 1980. There are kitchen facilities and accommodation for up to 26 persons. West of the main building is a house for the station manager and a new building from 1966 housing a 6,000-volume library and a laboratory for research. It is equipped with a car garage and a shed at the harbor used for boats and other equipment. There is a research vessel called *Porsild* that was acquired in 1994. The vessel is 50 foot (15.1 m) long by 16 ft. (5 m) wide. The *Porsild* has a 362 HP Scania diesel engine. There is room for 12 passengers, and the ship is well-equipped for oceanographic and biological investigations.

The Disko Island consists mainly of Paleogene volcanic rocks, which lay on top of Paleocene sediments resting on Cretaceous sediments. The Paleocene and Cretaceous sediments are mainly located on the eastern side of the island. Several glaciers are located in the central part of the island at altitudes above 3,000 ft. (1,000 m) above sea level. One glacier has recently surged, in the Kuannersuit Valley, and the glacier has advanced more than 6 miles (10 km) since 1995. Disko is located on the border between Low and High Arctic climate and has rich vegetation.

The Arktisk Station has its own weather station that provides data for research purposes. Average summer and winter temperatures are 45°F (7.1°C [1991–2004]) and 3.2°F (−16.0°C), respectively. Average annual precipitation is around 23 in. (58.5 cm), of which 42 percent is snow. Because of a relatively warm ocean current, the Disko Island ice cover often lasts only from February until May. Whales may be observed from the station.

Porsild remained the manager of the station until 1946 and carried out mainly botanical research. Because of the war (1940–1945), visits from foreign scientists dwindled, and the research activity was limited. In 1946, a new botanist, Paul Gelting, took over the station. Gelting focused on marine mammals' investigation as requested by the Greenland administration. In 1954, the station was affiliated to the University of Copenhagen from where scientific station managers were recruited. In 1976, a physical geographer Niels Nielsen became the station manager, and the research scope was widened to include geology, landscape evolution, and climate.

The station arranges field courses regularly for botanists, zoologists, geographers, and geologists. The station hosts scientists from all over the world who carry out research both on the Disko Island and in the surrounding waters. The station celebrated its 100-year anniversary in 2006, and a book describing the station, its history, and research was edited by a group of researchers related to the work at the station: *Arktisk Station 1906–2006*, Copenhagen University, publisher Rhodos.

Bent Hasholt

See also: Drifting Research Stations in the Arctic Ocean; Greenland, U.S. Bases in; Nuuk Ecological Research Operations (NERO); Sermilik Station; Toolik Field Station (TFS)

Further Reading

Arktisk Station. http://arktiskstation.ku.dk/english/. Accessed January 8, 2014.

Association of Polar Early Career Scientists (APECS)

The Association of Polar Early Career Scientists (APECS) is an international and interdisciplinary organization for undergraduate and graduate students, postdoctoral researchers, early faculty members, educators, and others with interests in the polar regions and the wider cryosphere. APECS was founded in 2006 as an early-career-scientist-driven initiative of the International Polar Year (IPY) 2007–2008, which was a large collaborative, interdisciplinary, and international effort in studying the polar regions.

One of the features of the IPY was the unprecedented participation of young and enthusiastic polar researchers. As of May 1, 2013, APECS comprises more than 4,000 members hailing from 76 countries worldwide, corresponding to every major and minor polar research division and discipline; the APECS membership represents the remarkable success of the IPY and the diversity that is shaping the future of polar research. APECS works closely with many international organizations and leading polar researchers, educators, and funding agencies to provide a continuum of knowledge in polar research for generations to come.

The main goals of APECS include facilitating international and interdisciplinary networking to develop new research directions and collaborations; providing opportunities for professional career development; and promoting education, outreach, and science communication as an integral component of polar research.

APECS largely focuses on secondary education and training by complementing traditional educational programs. APECS works closely with its partners to organize in-person career development workshops and discussion panels at major international polar conferences and symposia. Furthermore, the most successful online APECS initiatives and resources in recent years include Career Development Webinars, Virtual Poster Session, International Polar Weeks, Celebration of Antarctica Day, and several databases such as the very popular APECS jobs listings, mentor listings, polar funding resources, and graduate programs. In addition to numerous resources, APECS provides a platform for students, researchers, educators, and others interested in polar regions to implement their various projects and initiatives. APECS members publish regularly in peer reviewed and popular journals, as well as prepare reports, book chapters, and assessments on education, outreach, polar science communication, skills enhancement, and professional career development.

Organizationally, the APECS leadership consists of a council, an executive committee, and a director. The council is made up of 15–20 members accepted for participation through an open application process. The five-person executive committee is annually elected by the council. The executive committee works closely with the director, who is the only full-time paid employee within the organization (as of May 1, 2013). APECS's International Directorate office is located in Tromsø, Norway, and is supported by the Norwegian Polar Institute, the University of Tromsø, and the Research Council of Norway.

Alexey K. Pavlov and Allen Pope

See also: Arctic Circle

Further Reading

APECS Website. http://apecs.is. Accessed January 8, 2014.

Also access the APECS presence on social media on Facebook (http://facebook.com/apecs4u) and Twitter (@Polar_Research).

Atomic Detonations and Weapons in the Arctic

A number of atomic weapons have been detonated above and below ground in the Arctic. At Novaya Zemlya, Russia, 130 nuclear tests were conducted from 1955 to 1990. Starting in 1957 and lasting until 1962, the Soviet Union conducted 85 atmospheric nuclear tests over the Novaya Zemlya Archipelago (74° N 56° E). Fifteen of these atmospheric tests occurred over 35 days (September 20 to October 25, 1958). On October 30, 1961, the world's largest atmospheric thermonuclear weapon detonation took place on the Novaya Zemlya Sukhoy Nos test site (Zone C). This nuclear detonation was called Tsar Bomba. Tsar Bomba was initially designed with a nuclear weapon yield of 100 megatons of TNT, but was reduced to 50 megatons over concerns about nuclear fallout and destroying the delivery aircraft.

In 1963, after signing the Partial Test Ban Treaty, the Soviet Union's atmospheric tests were officially suspended. The first underground test at Novaya Zemlya occurred on September 15, 1964. From 1964 until 1990, there were 32 underground nuclear tests involving 128 separate nuclear explosive devices at the Novaya Zemlya sites. On September 12, 1973, the largest underground test occurred at Novaya Zemlya occurred. This test used four nuclear devices with a nuclear weapon yield of 4.2 megatons of TNT resulting in an earthquake that measured 6.97 on the Richter scale and setting off an 80-million ton rockslide/avalanche. This rockslide/avalanche blocked two glacial streams, resulting in the creation of a 2-km (1.2-mile) lake. The testing of underground nuclear devices peaked in the 1970s at Novaya Zemlya, which was prior to the Threshold Test Ban Treaty of 1976. The Threshold Test Ban Treaty of 1976 prohibited underground tests of more than 150 kilotons.

In the early 1960s, under the direction of the U.S. Atomic Energy Commission, a nuclear testing facility was created on Amchitka Island in the western Aleutian Islands of Alaska. These facilities were used for three below ground atomic devices. The first detonation occurred on October 29, 1965. It had a nuclear weapon yield 0.08 megaton of TNT named "Long Shot." The next occurred on October 2, 1969, and had a nuclear weapon yield 1 megaton of TNT and was called "Milrow." On November 6, 1971, "Cannikin," an underground atomic device with a nuclear weapon yield 5 megaton of TNT, was detonated. Cannikin was the largest in U.S. history.

PROJECT CHARIOT

As international plans were being discussed for limiting or eliminating nuclear detonations in the atmosphere, the U.S. Atomic Energy Commission (AEC) was interested in finding peaceful uses for nuclear devices. The research project for the peaceful use of nuclear devices was called "Operation Plowshare." A subproject of this research was called "Project Chariot." Project Chariot was the name for a proposed experiment to use nuclear devices as a means to construct an artificial harbor at Cape Thompson, Alaska (or Eebrulikgorruk as named by the Inupiat). Cape Thompson (68° 8´N 165° 58´W) is located about 30 miles (48 km) south of Point Hope, Alaska, and about 40 miles (64 km) north of Kivalina, Alaska. The local Inupiat population used Cape Thompson for subsistence activities. The project was conceived by Edward Teller commonly referred to as "the father of the hydrogen bomb." Teller's project proposed burying a string of nuclear devices and detonating them to create a deepwater harbor. Dr. Teller traveled the state of Alaska promoting Project Chariot and garnered significant support from the Alaska political, church, and university leaders. The project was also supported by Alaskan newspaper editors. The small group of Alaskan distracters requested scientific studies to support the claims made by the project advocates. The project never took place due to serious concerns by the local Alaskan Native population, the usability of the harbor due to its remote location, and the cost of the project. In 1962, the AEC suspended Project Chariot and halted all the related environmental studies.

Andrew J. Hund

Since the mid-1950s, nuclear weapons have been placed in the Arctic, accidentally or purposefully. In 1968, a U.S. B52 bomber carrying four nuclear weapons crashed near Thule Airbase in Greenland, releasing approximately one pound of plutonium into the atmosphere. The U.S. military also housed nuclear surface-to-air and other tactical warheads at Thule Airbase, which was in violation to the Greenland Danish agreement prohibiting nuclear weapons on the island. In 1977, the Soviet submarine K-171 accidentally launched a nuclear warhead overboard in the Pacific Ocean near the Kamchatka Peninsula. The lost nuclear warhead was later recovered.

Andrew J. Hund

See also: Human Impacts and the Antarctic Wilderness; Novaya Zemlya, Nuclear Tests; Novaya Zemlya, Nuclear Tests, Environmental Legacy of; Nuclear Power in the Arctic; Nuclear Waste in the Arctic; Radioactivity; Radioactivity in the Arctic; Sunken Soviet/Russian Nuclear Submarines in Arctic

Further Reading

Atland, K. "Michail Gorbacheve, the Murmansk Initiative, and the Denuclearization of Interstate Relations in the Arctic." *Cooperation and Conflict: Journal of the Nordic International Studies Association* 43, no. 3 (2008): 289–311.

Diakov, A., and F. Von Hippel. *Challenges and Opportunities for Russia-U.S. Nuclear Arms Control.* A Century Foundation Report. New York and Washington, DC: The Century Foundation, 2009, pp. 15–16.

Wallace, M., and S. Staples. *Ridding the Arctic of Nuclear Weapons: A Task Long Overdue.* Toronto: Canadian Pugwash Group, March 2010.

Aurora Australis

The southern lights or aurora australis are a colorful display of energy emissions observed in the southernmost night sky. The southern lights have similar features to the northern lights (a.k.a. aurora borealis) and change simultaneously with changes that occur in the northern lights. Auroras help us understand that everything is connected and more specifically demonstrate the spectacular fact that our planet earth is electrically and magnetically connected to the sun. The dance of the southern lights is made possible by electrons in solar winds that have the capacity to transfer their own energy as they interact with electrons in elements in the upper atmosphere. The energy exchange between particles occurs at very high altitudes between 20 and 200 miles (32–320 km) above the earth's surface. When high-energy electrons collide with elements in the upper atmosphere, they excite the electrons in the matter that they collide with. After some time, these excited electrons release the excess energy absorbed as photons of visible light. When the electrons release these photons, they are able to return to their ground state. When we observe the southern lights, we are seeing the release of excess energy in a lyrical cascade or spirit dance across the southernmost night sky. The southern lights are equally beautiful and intriguing as the northern lights.

Particular colors observed during a southern light display depend on which kinds of elements are struck by the high-energy electrons within the solar winds. Of course, the energy of the electrons in the solar winds is equally important to the process. The different colors observed in the southern light sky are the result of electronic transitions of various energies that dominate particular altitudes. At the highest altitudes, the element of oxygen has particular energies, thus energetic transitions characteristic of the frequencies associated with the color red, for example, may be observed. By contrast, at a lower altitude, the element of oxygen may have different energies that dominate, and thus different electronic transitions would be possible, perhaps characteristic of the frequencies and energies associated with the emission of green light. The amount of energy released is directly responsible for the color observed. The southern lights dance with colors that move along with

SOLAR WINDS

The sun generates high-energy solar winds, which stream away at speeds of approximately 1 million mph. The solar winds are made up of high-energy particles that interact with earth's magnetosphere, which has its own electrical and magnetic properties. Recently, it was discovered through computer simulations that solar winds have the capacity to further impact earth's magnetosphere by extending its magnetotail up to 1,000 times more in volume than originally thought. When solar winds come in contact with the earth's magnetic field, they have the effect of stretching the magnetic field lines in such a way to promote reconnection of the field. Moreover, new scientific evidence supports the idea that the source responsible for both the southern and northern lights is reconnection of earth's magnetic field through interaction between electrons in solar winds and the earth's magnetosphere. Importantly, electrons from the solar wind come in contact with the earth's magnetosphere, and they follow the lines of magnetic force (due to their own charge) and move through the magnetosphere where they are then accelerated. When the accelerated electrons come in contact with elements in the upper atmosphere (e.g., diatomic oxygen [O_2] and diatomic nitrogen [N_2]), they transfer energy to the electrons they meet. Auroras occur largely at the higher latitudes because that is where earth's magnetic field directs the charged particles toward the earth's North and South Poles. The underlying scientific nature of both the southern and northern lights is the idea of energy transfer through connection.

Karen Knaus

atmospheric currents. Southern lights generally center on the magnetic pole that corresponds with the Antarctic Circle. Furthermore, the southern lights are an exciting natural phenomenon that can simply be explained as the interaction of electrons in one form of matter upon electrons in another form of matter, where energy exchange is made possible. The energy exchange concludes with a finale where excess energy is released in the form of cascading packets of colorful light in the southernmost sky. The southern lights are a gift from nature and science, which demonstrates that energy can neither be created nor destroyed, but rather energy can be transformed through interaction and/or connection events in the universe. The northern and southern light displays are equally beautiful and intriguing. As solar winds increase, the number of opportunities to view both the southern and northern lights increases.

Karen Knaus

See also: Aurora Borealis; Auroral Substorm; Ionosphere, Polar

Further Reading

Chandler, D. "Mysterious Electron Acceleration Explained. Computer Simulation Identifies Source of Aurora-Causing High-Speed Electrons in Space." 2012. MIT News. http://web.mit.edu/newsoffice/2012/plasma-phenomenon-explained-0227.html. Accessed January 8, 2014.

Combs, L., and Viereck, R. *Aurora.* Boulder, CO: The Space Environment Center, 1996.

NOAA Space Weather Prediction Center. Auroral Activity Extrapolated from NOAA POES. http://www.swpc.noaa.gov/pmap/index.html. Accessed January 8, 2014.

Waugh, R. "Fire Down Below: 'Southern Lights' Blaze above Antarctica as Space Station Hurtles Over at Height of Solar Storm." March 13, 2013. Mail Online. http://www.dailymail.co.uk/sciencetech/article-2114274/Southern-lights-blaze-Antarctica-International-Space-Station-hurtles-over.html. Accessed January 8, 2014.

Aurora Borealis

The northern lights (a.k.a. "aurora borealis") are a colorful display of energy emissions that can be seen in the northernmost night sky. It was believed for some time that the sun was responsible for the northern lights. The dance of the northern lights is made possible by electrons in the solar winds that have the capacity to transfer their own energy to electrons in elements in the upper atmosphere that they come in contact. The energy exchange between particles occurs at very high altitudes ranging between 20 and 200 miles (32–320 km) above earth's surface. When high-energy electrons collide with elements in the upper atmosphere (that contain their own electrons), they excite the electrons in the matter that they collide with. After some time, these temporarily excited electrons release the excess energy absorbed as a result of the collision in packets of energy known as photons. Photons of visible light are released when electrons release this excess energy and naturally fall back down to their ground energy state. The transfer of energy from one form to another is natural. Electrons have the ability to further absorb and emit electromagnetic radiation (energy) in various forms including visible light, which is what is observed during the display of the northern lights. Without their interaction with other particles and/or energy sources, electrons would not be able to take and give their own energy, and we would not be able to see the colorful displays characteristic of the northern lights.

Particular colors observed during a northern light display depend on which kinds of elements are struck by the high-energy electrons from solar winds. Of course, the energy of the electrons in solar winds is equally important in the process. The different colors observed in the northern light sky are the result of electronic transitions of various energies that dominate particular altitudes. At the highest altitudes, the element of oxygen has particular energies, thus energetic transitions characteristic of the frequencies associated with the color red, for example, may be observed. By contrast, at a lower altitude, the element of oxygen may have different energies that dominate, and thus different electronic transitions would be possible, perhaps characteristic of the frequencies and energies associated with the emission of green light. The amount of energy released is directly responsible for the color observed. The northern lights dance with colors that move along with atmospheric currents. Northern lights generally center on the magnetic pole that corresponds with the Arctic Circle. Furthermore, the northern lights are an interesting phenomenon that can simply be explained as the interaction of one form of matter upon another, which leads to an energy exchange. The energy exchange concludes with a final release of energy in the form of a colorful light display in the northernmost night sky. In a way, we can say that the northern lights are a gift from nature, which demonstrates that energy can neither be created nor destroyed, but rather transferred through interaction events in the universe. As the solar winds increase, opportunities to see the northern lights increase. The northern lights allow us to see energy being released in the form of visible light of various energies, and the displays are equally beautiful and intriguing.

Karen Knaus

See also: Aurora Australis; Auroral Substorm; Ionosphere, Polar

Further Reading

Chandler, D. "Mysterious Electron Acceleration Explained. Computer Simulation Identifies Source of Aurora-Causing High-Speed Electrons in Space." 2012. MIT News. http://web.mit.edu/newsoffice/2012/plasma-phenomenon-explained-0227.html. Accessed January 8, 2014.

Combs, L., and Viereck, R. *Aurora.* Boulder, CO: The Space Environment Center, 1996.

NOAA Space Weather Prediction Center. Auroral Activity Extrapolated from NOAA POES. http://www.swpc.noaa.gov/pmap/index.html. Accessed January 8, 2014.

Auroral Substorm

Aurora shows itself in many different forms and shapes. Sometimes there is just a static broad arc that is just barely bright enough to be seen in the dark sky, and sometimes the whole sky lights up with colorful and dynamic displays. All auroras are caused by charged particles (electrons and protons) that are impacting the upper atmosphere. The visible aurora is caused by energetic electrons. The difference between the different types, shapes, and colors arises from the energy that the electrons have and the way these electrons get their energy in the first place.

The most spectacular aurora is called an "auroral substorm." The auroral events during a substorm follow a pattern that implies that these individual auroral shapes and movements are a part of a larger event. This is how a substorm looks to an observer on the ground in a perfect position near midnight and at a latitude just south of the Arctic Circle: first a quiet diffuse-looking faint green arc in the north starts moving south. It may take 30 minutes or an hour for the arc to steadily move, until it is overhead. This is called the "expansion phase." Then, suddenly, things begin to happen very fast. The arc gets thinner and develops a few ripples. New, very thin arcs appear right next to it, and the aurora gets very bright. The arcs bend themselves into a large spiral form until the entire sky is filled with bright aurora. This sudden brightening moves westward like a wedge along the quiet green arc. Small rays dance along the arcs, and the bottom edge of the arcs turns pink and purple. This sudden explosion of aurora all over the sky may take only a few seconds. This is called the "breakup."

The aurora may stay bright and dynamic with changing colors for several minutes, or even tens of minutes. Then, it slowly starts moving north again, staying

AURORA SOUND

People have long reported that they can sometimes hear the aurora. This is a phenomenon that does not yet have a satisfying explanation. The aurora happens at an altitude of about 100 km (60 miles), and sound from that distance would take more than five minutes to travel to the ground. The air at auroral altitude is very thin, and that affects the sound as well: any sound waves from there would diminish in amplitude as they travel into denser air below. It is thus not possible that the sound that people report hearing synchronous with the aurora actually comes from the aurora. Possible explanations that have been put forward include radio waves that are generated by the aurora and that are somehow turned into sound near the ground where they would then be heard at the same time as aurora brightens. Such radio waves are indeed observed, using sensitive radio receivers. However, no known mechanism could transform these radio waves into sound without long antennas and sophisticated electronics. It was postulated in the 1950s that the human brain might be able to detect radio directly, like migrating birds can sense the magnetic field and use it as a compass. There were even experiments conducted where people were exposed to artificial high-amplitude radio waves. But this suspected extrasensory ability was never detected or found. One possible explanation is synesthesia, where a cross-feed in the brain causes nerve impulses from the eyes to be perceived as sound. A mild form of synesthesia is more widespread than most people assume and might well be the best explanation of auroral sound.

Dirk Lummerzheim

active with curls and spirals, but also slowly diminishing in brightness as the southern edge of the auroral region moves north. There are usually pulsating patches of aurora developing that can linger for hours as everything becomes quiet again. This is called the "recovery phase." If the observers were not at this perfect position, but further west, they would see a big aurora moving in from the east; if the observers were too far east, they would see a gradual brightening of the sky north of a quiet arc and pulsating patches in the entire sky.

It was only in the 1950s that Syun Akasofu and Sidney Chapman at the University of Alaska recognized that this pattern is a global event, and observers at different time zones are just seeing different aspects of the same thing. Akasofu had set up all-sky cameras throughout Alaska, Canada, and Scandinavia, and thus got a global view of the aurora. At the time, magnetometer observations had already identified what a magnetic storm is, and there was some understanding that magnetic storms also caused bright aurora. It was thus that the name "substorm" came about. Today, we understand that a substorm starts in the earth's magnetosphere after the magnetic field in the solar wind turns southward. This makes the connection between the solar wind and the earth's magnetic field much stronger, and the solar wind starts transferring a lot of energy into the magnetosphere. It distorts the entire magnetosphere, dragging much of it to the side that is opposite of the sun and stretching it into space. That relates to the expansion phase of the substorm. Eventually, this process has to stop and reverse, and this happens in a sudden release. At this sudden release of energy, strong electrical currents start flowing in the magnetosphere toward earth, and a large number of electrons are accelerated into the upper atmosphere, causing the breakup. Usually, this happens on the side away from the sun, that is, near midnight. And then, everything slowly returns to a normal position, which is the recovery phase of the substorm. When conditions are right, the whole process can repeat several times during a day, and we can have multiple substorms in a night.

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See also: Aurora Australis; Aurora Borealis; Ionosphere, Polar

Further Reading

Akasofu, S. -I. "The Development of the Auroral Substorm." *Planetary and Space Science* 12 (1964): 273–82.

Sarris, T., and X. Li. "Evolution of the Dispersion Less Injection Boundary Associated with Substorms." *Annales Geophysicae* 23 (2005): 877–84.

Australasian Antarctic Expedition (1911–1914)

The main goal of the Australasian Antarctic Expedition (1911–1914) was to explore approximately 2,000 miles (3,200 km) of Antarctica coastline south of Australia.

The geologist Douglas Mawson (1882–1958) was charged with the leading of the expedition, which was mainly financed by the Australasian Association for the Advancement of Sciences and up to a minor degree by subscriptions and donations. In contrast to other expeditions of the heroic age of Antarctic exploration that were predominantly staffed by Europeans, the Australasian Antarctic Expedition drew the majority of the expedition participants from Australian and New Zealand universities.

After arriving in Antarctica in December 1911, the expedition established a base at Cape Denison in Commonwealth Bay and two auxiliary camps. The expedition ship *Aurora*, a former auxiliary steamer of the Newfoundland sealing trade, began immediately with the exploration of the coast, while the main part of the expedition under Mawson's command completed the bases and prepared for sledge expeditions to be conducted beginning in the second half of 1912. Routine meteorological observations as well as other scientific observations began immediately after the construction of the bases, as the main goal of the expedition was a comprehensive exploration of the territory and not reaching a new furthest south. The meteorological observations proved that Cap Denison was up to a certain degree an ill-suited place for a base camp due to the extreme strong winds with more or less permanent katabatic winds.

Five major sledge expeditions were carried out in 1912 of which the last one, designed to explore King George V Land, became a catastrophe. After the initial good progress, one of the expedition members fell into a snow-covered crevasse, pulling much equipment, provisions, and a number of dogs into the crevasse. The survivors of the incident, Mawson and Xavier Mertz, decided to abandon any plans of further exploration immediately and began their home journey to Cape Denison with only insufficient supplies left to them. Consequently, they needed to use the sledging dogs as assets of last resort, thus limiting their means of transportation even further. After Mertz died, probably of hypervitaminosis A, caused by eating the dog livers, Mawson was the sole survivor of the sledging team and needed to resort to man-hauling. Despite all obstacles, he finally reached safety, still carrying on his sledge a substantial amount of geological specimen.

Any attempt of picking up the surviving expedition members by the Aurora failed in February 1913, and Mawson with six men needed to prepare for another unintended overwintering, before they were finally picked up during the Antarctic season 1913–1914.

In addition to substantial scientific records that have been published only nearly a decade after the conclusion of the Australasian Antarctic Expedition, it needs to be mentioned that the expedition made extensive use of wireless communication, eventually including the first wireless communication between Antarctica and another continent, and that the records of the expedition include a substantial amount of high-quality professional photographs as Mawson had decided taking the professional photographer Frank Hurley onboard of the expedition instead of familiarizing himself and other expedition members with photography.

Ingo Heidbrink

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

Further Reading

Bredeson, C. *After the Last Dog Died: The True-Life, Hair-Raising Adventure of Douglas Mawson and His 1912 Antarctic Expedition*. Washington, DC: National Geographic, 2003.

Cormick, C. *In Bed with Douglas Mawson: Travels Round Antarctica*. Chatswood, New South Wales: New Holland Publishers (Australia), 2011.

Mawson, D. *The Home of the Blizzard: Being the Story of the Australasian Antarctic Expedition, 1911–1914*. London: Hodder and Stoughton, 1930.

Mawson, D., F. Jacka, and E. Jacka. *Mawson's Antarctic Diaries*. London: Unwin Hyman, 1988.

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Baffin Bay

Baffin Bay (73° N 67° W) is a marginal sea of the North Atlantic Ocean measuring 900 miles (1,450 km) long by a range of 70–400 miles (110–650 km) wide. Borders of Baffin Bay are the west coast of Greenland (east), a line running along 70° N from Greenland to Baffin Island (south), the east coast of Baffin, Bylot, and Devon Islands (west), and northern Ellesmere Island across to Cape Bryant of Northern Greenland (northern limit). The total surface area of Baffin Bay is 266,000 square miles (689,000 sq. km). The average depth is 2,825 ft. (860 m).

Baffin Bay has been inhabited for thousands of years, starting with the Dorset (500 BC–AD 1200) being the first people to the region, then the Thule, and then the Inuit. The first European to visit the bay was John Davis (1550–1605) in 1585, with Muscovy Company employee William Baffin and Robert Bylot delineating the bay over five trips from 1612 to 1616. John Ross (1777–1856) visited the area in 1818. Presently, there are several Inuit villages along the Baffin Bay coasts, such as Arctic Bay (73° 2′N 85° 9′W), Pond Inlet (72° 41′N 77° 57′W), and Clyde River (70° 28′N 68° 35′W).

Most of the year, Baffin Bay is ice covered and is hazardous to travel due to icebergs. In the northern portion of the bay is a larger polynya measuring more than 31,000 square miles (80,000 sq. km). This North Water Polynya makes the Baffin Bay productive for the entire food chain, such as phytoplankton, copepods, algae, fish, birds, and mammals. Two-thirds of the world population of little auks and thick-billed murres breed on the shores of Baffin Bay. More than 80 percent of the world's narwhals are found in Baffin Bay and are year-round residents. Baffin Bay is home to almost a dozen mammal species and more than 100 fish. Common fish species in Baffin Bay include Arctic char, polar cod, Arctic flounder, halibut, turbot, four-horned sculpins, capelin, and herring. Baffin Bay and Davis Strait are home to large cold water reefs, sponges, clams, shrimp, and echinoderm species.

The Baffin Bay shores are mostly covered by ice, snow, and rocks and scantly covered with low biotic diversity and simple vegetation. The vegetation that is present consists of about 400 plant and tree species consisting of prostrate and hemiprostrate dwarf shrubs, and mosses, low-growing forbs, sedges, shrubs, rushes, and lichens. Vegetation grows better in the wetter areas than in drier areas. In the wet areas, vegetation coverage can reach 60 percent. Typical mosses are turgid aulacomnium, tomentypnum, juniper polytrichum, and splendid feather moss. Lichen species include *Cetrariella deliseii*, chocolate chip, and whiteworm. Other

Icebreaking tankers, the SS *Manhattan* (left) and the Canadian ship *Louis S. St. Laurent*, crunch through the snow-covered ice of northern Baffin Bay, May 22, 1970. Arctic ice coverage had receded to record lows raising the prospect of greater maritime traffic through the long-sought waterway known as the Northwest Passage. (AP Photo)

vegetation includes tundra grass, Arctic and polar willows, mountain avens, various berries, mushrooms, river beauty, purple saxifrage, Arctic poppies, and seaweed from the ocean. All vegetation is vulnerable to frost at any time.

Birds present year-round are the gyrfalcon, snowy owl, common raven, and rock and willow ptarmigan. Most of the birds found in the Baffin Coastal Tundra and Baffin Bay/Davis Strait are migratory. Common migratory geese, swans, and ducks are the snow, Ross, Brant, and Canadian geese; Tundra swan; king and common eider, surf scooter, and long-tailed duck. There are several loons such as the red-throated, Pacific, common, and yellow-billed loon as well as plovers (white-faced, American golden plover, semipalmated). Birds of prey include the rough-legged hawk, Peregrine falcon, and short-eared owl. Other common migratory birds include the sandhill cranes, Arctic terns, thick-billed murres, black guillemots, black-legged kittiwakes, horned larks, wheatear thrush, savanna sparrows, Lapland longspurs, snow buntings, and redpolls (common, Greenland, and Arctic). This ecoregion has no reptiles or amphibians.

Andrew J. Hund

See also: Arctic Camel; Arctic Salmon; Foxe Basin; Greenland; Inuit

Further Reading

Greene, C. H., et al. "Arctic Climate Change and Its Impacts on the Ecology of the North Atlantic." *Ecology* 89, no. 11 (2008): S24–38.

Zweng, M. M., and A. Munchow. "Warming and Freshening of Baffin Bay, 1916–2003." *Journal of Geophysical Research* 111 (2006): 1–13.

Barents Euro-Arctic Council (BEAC)

The Barents Euro-Arctic Council (BEAC) was officially formed on January 11, 1993. The BEAC formation was initiated by the Norwegian minister of foreign affairs, Thorvald Stoltenberg. The BEAC is made up of two bodies: the Barents Euro-Arctic Council (an intergovernmental body) and the Barents Regional Council (BRC; an interregional body). The official BEAC members are from Denmark, Finland, Iceland, Norway, the Russia Federation, Sweden, and the European Commission. The Ministries of Foreign Affairs from the respective countries are representatives to the BEAC. The BEAC chair is selected from the group from the one of the four countries of Norway, Finland, Russia Federation, and Sweden, on a two-year rotating schedule. At the XIII BEAC Ministerial Session at Kiruna, Sweden, in October 2011, Norway took over the BEAC Chairmanship. The prior BEAC chairmanship belonged to Sweden from 2009 to 2011.

The focus of the BEAC is to be an intergovernmental and interregional body to discuss, cooperate, and deliberate issues affecting the Barents region. The Barents region is a regional and international cooperative formed after the fall of the Soviet Union. It is primarily a social and political group with an overall objective of advancing and discussing the sustainable development of the region. A current project of the BEAC is the planning and the development of the 930-mile (1,500-km) Barents Road. The Barents Road is based on an ancient trade route that runs from Bodø, Norway, across Sweden and Finland to Murmansk, Russia.

The countries included as regular BEAC members are those roughly bordering the Barents Sea. The Barents region is considered to stretch from Nordland (66° 50′N 14° 40′E) in Northern Norway to the Kola Peninsula (67° 41′N 35° 56′E) to Novaya Zemlya in the Russian Federation. The southern borders are considered the Gulf of Bothnia (63° N 20° E) of the Baltic Sea between Sweden and Finland, over to Ladoga Lake (61° N 31° 30′E) near St. Petersburg and Lake Onega (61° 41′N 35° 39′E). The Barents region has a population of around 6 million people, of which around 75 percent live in the Russian Federation.

Included in the BEAC membership are three northern indigenous groups, which are the Nenets and the Vepsians (or Veps) of the Russian Federation and the Sami people of Norway, Sweden, Finland, and the Kola Peninsula of the Russian

Federation. These northern indigenous groups form the Working Group of Indigenous Peoples (WGIP) and work in an advisory capacity for the BEAC and BRC as well as participate in all the Barents Working Groups. The WGIP chair is a member of both the Committee of Senior Officials (CSO) and the BRC. Since 2011, representatives from each indigenous group became participants in the CSO, and the indigenous groups are represented at the BEAC Ministerial sessions. The BEAC membership also includes observer states. The observer states are Canada, France, Germany, Italy, Japan, the Netherlands, Poland, the United Kingdom, and the United States.

The BRC is made up of 13 regional locations and a representative from the three indigenous groups. The 13 regions, counties, or provinces represented are in Finland (Kainuu, Lapland, and Oulu); Norway (Finnmark, Nordland, and Troms), Russia (Arkhangelsk, Karelia, Komi, Murmansk, and Nenets), and Sweden (Norrbotten and Västerbotten counties). In 2008, a county in Finland (North Karelia) was approved for observer status. The four countries rotate chairmanship duties of the cooperative every two years. In October 2013 Finland took over the BRC chairmanship, which will expire in October 2015.

Besides the two main bodies, there are a number of committees and working groups. Within the BEAC, the committee and working groups are Joint Committee on Rescue Cooperation, Working Group on Customs Cooperation, Working Group on Economic Cooperation (WGEC), Working Group on Environment, and the Steering Committee for the Barents Euro-Arctic Transport Area. A subgroup of the WGEC is the Barents Forest Sector Task Force. Each of these BEAC committees and working groups focus on and work on intergovernmental issues relating to their respective title. The BRC working groups include the Regional Working Group on Environment, the Regional Working Group on Investments and Economic Cooperation, and the Regional Working Group on Transport and Logistics. Each of these BRC committees and working groups focuses on and work on interregional issues relating to their respective title.

The BEAC and BRC have joint working groups, such as the Joint Working Group on Culture, the Joint Working Group on Education and Research, the Joint Working Group on Energy, the Joint Working Group on Health and Related Social Issues (JWGHS), the Joint Working Group on Tourism, and the Joint Working Group on Youth. The JWGHS has three subgroups, which include the Steering Committee on Children and Youth at Risk, the Barents Tuberculosis Programme, and the Barents HIV/AIDS Programme. The BEAC and the BRC on occasion will coordinate with other northern and Arctic groups, such as the Arctic Council, the Council of Baltic Sea States, and the Nordic Council of Ministers.

Andrew J. Hund

See also: Arctic Council

Further Reading

Barents Euro-Arctic Council Website. http://www.beac.st/in-English/Barents-Euro-Arctic-Council. Accessed January 8, 2014.

Joenniemi, P., and A. Sergounin. *Russia and the EU's Northern Dimension.* Paper presented at the ISA Convention, Chicago, 2001.

Joenniemi, P., and C. -E. Stålvant, eds. *Baltic Sea Politics: Achievements and Challenges. Nordic Debate.* Stockholm, Sweden: Nordic Council, 1995.

Barents Sea

The Barents Sea is a marginal sea of the Arctic Ocean and is located off the coast of Norway and Russia between the Norwegian (west) and Kara (east) Seas. The western sea border is the Svalbard (78° N 16° E). The eastern sea border is the Kara Strait, Novaya Zemlya Archipelago (74° N 56° E), and Franz Josef Land (80° 34′N 54° 47′E). The Barents Sea was formerly known as the "Sea of Murmans" by the Russians.

The Barents Sea's northern border is Cape Kohlsaat (81° 14′N 65° 10′E) of Graham Bell Island, on the eastern side of Franz Josef Land, Russia. The western northern border is Cape Leigh Smith on North East Land of Archipelago of Svalbard, Norway. Russia and Norway have an ongoing border dispute over the Barents Sea. This is called the Barents Sea "loophole." The main difference between Russia and Norway was whether to determine the area based on the median line (favored by Norway) or meridian (favored by Russia). In 2010, Russia and Norway reached an agreement to divide a 67,000-square-mile (175,000-sq.-km) disputed area and resolve fishery protection and management and ownership of oil reserves. The Barents Sea is a significant fishery, and it is estimated to have 250 million recoverable barrels of oil.

Several rivers empty into the Barents Sea, such as the Indiga, Kola, Korotaikha, Oma, Pechenga, Pesha, Soima, Tuloma, and Voron'ya Rivers. The total area of the Barents Sea is about 542,473 square miles (1,405,000 sq. km). The average depth is about 760 ft. (230 m) with a maximum depth of around 1,500 ft. (450 m). The shallow Barents Sea has a highly productive seafloor. The Barents Sea supports more than 40 different species, 20 million seabirds, and more than 1,500 nesting colonies in the summer season. The most common species are the thick-billed murre, black-legged kittiwake, and little auks. Other common seabirds are cormorants and various gulls.

There is radioactive contamination in the Barents Sea. Nuclear waste has been dumped on the western and eastern sides of Novaya Zemlya, from 1960 to 1991, in the Barents Sea and Kara Sea, respectively. Low-level radioactive liquid waste has also been dumped in the open Barents and Kara Seas. Scientific assessments by the International Atomic Energy Agency claimed that the radioactive contamination per individual of the Kara and Barents Seas ranges from 1 to 20 microsieverts annually.

There have also been nuclear accidents in the Barents Sea. For example, on August 28, 2003, on a recovery mission, the pontoons supporting the submarine K-159 broke free resulting in its rolling and sinking down 781 ft. (238 m) to the Barents Sea seafloor. Nine people perished in the incident. Another incident was that involving K-278 sub in which its compressed air system enabled a fire to burn for about five hours, until the sub sank 5,510 ft. (1680 m) to the seafloor of the Barents Sea. On August 12, 2000, the Russian Oscar II class submarine K-141 Kursk sank in the Barents Sea.

Andrew J. Hund

See also: Arctic Basin; Arctic Ocean; Benthic Community; Continental Shelf Claims in the Arctic; Kara Sea; United Nations Convention on the Law of the Sea (UNCLOS)

Further Reading

Matishov, G., N. Golubeva, G. Titova, A. Sydnes, and B. Voegele. United Nations Environment Programme (UNEP). Barents Sea, GIWA Regional Assessment 11: The Barents Sea Report. Kalmar, Sweden: University of Kalmar, 2004.

Bartlett, Robert "Bob" Abram (1875–1946)

The evacuated crew watched from the ice, the strains of Chopin's funeral march streaming through the Arctic air as the ship slowly sank. Alone on the foundering ship, Captain Bartlett removed this last record from the gramophone, threw it into the stove, walked calmly to the lowering deck, and stepped off onto the ice. Such cinematic moments were the stuff of Captain Robert Abram Bartlett's long career as a sealer, a skipper, an Arctic explorer, a speaker, and a writer. The 1914 sinking of the *Karluk* and Bartlett's subsequent 700-mile trek, with an Inuk hunter named Kataktovik, across the Chukchi Sea ice fields to Siberia may have been his most dramatic accomplishment. Bartlett accompanied the controversial Admiral Robert Peary on his trek to the North Pole, which Peary claimed to have reached. In this capacity, Bartlett was the first captain to take a ship north of 88°. Bartlett's enduring loyalty to the dubious Peary was one of many marks of his own unfathomable character.

Bartlett was the eldest of the 10 children of Captain William Bartlett and his wife Mary Jemima Leamon, who were among the aristocratic residents of Brigus, Newfoundland, an affluent fishing and sealing town. Born in the summer of 1875, Bob spent many summers fishing with his father, a celebrated sealing skipper who held the record catch for the Gulf of St. Lawrence. As a boy, Bob was a witness to the 1885 Labrador or Eskimo Coast Disaster in which 80 fishing ships were wrecked and 75 people killed, many of them women and children from Newfoundland who went north annually as part of family fishing enterprises. Captain William Bartlett rescued dozens of survivors, taking them back to the island in the *Panther.*

This would not be Bob's only time facing down the cruelty of the sea. As a young man, he was shipwrecked off Newfoundland and spent the Christmas season nursing his wounds, most of them psychological. With surprisingly gentle encouragement from his normally stern father, to whom men would nervously doff their caps, Bob returned to the sea in the spring on a sealing vessel—and never looked back. He was ready for the *Karluk* episode when it came and for another crisis three years later when he saved the survivors of Donald Baxter MacMillan's Crocker Land Expedition, who had been trapped in ice for no less than four years.

Captain Bartlett had been rewarded with many honors over his life. For his successful rescue of the *Karluk* men stranded on desolate Wrangel Island, Bartlett was rewarded by the Royal Geographical Society. In 1909, the National Geographic Society awarded him the Hubbard Medal for his achievements in exploration and research. The next year, he was awarded an honorary fellowship from the American Geographical Society. After his death, his childhood home, Hawthorne Cottage, became a national historic site, a Canadian stamp was issued in his honor, and a Canadian Coast Guard ship was named after him even though he was a U.S. citizen. Even though he was born in Newfoundland, he became an American citizen (Newfoundland joined Canada only in 1949, after Bartlett's death).

Bartlett led numerous scientific expeditions to the Arctic, the place that gave him true peace. These trips were sponsored by various museums, such as the Cleveland Museum of Natural History, for which he collected specimens such as polar bears, musk ox, murres, and the tiny Arctic flowers he loved and gathered as a hobbyist. These voyages were also funded by paying and working guests—young men from wealthy New England and New York families who, in their words, sought manly pursuits for their sons. Bartlett never married, and the love of his life seems to have been his mother.

Bartlett gave his papers to Bowdoin College, Maine, but did not keep copies of most of the letters he wrote himself. His books were almost certainly ghostwritten. He kept no diary. He remains a hard man to read. But he did leave us with the lasting image of Chopin and the sinking *Karluk* and, just as revealingly, in his tiny black appointment book, he had pasted the verses of Omar Khayyam.

Maura Hanrahan

See also: Bering, Vitus Jonassen (1681–1741); Cook, James (1728–1779); Cook, James, Voyages of; Kotzebue, Otto von (1787–1846); Peary, Robert Edwin (1856–1920); Rasmussen, Knud (1879–1933)

Further Reading

Bartlett, R., and R. Hale. *The Last Voyage of the* Karluk. Toronto: McLelland, Goodchild and Stewart, 1916.

Horwood, H. *Bartlett: The Great Canadian Explorer.* New York: Doubleday, 1977.

Bearded Seal

Bearded seals (*Erignathus barbatus*) are the largest of the northern seals from the family Phocidae. Bearded seals have a patchy circumpolar distribution, in north Canada, Greenland, Barents Sea, Russian Arctic, Bering, and Okhotsk Seas. Currently, two subspecies are recognized: the Pacific bearded seal (*Erignathus barbatus nauticus*) inhabits the Bering and Okhotsk Seas and is also found near Hokkaido, Japan, and the Atlantic bearded seal (*Erignathus barbatus barbatus*) that inhabits the western Laptev Sea, Barents Sea, and North Atlantic Ocean, as far south as the Gulf of St. Lawrence, Iceland, and Norway. However, the validity of these subspecies has been questioned.

Bearded seals are large and heavy bodied with comparatively small head, small eyes, and short, square-shaped front flippers with strong claws. They have conspicuous and very abundant long pale whiskers, often forming a dense patch that gives the species the common name. Adults can reach 6.5–8.2 ft. (2–2.5 m) and have pale or dark gray to brown color, sometimes with irregular light-colored patches. The average weight is about 550–660 pounds (250–300 kg) but varies a lot during the annual cycle. Females are larger than males and can reach more than 930 pounds (425 kg) in the spring.

The bearded seal is an ice-obligate species that relies on sea ice as a platform for resting, breeding, molting, and hauling out, and the availability of sea ice is its major habitat determinant. They generally inhabit areas of shallow water of less than 650 ft. (200 m) that are at least seasonally ice covered. They prefer drifting pack ice over

Bearded seal in Alaska's Bering Sea. (National Oceanic and Atmospheric Administration) shallow water shelves and generally prefer to stay near polynyas and other natural openings in sea ice for breathing, hauling out, and access to prey.

Their movement patterns are highly dependent on the local ice conditions. In the spring, large numbers of bearded seals move north as the seasonal sea ice retreats and subsequently move south in the autumn/winter as sea ice forms. Bearded seals feed predominantly on or near the bottom and dive to depths around 325 ft. (100 m), although they are capable of deeper dives, up to 980 ft. (300 m), and one-year-old seals have been recorded diving down to almost 1,650 ft. (500 m). They can stay under the water up to 19 minutes, but usually the dive is shorter than 10 minutes. They eat clams, shrimps, crabs, octopuses, fish, and other prey that can be found in, on, or near sea bottom. The diet varies by age, location, season, and possibly also changes in prey availability in marine communities.

Bearded seals usually occur at quite low densities and are typically solitary animals, except when breeding or molting. When sea ice is limited, they form small, loose aggregations, for example, at the time of molting in midsummer. Bearded seals live usually 20–25 years (maximum 31 years) and reach their final body size at the age of 9–10 years. Females become sexually mature at 3–6 years and males at 6–7 years. Mating takes place at the end of lactation period. Bearded seals are highly vocal, especially during the breeding season when males sing to attract females or when males defend their aquatic territory. Their song can be heard for up to almost 20 km. They give birth to a single pup in the spring, from March to May. Pups are born on small drifting ice floes in shallow areas and enter the water and swim only hours after birth. They grow rapidly at an average rate of more than 7 pounds (3.3 kg) per day and become proficient divers during the next 18–24 days. During this time, pups consume an average of more than two gallons (8 liters) of milk a day and reach about 220 pounds (100 kg) by the time they are weaned. Mothers spend more than 90 percent of their time in the water while caring for a dependent pup. The amount of time spent in the water and the pup's ability to swim quickly after the birth are probably an adaptation to polar bear predation.

The size of the global population is not known, and crude estimates suggest a population of 500,000, of which more than 50 percent stay in the Bering Sea. Polar bears, killer whales, Greenland sharks, and walruses are important predators upon bearded seals. Bearded seals have been hunted by indigenous peoples of the Arctic for subsistence for thousands of years and are still hunted. Current levels of subsistence harvest are not well known and are estimated to be annually approximately 6,800 in the United States, roughly 2,400 in Canada, and 500–1,000 in Greenland. They are protected by various laws, and subsistence hunting by indigenous people of the Arctic is allowed for personal use and not regulated unless populations are depleted.

Monika Kędra

See also: Antarctic Fur Seals; Crabeater Seal; Harp Seal; Hooded Seal; Leopard Seal; Polar Bear; Ribbon Seal; Ringed Seal; Ross Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Spotted Seal; Weddell Seal

Further Reading

Berta, A., and M. Churchill. "Pinniped Taxonomy: Review of Currently Recognized Species and Subspecies, and Evidence Used for Their Description." *Mammal Review* 42 (2012): 207–34.

Charrier, I., et al. "Bearded Seal Males Perceive Geographic Variation in Their Trills." *Behavioral Ecology Sociobiology* 64 (2013): 1679–89.

Bear Island (*Bjørnøya*)

Bear Island (Norwegian name *Bjørnøya*) (74° 31′N 19° 1′E) is an uninhabited Arctic island located in the Barents Sea approximately halfway between Cape North (Norway) and the Spitsbergen Archipelago. The size of the island is about 69 square miles (178 sq. km) with a maximum north–south extension of around 12.5 miles (20 km) and about 9.5 miles (15.5 km) west–east. The tallest peak on Bear Island is Myserifjellet (74° 26′N 19° 10′E) at around 1,750 ft. (536 m). Temperatures are moderate for the latitude with a January mean of 17.4°F (−8.1°C) and 40°F (4.4°C) mean temperature during July and August. Besides providing a potential base for fishing and whaling operations, coal deposits have attracted attention for commercial activities during several historical periods.

The first recorded sighting of the island dates back to June 10, 1596, when Dutch explorers Wilhelm Barents (1550–1597) and Jacob van Heemskerk (1567–1607) saw the island. Despite Bear Island being considered as *terra nullius*, several nations claimed sovereignty over the island during the centuries or used it as an operational base for the hunting of ocean mammals like walrus. In the context of these economic activities, a number of small settlements were established. For example, a small Russian settlement in the eighteenth century, or the coal mining settlement of Tunheim at the beginning of the twentieth century, but all of them given up after short periods. Today, the only permanent settlement on Bear Island is the meteorological station at Herwighamna.

The question of sovereignty over Bear Island became particularly relevant when steam-powered fishing and whaling vessels were introduced to the European fleets at the end of the nineteenth century, and the German Empire and Russia recognized the geostrategic importance of the island at the entrance to the Barents Sea. The German Sea Fisheries Association with the support from the imperial navy sent out expeditions to Bear Island in 1899. Primary objective of the expedition was to explore options for a fisheries and whaling station, but an obvious secondary objective was claiming the island for the German Empire. Russia's reaction was also sending out a naval vessel, and finally the conflict was solved with none of the nations claiming sovereignty. The question of sovereignty was finally ended with the Spitsbergen Treaty of 1920. While giving sovereignty over the island, the treaty established a controlled open access regime for economic activities of all treaty nations and prohibited any kind of military installations in the treaty area. During World War II, Bear Island gained attraction due to its proximity to allied convoy routes, but was not occupied by adversaries.

Opposite of Spitsbergen today, cruise ships only rarely visit Bear Island, leaving the island largely to nature and a few scientists, mainly ornithologists. A noticeable threat for the ecology of the island and the surrounding sea consisted of the wreck of the Soviet nuclear-powered attack submarine K-278 *Komsomolets*, which sank in April 1989. The sunken submarine is located 118 miles (190 km) southwest of Bear Island. The nuclear reactor and its radioactive fuel are still onboard the wreck, and ongoing corrosion might cause a radioactive pollution in the future.

Ingo Heidbrink

See also: Abandoned Arctic Islands; Barents Sea; Sunken Soviet/Russian Nuclear Submarines in Arctic

Further Reading

Gray, L. *Spitsbergen and Bear Island.* Washington, DC: Government Printing Office (GPO), 1919.

Hagenæs-Kjelldahl, D., and L. Hansen. *Bear Island.* London: IK Foundation, 2006.

Beaufort Sea

The Beaufort Sea represents an extension of the Arctic Ocean situated between Alaska, northwestern mainland Canada (Yukon, Northwest Territories), and the western islands of the Canadian Arctic Archipelago (Banks Island, southwestern Prince Patrick Island). To the north, it connects to the Arctic Ocean proper, while to the west it borders the Chukchi Sea, another marginal sea of the Arctic Ocean. In total, it covers an area of approximately 18,000 square miles (476,000 sq. km). Named after Sir Francis Beaufort (1774–1857), rear admiral of the Royal Navy, the sea was navigated by Robert McClure onboard HMS *Investigator* in 1850 in the search for the lost Franklin Expedition into the Northwest Passage. Today, the sea is shared by the United States and Canada, though there is a territorial dispute over seaways from the Alaska-Yukon border. The Beaufort Sea coast is sparsely populated with Tuktoyaktuk, Canada (population 930), and Prudhoe Bay, Alaska (population 2,150), being the major settlements. Prudhoe Bay is the Trans-Alaska Pipeline starting point, which transports crude oil southward from Prudhoe Bay. The latter reflects the large reserves of oil and natural gas underneath the seafloor of the Beaufort Sea. Exploration of these reserves, first started in the 1950s, has continued to the present day, with major oil- and gas-fields discovered in the past few decades.

The Beaufort Sea is frozen over for much of the year, though parts of it become ice free during summer (August–September). The relatively narrow coastal strip

Aerial view of Prudhoe Bay, Alaska. One of the world's largest oil fields, it serves the Trans-Alaska Pipeline. (U.S. Fish and Wildlife Service)

of summer open water has greatly expanded in the early twentieth century so that larger parts are now seasonally ice free. This was evident in the sea ice minimum year of 2012, when virtually all of the sea became open during summer. Nevertheless, sea ice still dominates the Beaufort Sea for much of the year. Near the coast, sea ice is attached to the land or landfast, whereas farther offshore, it can drift with the wind and currents as pack ice. The blanket of sea ice covering the sea is not uniform, but open areas (flaw leads and polynyas) occur throughout. Ice breaks up in late May, promoted by the seasonal river discharge near the coasts. By late September, most of the Beaufort Sea is ice free, though freeze-up occurs in mid to late October.

Close to the coast, the influence of rivers is substantial. In particular, Canada's longest river, the Mackenzie River, flows into the Beaufort Sea and constitutes an important, though seasonally fluctuating, source of freshwater, nutrients, and sediments for the sea. Water depths in the Beaufort Sea are relatively shallow close to the coast along the 55-mile (90-km) wide continental shelf, typically less than 200 ft. (60 m). Deep water is found farther offshore, where depths reach a maximum of 16,000 ft. (5000 m). The oceanography of the Beaufort Sea is strongly influenced by the Beaufort Gyre, one of two major current systems of the Arctic Ocean (the other being the Transpolar Drift). This wind-driven clockwise current transports sea ice and surface waters westward. Sea ice in the Beaufort Gyre can be circulated for several years, attaining maximum thicknesses and a ridged appearance (due to floes bumping into each other) compared with other regions of the Arctic Ocean. Below the surface water driven by the Beaufort Gyre is a reversed (counterclockwise) flow of water initiated by the Beaufort Undercurrent, which flows eastward near the coast in relatively shallow water (165 ft. [50 m] depth). Water masses of both Pacific and Atlantic Oceans occur in the Beaufort Sea. Pacific water flows in via the Bering Strait, the waterway between Alaska and Siberia. Deeper waters (650 ft. [200 m] depth and more) are of Atlantic origin, and transported into the Beaufort Sea via the Transpolar Drift, which moves sea ice from the Arctic coast of Russia across the Arctic Ocean basin and eventually into the North Atlantic via the eastern coast of Greenland. Both Pacific and Atlantic waters are moved eastward along the continental margin by the Beaufort Undercurrent.

The Beaufort Sea became an important whaling ground in the late nineteenth century. It is still rich in marine mammals, though modern-day hunting (as well as fishing) is largely restricted to local inhabitants. The world's largest stock of bowhead whales frequents the area, along with sizable populations of beluga whales and walrus, as well as seals (bearded seal, ringed seal) and polar bears. These animals ultimately rely on phytoplankton (photosynthesizing algae) productivity, which provides food for zooplankton. In turn, this supplies food for mollusks, crustaceans, seabirds, and fish, including regionally abundant species such as Arctic cod, polar cod, and Pacific herring.

Anna J. Pieńkowski

See also: Arctic Basin; Arctic Ocean; Beaufort Sea Dispute; Chukchi Sea; Continental Shelf Claims in the Arctic; United Nations Convention on the Law of the Sea (UNCLOS)

Further Reading

Johnston, D., and P. Saunders. *Ocean Boundary Making: Regional Issues and Developments.* London: Taylor and Francis, 1988, pp. 48–49.

Lawson, K. "Delimiting Continental Shelf Boundaries in the Arctic: The United States—Canada Beaufort Sea Boundary." *Virginia International Law Journal* 22 (1981): 221–46.

Beaufort Sea Dispute

The Beaufort Sea dispute is a disagreement over the maritime boundary between the United States and Canada. The dispute centers on the exact location of the Beaufort Sea international boundary between Alaska and the Yukon. The Canadians claim the boundary should run along 141st meridian west. The basis for the Canadian government's claim is the Treaty of St. Petersburg of 1825. This treaty was signed by the Russian Empire and the United Kingdom. Canada, being the successor to the United Kingdom, argues that the Treaty of St. Petersburg establishes their claim to the Beaufort Sea. The United States rejects the 141st meridian west boundary line. The United States maintains the boundary runs straight out conforming to an equidistance line from the Alaska coast. The difference between the two countries' assumed boundaries resembles a wedge and is an area just under 8,300 square miles (21,000 sq. km).

The Beaufort Sea is a marginal sea to the Arctic Ocean. In the area where Alaska and the Yukon meet, there is continental shelf running offshore for about 40 nautical miles near the 141st meridian west. This continental shelf runs from Russia, under the Chukchi Sea and along the northern Alaska and the Canadian provinces of the Yukon and Northwest Territories to approximately the Amundsen Gulf. Geological studies have uncovered hydrocarbon potential like Prudhoe Bay State #1 oil around Tuktoyaktuk on the Canadian side. To the west of the Tuktoyaktuk area, in Alaska, is the Prudhoe Bay State #1 oil well in Prudhoe Bay off the coast of Alaska (70° 18′N 148° 43′W). In 1968, Prudhoe Bay was a major discovery and the largest oil field in North America measuring 213,543 acres (86,418 hectares). Original estimates claimed that the oil well had 25 billion barrels of oil with 13 billion barrels considered recoverable. Prudhoe Bay also contained 26,000 billion cubic feet of natural gas.

Canada and the United States both agree with the United Nations Convention on the Law of the Sea (UNCLOS) in regard to the continental shelf provision. The Convention on the Continental Shelf specifies that coastal states have authority over their continental shelf and the areas surrounding them. Under UNCLOS, coastal states are granted exclusive economic zones, which give exclusive development rights over all natural resources on continental shelf and territorial waters, which grant coastal states control over their fishing, mineral, and oil rights up to 200 nautical miles (230 miles; 370 km) from the coast. The Beaufort Sea area in dispute has considerable natural resources, especially natural gas and oil resources.

Both countries agree that the maritime boundary should be equitable, as established under the International Court of Justice. However, neither the United States nor Canada can agree on what is equitable. The United States argues in favor of the equidistance principle as an equitable boundary, while Canada argues the equidistance principle would not be an equitable boundary and would unfairly favor the United States. The Canadians note that the Yukon coast is curved in (concave) and the Alaska coast is curved out (convex). The different coastal shapes results in the United States getting a larger area of the Beaufort Sea than Canada is willing to relinquish. Both countries are not pushing for a resolution in the International Court of Justice to the maritime boundary. Both countries do agree and have cooperated on measures aimed at preserving and protecting the coastal waters environment.

Canada and the United States have issued oil exploration permits in the disputed area of the Beaufort Sea, but have placed a moratorium on further exploration. Up to 2004, the United States has leased eight ocean surface plots in the area with the intention of bringing possible oil reserves to market. The Canadian government has lodged a diplomatic complaint over the United States' leasing. The Canadian complaint is problematic because the United States for years has accepted the UNCLOS as customary law, but refused to ratify the treaty over objections to Part XI (International Seabed Authority [ISA]). As a result, no resolution over the Beaufort Sea has occurred, but if the United States ratified UNCLOS, Canadian could have their case heard in a tribunal.

The U.S. secretary of commerce, Gary Locke, in 2009 announced a fishing moratorium on the Beaufort Sea. This moratorium included the disputed area. In response, the Canadian government filed a diplomatic note with the United States over the fishing moratorium. In 2010, the United States and Canada started negotiations over resolving the Beaufort Sea differences. The two sides are continuing to discuss the disputed area and working on an equitable solution.

Andrew J. Hund

See also: Arctic Ocean; Beaufort Sea; Continental Shelf Claims in the Arctic; Sector Principle in the Arctic; United Nations Convention on the Law of the Sea (UNCLOS)

Further Reading

"Convention between Great Britain and Russia concerning the Limits of Their Respective Possessions on the North-West Coast of America and the Navigation of the Pacific Ocean, 16 February 1825: Article 3," 75 Consolidated Treaty Series (CTS) 95.

"Convention Ceding Alaska between Russia and the United States, 30 March 1867," 134 CTS 331, 15 Stat 539. Treaty Series No. 301.

Belgrano II Antarctic Station

In the history of Antarctic Stations, three of them had the name "Belgrano": stations Belgrano I, Belgrano II, and Belgrano III. All of the stations were built and managed by Argentina. Belgrano I station was founded in 1955, being the southernmost station built by Argentina. In 1979, Belgrano II station was erected in replacement of Belgrano I. Later, another station was built, Belgrano III, which functioned from 1980 until 1984. The only one of the three bases that is still in operation is the Belgrano II. It remains today as the southernmost of the permanent scientific stations of Argentina.

The Idea

Belgrano I station was inaugurated on January 18, 1955, to ensure Argentinean presence south of the Weddell Sea, to start scientific research activities, and as a starting point for a proposed expedition to the South Pole (which would take place years later, in 1965). It was the southernmost station in all the Antarctic Continent until the foundation of U.S. Station Amundsen-Scott in the South Pole, one year later.

It was placed about 2 miles (3 km) off the coast on the ice barrier. The initial crew of 14 men who stayed for the first Antarctic year-round camping endured outside temperatures below −76°F (−60°C) with winds of more than 150 mph (250 km/h). During winter, the station was completely covered by ice, leaving only chimneys, antennas, and towers free of snow. When the ice shelf began to destabilize, the station had to be abandoned for safety reasons. Some years after it was no longer inhabited, the ice area where the base was located disconnected into a large tabular iceberg of about 60 miles (100 km) long. The remains of the buildings drifted in the ocean on top of the iceberg and have not been found. To continue with the scientific projects that started at Belgrano I, Argentina government decided to build a new station.

Belgrano II

On February 5, 1979, Belgrano II replaced Belgrano I. After the previous experience, it was decided to establish the new facilities on land. The location and characteristics of the new emplacement of the station had to be carefully chosen to continue with the auroral, atmospheric, and meteorological studies. Belgrano II was built and is located on the largest rock promontory of Bertrab Nunatak, in the Filchner-Ronne Ice Barrier, on the southern edge of the Weddell Sea (77° 52 'S 34° 37'W). It is approximately 800 miles (1,300 km) north of the South Pole and is the southernmost station built on solid ground.

Since the station is about 6 miles (10 km) away from the ocean, and accessible only for a few weeks of the year, access to the area is complicated and only possible by helicopter or small aircrafts. Usually, resupply of the station and rotation of personnel is done by ship to the ice edge and then on to Belgrano II by helicopter or ski aircrafts.

Extreme Conditions

One of the most interesting features of the station is that due to its latitude, it has four months of daylight, four months of twilight (low daylight and short nights) and four months of polar night. Thanks to this, the magnificent aurora australis is common during the polar twilight and night periods. The average temperatures range from 40º F to −76º F (5ºC to −60ºC). Flora and fauna are scarce around the station and are highly specialized for living in the frigid climate. Flora in the area is represented mainly by mosses and lichens (very particularly, organisms adapted to extreme temperatures and drought) that live on rocks, and also unicellular algae that live under the ice. Fauna is present only during the Antarctic summer, represented mostly by birds: skuas, petrels, seagulls, and eventually migratory species that are traveling south.

Activities in the Station

The station operates all year-round, and the activities carried out by the personnel (usually between 18 and 20 men) are related to science. Although the logistics of the Argentine Antarctic stations is carried out by military, their presence relates only to science support. General station tasks are primarily scientific: maintenance of shelters, survey, and exploration; support for foreign scientific activity; communications; and operating and maintenance of satellite dishes.

The studies are conducted at the Belgrano Laboratory (LABEL, Laboratorio Belgrano), which operates a full meteorological station and collects data for several scientific programs from different areas such as ozone layer and southern aurora studies jointly with Spain and Italy; astronomic observations; magnetic field variation analysis; cosmic rays and atmospheric studies; and solar energy resources through a satellite station that is allowed to transmit data on a real-time basis. Since February 1998, in cooperation with AWI joint program from Germany, the lab has a geodetic GPS receiver and a seismological recording station that is the southernmost seismograph operating over firm rock.

Luciana M. Motta

See also: Antarctic Programs and Research Stations/Bases

Further Reading

Anav, A., M. Ciattaglia, M. Di Menno, C. Moriconi, and C. Rafanelli. "Five Years of Total Ozone Measurements at Belgrano II Antarctic Station—Fifth WMO Meeting on Brewer Operation, Calibration and Data Reporting." Halkidiki, Greece, September 16–18, 1998.

Bellingshausen Sea

The Bellingshausen Sea is a marginal sea of the Southern Ocean, located off of the Antarctic coast between the Antarctic Peninsula (west) and Amundsen Sea (east). On the western border is the western side of the Alexander Island (71° S 70° W), while the eastern border is Cape Flying Fish on Thurston Island. The southern border is the southern part of Peter I Island (68° 51′S 90° 35′W). The northern border is the Antarctic coast and includes the English, Bryan, and Eights coasts. The Bellingshausen Sea is named after Admiral Fabian Gottlieb Thaddeus von Bellingshausen (1778–1852), who explored the area in 1821.

The Bellingshausen Sea covers an area more than 180,000 square miles (480,000 sq. km). There are three major islands in the Bellingshausen Sea, which are Alexander I, Peter I, and Charcot Islands. Alexander I Island is the largest Antarctica Island at about 240 miles (390 km) long and 50 miles (80 km) wide. It is separated from the mainland by Marguerite Bay and the George VI Sound. The George VI

Ice Shelf fills in the George VI Sound with ice, making an ice bridge from Palmer Land to Alexander I Island. Peter I Island (68° 51′S 90° 35′W) is a volcanic island approximately 250 miles (400 km) off the Antarctic coast. It is about 11 miles (18 km) long and around 5 miles (8 km) wide. The Charcot Island (69° 45′S 75° 15′W) is about 30 miles (48 km) long and around 25 miles (40 km) wide and lies approximately 55 miles (89 km) west from Alexander I Island. Other notable islands in the Bellingshausen Sea are Latady (70° 45′S 74° 35′W), Smyley (72° 55′S 78° W), and Spaatz Islands (73° 12′S 75° W).

There are two significant bays in the Bellingshausen Sea, which are the Ronne Entrance and Marguerite Bay. The Ronne Entrance (72° 30′S 74° W) is in between George VI Sound (71° S 68° W) and the Bellingshausen Sea just southwest of Alexander Island. Marguerite Bay (68° 30′S 68° 30′W) is located between the Adelaide Island in the north, runs along the Fallieres Coast of the Antarctic Peninsula and Alexander I Island and the George VI Sound to the south. Within Marguerite Bay, there are several islands, such as Horseshoe (67° 51′S 67° 12′W), Lagotellerie (67° 53′S 67° 24′W), and Pourquoi Pas Islands (67° 41′S 67° 28′W). There are three research stations in Marguerite Bay, which are Argentina San Martin Base (68° 8′S 67° 6′W) and the British Antarctic Survey bases Rothera (67° 34′S 68° 8′W) and Fossil Bluff (71° 20′S 68° 17′W).

The maximum depth of the Bellingshausen Sea is approximately 14,000 ft. (4,400 m). Over 2 mya, an asteroid crashed into the Bellingshausen Sea. The asteroid is called the "Eltanin" and is estimated to be between 0.5 and 2.5 miles (0.8–4 km) in diameter. The impact of an asteroid of this size is estimated to have triggered a tsunami of more than 600 ft. (200 m) tall that crashed onto the Antarctica Peninsula and southern Chile.

Andrew J. Hund

See also: Amundsen Sea; Weddell Sea

Further Reading

Gersonde, R., T. T. Kyte, U. Frederichs, H. Bleil, G. Schenke, Kuhn, T. Frank. "The Late Pliocene Impact of the Eltanin Asteroid into the Southern Ocean—Documentation and Environmental Consequences." *Geophysical Research Abstracts* 7 (2005).

Turner, D., and N. Owens. *A Biogeochemical Study in the Bellingshausen Sea: Overview of the STERNA 1992 Expedition.* DSR II 42 (1995): 907–32.

Beluga Whale

The beluga whale (*Delphinapterus leucas*) is a small cetacean found in locations throughout the Arctic and subarctic regions. Although technically not a whale in that it belongs to the smaller toothed suborder of cetaceans that includes dolphins, the name is commonly used due to its popular associations, much as with the killer whale. The beluga is alone in its genus, sharing the Monodontidae family with only one other species: the narwhal. The beluga was first described by Peter Simon Pallas in 1776. Pallas, who was appointed to the St. Petersburg Academy of Sciences by Catherine II of Russia, discovered and described numerous animals during his expeditions to northern Russia. The English word "beluga" is a corruption of the Russian word for white (*belyy*). The beluga whale is not at all related to the beluga sturgeon of the Caspian and Black Sea regions.

The beluga is one of several cetaceans that lives exclusively in a polar region and as such enjoys anatomical advantages that facilitate its survival. Among these evolutionary advantages are its large stores of blubber for warmth (layers of up to 6 inches [15 cm]), white coloration for camouflage, and a large thyroid for increased metabolism. Unlike other cetaceans, Belugas shed their skin every season. During the winter months, the skin thickens to develop an extra layer, which is then rubbed off using the gravel of estuary riverbeds in their summering range. Perhaps the most interesting physiological feature is a highly developed sonar capability that allows the whales to easily discover blowholes. The sonar process is called echolocation and is affected by the animal's melon, a large organ located in the head that focuses and interprets sound vibrations. The beluga's melon gives the animal the appearance of having a large swollen protuberance on its forehead. It is malleable, changing in shape and

Beluga whale. Beluga whales are almost an endangered species and considered "near threatened." (Shutterstock.com) appearance with the sounds produced by the animal. The whale's propensity for producing high-pitched twittering sounds has led to the colloquial name "Sea Canary."

The beluga's most striking feature is its pure white coloration. Calves are dark gray when born but lighten over time and achieve full white coloration by their 10th year. Size is variable, and there is a fair degree of sexual dimorphism. Adult males are bigger and heavier, reaching 18 ft. (5 m) in length and sometimes weighing in excess of 3,500 pounds (1,500 kg). After achieving sexual maturity, females give birth on average once every third year; the gestation period is fairly long (14–15 months). Calves nurse for an entire year until their teeth develop, and they can begin hunting. Diet varies according to season, although fish is generally the food of choice. Belugas can dive to more than 2,000 ft. (600 m) in depth to find food, although most dives are less than 100 ft. (30 m). Rough estimates of the beluga whales' life span are between 35 and 50 years, but the normative age of a whale in the wild has yet to be determined to a scientific certainty.

Beluga whales are social, traveling in pods that average a dozen but can include many more. Typically, a single dominant male leads a pack. In the summer months, pod conglomerations can number in the high hundreds and can be observed in estuaries and coastal areas free of ice. Distribution is circumpolar, with an estimated 150,000 individuals found along the coasts of Alaska, northern Canada, Greenland, and northern Russia. Generally, pods winter further north but migrate south when the sheet ice begins to melt. Some populations, however, do not migrate and are considered resident pods. During the summer, pods inhabit large river estuaries and will sometimes swim well upriver in search of food or to avoid the predation of calves by killer whales.

Belugas were hunted through the early part of the twentieth century for their meat, blubber, and oil from their echolocation chambers, the latter of which was used for lighthouse lanterns. Despite this legacy of hunting and climate change developments such as earlier melting of the pack ice, the global population is fairly robust. Locally, however, some pods have experienced recent decline, including several of the Alaskan populations (endangered).

Due to their size and coloration, beluga whales are highly sought after by aquariums. Breeding programs have met with little success, so whales have been caught in the wild at places such as the Churchill River estuary and specially flown to Vancouver and other large aquariums. Canada banned Beluga capture in 1992, leaving Russia as the only country currently selling to aquariums. Belugas both in captivity and in the wild have displayed a curiosity about humans, perhaps also leading to their popularity.

Andrew J. Howe

See also: Bowhead Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Northern Bottlenose Whale; Southern Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Burns, J., and G. Seaman. "Investigations of Belukha Whales in Coastal Waters of Western and Northern Alaska, 1982–1983: Marking and Tracking of Whales in Bristol Bay." *Biology and Ecology*. U.S. Department of Commerce, NOAA, OCSEAP Final Report II 56 (1983): 221–357.

O'Corry-Crowe, G. "Beluga Whale *Delphinapterus leucas*." In W. Perrin, B. Würsig, and J. Thewissen. *Encyclopedia of Marine Mammals*. New York: Academic Press, 2002, pp. 94–99.

Benthic Community

Benthos is a term derived from the Greek word *bathys*, meaning "depth (of the sea)." It refers collectively to all aquatic organisms that live on, in, or near the bottom of the sea or other water bodies. Benthic communities are found in all marine sedimentary environments, at all depths, from seashore and shallow coastal areas to the abyssal depths. The marine benthic communities include a wide range of fauna and flora, and marine sediments are home to very diverse and abundant communities of animals.

Benthos can be classified as phytobenthos, which includes plants, mainly algae and diatoms, and zoobenthos, which comprises animals and protozoans. Organisms that live buried in the soft sediment such as mud or sand are called infauna, while the ones that live either attached to the bottom or other substrate, or live on the sediment surface, are called epifauna.

Hyperbenthos include animals that live in the water layer close to the seabed. Hyperbenthic communities are distinctly different from that of other benthic and planktonic (water column) ones. Benthic animals are classified as either being sessile, or discretely motile, or motile. Sessile organisms are attached to the seafloor, or solid substrate, such as rocks or other organisms, and through their life span, they do not move sufficiently to feed in an area different from that in which they settled as larvae.

Discretely motile organisms move only between bouts of feeding, while motile organisms move about the bottom freely and independently of feeding. Depending on the size range, benthic organisms are further classified into (1) macrofauna: organisms that are larger than 1 mm such as polychaete worms, mollusks, including bivalves and gastropods; echinoderms like sea stars, sea cucumbers, and brittle stars; crustaceans like crabs, lobsters, amphipods, or cumaceans; and corals or sponges; and (2) meiofauna: organisms between 0.1 and 1 mm in size, such as nematodes, foraminiferans, gastrotichs, and small crustaceans such as copepods or ostracodes; (3) microbenthos: organisms smaller than 0.1 mm, mainly bacteria, diatoms, ciliates, and flagellates.

Benthic organisms can display a variety of feeding modes. Suspension feeders (filtrators), such as sponges, cnidarians, bryozoans, or ascidians, are animals that feed by straining suspended matter and food particles from water. They can feed on a wide range of particulate organic matter, from bacteria and organic particles to small and large zooplankton. Surface deposit feeders and subsurface deposit feeders (burrowers) feed on the organic matter from the sediments, either on or near the surface or burrowing in the sediment. Predators feed on the other fauna in benthic assemblages and scavengers feed on the dead animals or plants. In shallow waters, where light easily penetrates water column, primary producers, such as algae or benthic photosynthesizing diatoms, may become a significant food source. In deeper areas, benthic organisms are dependent on the production in the overlying water column and organic matter, which sediments down to the depths. Thus, benthic abundance, biomass, and distribution are highly related to the downward transfer of organic material between water column and seafloor. Thus, most organisms in deep sea are detritivores, consuming detritus (decomposing plant and animal parts as well as organic fecal matter) or scavengers. Many are also omnivores. The diversity, abundance, and biomass of benthic communities vary with latitude, depth, water temperature and salinity, sediment type, and ecological circumstances such as predation and competition. Hard and sandy substrates are often populated by suspension feeders, while soft bottoms are mainly dominated by deposit feeders, of which the polychaetes are the most important. Demersal fishes, starfish, snails, cephalopods, and the larger crustaceans are important predators and scavengers.

Polar marine ecosystems are characterized by seasonal or permanent ice cover, low temperatures, variable salinities near shore, and strong seasonality including changing light availability during the polar night and midnight sun and variable levels of organic material input. At high latitudes, seasonality and quantity of food resources strongly affect the survival of polar benthic fauna, which is additionally exposed to extreme disturbance like ice scour, especially in shallower areas. Ice scour can be very effective at removing bottom organisms, especially the ones attached to the bottom in shallow coastal areas causing considerable damage to benthic communities.

Polar benthic fauna has to face harsh polar conditions but it has become highly adapted to these. In many polar shelf systems, benthic biomass is very high, mainly due to low grazing in the water column and large organic matter flux fueling seafloor communities and further supporting high biomass, abundance, and diversity of benthic organisms. The highest export of organic matter, produced in the surface layers, to the seafloor, is observed in spring when primary production is far greater than the water column consumption. Also, compared to the counterparts in the warmer regions, many polar benthic organisms reach much greater sizes, and gigantism is quite common especially in the Antarctic benthic faunas. Lower water temperatures slow metabolic rates to the extent that growth rates are slow enough to enable organisms to live longer. As a result, many polar organisms can have considerably longer life spans and may reach larger sizes.

Due to high biomass and abundance of many polar benthic organisms, they become key prey for higher trophic level animals foraging on the seafloor. In the Arctic diving sea ducks, bearded seals, walrus, and gray whales are among benthic feeding predators. In the Antarctic, benthic animals are an important source of food for fish, penguins, and seals. It should be stressed that benthic communities in the Arctic and Antarctic are quite different. The Antarctic species diversity is likely much higher than the Arctic and is characterized by much higher level of endemism (species unique to the region). However, recent studies suggest that the difference in benthic diversity between the two polar regions might be much smaller than previously anticipated.

Monika Kędra

See also: Arctic Basin

Further Reading

Borja, A., and D. Dauer. "Assessing the Environmental Quality Status in Estuarine and Coastal Systems: Comparing Methodologies and Indices." *Ecological Indicators* 8 (2008): 331–37.

Bering, Vitus Jonassen (1681–1741)

During his Russian service, Vitus Jonassen Bering crossed Russia, Siberia, and the North Pacific Ocean. Vitus Bering was born in Horsens, Jutland, now Denmark, in 1681. The three great influences in his life were his ambition, marriage, and service to Russia.

Born into a poor family, Bering signed on as a ship's boy at the age of 15. For the next eight years, he served under Danish and Dutch captains, trained in the Amsterdam navigation school, sailed to India and the Dutch East Indies. He met the Russian admiral Cornelius Ivanovick Cruys in 1704 in Amsterdam, who persuaded him to join Russian Naval service as a Russian sublieutenant at the age of 22. Bering advanced higher in officer ranks reaching captain of second rank in 1720.

In 1713, Bering married Anna Christian Pülse. She was from a wealthy German-speaking Swedish family. Letters to her family portray her as dominating the family's life. During the war with Sweden, Vitus was the captain of various ships and to their humiliation, in 1721, he was not promoted again after the war although other service men were. The final insult came when Anna's younger sister married Thomas Saunders, who ranked as Vitus's superior thus rendering Anna socially subordinated to her younger sister. They made a decision that Vitus would retire from the navy, which he did. Within six months, he realized that he had made a mistake, attended an interview at Admiralty College, and requested return to active service. It was granted the same day, and he returned in the rank of captain first class and was assigned to the Baltic fleet.

In 1724, Peter the Great ordered two decked vessels to be built in Kamchatka, which would explore the northern coasts to see whether the Asian and American coasts were connected and locate a harbor for European vessels. On December 29, Bering was appointed the commander of the First Kamchatka Expedition. Leaving St. Petersburg in February 1725, he traveled across Siberia to its capital Tobosk. The following spring, he made his way to Kamchatka to set up a base for building the ships. In the summer of 1728, the ship *Gabriel* was launched carrying provisions of fish and fish oil for a year. It sailed from Kamchatka to the Bering Straits then into unknown seas. For most of the voyage, the seas were dark and cloudy with reduced visibility. At the narrowest place, the Bering Straits are only 39 miles wide, and with clear weather, it would be possible to see both continents as Cook would later observe. Bering did not observe this, but was convinced that a northwest passage did exist. He returned back to St. Petersburg in 1730 as his equipment was in poor condition and provisions running low. He was successful in charting new coastline and fixed the latitude and longitude points so accurately that Captain Cook later used them.

Bering was again commissioned on another expedition with two ships, the *St. Peter*, commanded by him, and *St. Paul*, to be commanded by Lieutenant Alexei Chiriskov (also spelled Chirikoff). Both ships were built in Okhotsk and sailed to Kamchatka. In June 1741, they set sail toward North America, but the two ships became separated during a storm. Chiriskov sited North America on July 15, and a day later, Bering sited a volcano, which is the second highest peak in the United States in the Prince William Sound of modern-day Alaska. He named it Mount St. Elias in honor of the patron saint of the day.

Bering is believed to have landed on Kayak Island but, due to poor weather conditions, began his voyage again discovering Aleutian Islands along the Kodiak Archipelago and naming them along the way. With unfamiliar waters, bad weather, turbulent seas, and dwindling supplies, on August 10, the decision was made to stop charting the American coast and head immediately for home. Fierce storms, fog, and strong headwinds greeted them. The crew was ill, and men were dying. Bering has been reported to have also been very ill. On the night of November 6, 1740, *St. Peter* became shipwrecked on the shores of the largest island in the Commander Islands, which now bears his name, Bering Island. It is a high, rocky, and desolate island that still experiences severe weather. Cold, hungry, and weak, more of the crew died with Bering himself dying on December 19, 1741, from what has historically been reported as scurvy. Six years after his death, the Russian classic poet Mikhail Lomonsov named Bering "The Russian Columbus."

For many reasons, Bering's work as an explorer was not well documented or recognized until the latter half of the twentieth century. In 1991, Danish archaeologists created a team to find Bering's grave. Six graves were discovered on Bering Island. Although there is not 100 percent proof that one was Bering, the expedition journal entries by Georg Steller, Bering's physician, and other evidence point to one of the remains discovered as being Bering's. Forensic examination of his remains revealed that he was of strong muscular build and of ideal weight for his size thus dispelling early paintings portraying him as overweight. It was previously assumed he died from scurvy, but his teeth were in good condition, thus refuting that theory. The cause of death was determined to be from heart failure. In 1992, all the remains were reinterred at a new burial site in Commander Bay near the original site on Bering Island. The Vitus Bering Memorial marks the new burial site.

Intimate glimpses of Bering's personal life with his wife can be found in 16 letters written between them from 1739 to 1740, which have now been translated from German into English. They are reported to have had nine children, many of whom perished in childhood.

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See also: Bransfield, Edward (1785–1852); Cook, James (1728–1779); Cook; James, Voyages of

Further Reading

Frost, O. *Bering: The Russian Discovery of America.* New Haven, CT: Yale University Press, 2003.

Lauridsen, P. *Vitus Bering: The Discoverer of the Bering Strait.* Freeport, NY: Books for Libraries Press, 1969.

Møller, P., and N. Okhotina Lind. *Until Death Do Us Part: The Letters and Travels of Anna and Vitus Bering.* Fairbanks, AK: University of Alaska Press, 2008.

Bharati Research Station

The Indian political leadership and scientific community have given importance to mapping Antarctica region since 1980s. The Bharati research station became operational on March 18, 2012. It was Indian's third station, which was preceded by the Dakshin Gangotri (1982) and Maitri (1988) research stations. The research bases were temporary shelters for the expedition teams and centers for gathering data about Antarctica. The Maitri research station is located in the Schirmacher Oasis and Dakshin Gangotri is a summer day shelter that was abandoned in 1990.

The Indian scientists planned for a station at a distance of 1,800 miles (2,900 km) from Maitri. Unlike Maitri, which was located more than 60 miles (100 km) from Antarctic Sea, Bharati on Larsemann Hills, one of the few geological arenas for constructing the history of Antarctica, was constructed on a rocky promontory. The nodal organization coordinating and executing India's polar expedition from 1998, National Centre for Antarctic and Ocean Research (NCAOR), Goa, in India took about more than a decade to make it a reality. When India expressed its desire to set up a third base in 2006, Australia objected to its proposed location. The area had been designated as "specially protected" by Australia. But India, which had signed the Antarctica treaty on August 1, 1983, cited Article 1 to justify its plan. India raised the issue in May 2007 about the new research center in the 30th Antarctica Treaty consultative Meeting (ATCM). The proposal for the new research base was granted by the ATCM.

In 2008, the 28th expedition of Indian Antarctica program found a suitable location in Larsemann Hills on the northeastern coast of Antarctica, situated roughly in middle of Thala Fjord and Quilty Bay at 69° 24′ 28″S 76° 11′ 14″E. Construction started in 2009 with a helipad and the installation of heavy equipment and machinery as well as pipelines being completed by 2011. In winter of 2011–2012, the structure of the base was assembled. As per the provisions of the Atlantic treaty, the self-sufficient structure could be disassembled. The center was constructed to withstand ice drifting. Bharati has its own source of energy and freshwater. The Bharati polar station, encompassing an area of 27,000 square ft. (2,500 sq. m), was built using 134 shipping containers brought from Germany. The three-tiered structure's ground floor contains laboratories and a workshop. The 24 bedrooms, kitchen, dining room, office space, and gymnasium and theater hall constitute the second floor. The air-conditioning system is installed in the third floor along with a storage facility.

The foundation stone of Bharati was laid on January 11, 2011, in New Delhi, and the ice hub became operational from March 18, 2012. Approximately 47 researchers will work in the center with only 24 overwintering. The station is capable of withstanding 200-mph (320-km/h) winds. The center's design will withstand extreme weather conditions and check snow drifts. India began preparations for the 32nd expedition of India's Antarctic program around the middle of August 2013 under the auspices of NACOR. By August 14, logistic personnel were selected, and medical tests were conducted for the first batch after a week. The rigorous training for acclimatization in extreme weather condition was over by September 5. A thorough study was made of atmospheric conditions with the help of digital flux gate magnetometer. The expedition will begin its journey to Bharati station on December 5, 2013, from launching station in Cape Town, South Africa. The expected time of arrival in the center is December 29, and the team will leave the station on January 8, 2014.

The third polar station in Antarctica will benefit Indian scientific researchers by providing various disciplines such as meteorology, earth sciences, environmental sciences, microbiology, communication technology, oceanography, glaciology, and cold region engineering with data. The analysis of minerals in the glaciers surrounding the Larsemann Hills as well as rocks of the river basins of Indian subcontinent will bring into light many facts of the massive tectonic shift since Antarctica was called Gondwanaland. The data gathered from Bharati also will be helpful in predicting natural disasters to a considerable extent. The station will assist in getting high-speed data by transmitting directly to National Remote Sensing Centre, Hyderabad, India, through special antennas. The communication linkage spanning ice stations Bharati as well as Maitri and NCAOR would facilitate data sharing for further research.

Patit Paban Mishra

See also: Antarctic Programs and Research Stations/Bases

Further Reading

Brady, A., ed. *The Emerging Politics of Antarctica.* New York: Routledge, 2012.

Jayaraman, K. "India Plans Third Antarctic Base." *Nature* 447, no. 9 (2007).

Luis, A. "Past, Present and Future Climate of Antarctica." *International Journal of Geosciences* 4 (2013): 959–77.

Ravindra, R., and R. Mohan. "Three Decades of Polar Science in India." *Geological Society of India* 78 (2011): 5–6.

Singh, J., and H., Dutta, eds. *Antarctica: The Most Interactive Ice-Air-Ocean Environment.* New York: Nova Science Publishers, 2011.

Blood Falls, Antarctica

Blood Falls is a vibrant red waterfall-like feature located at the tip of the Taylor Glacier in the McMurdo Dry Valleys of Antarctica. This feature forms when fluid from below the glacier reaches the surface through a crevasse or crack and spills over the glacier surface. This subglacial fluid is a hypersaline brine with a high concentration of iron; living microorganisms have also been discovered in Blood Falls. When the brine reaches the surface and interacts with the atmosphere, the iron oxidizes (see "What Causes the Color of Blood Falls?—Iron Oxide" sidebar) and stains the ice a rusty red color. Blood Falls is one of the many subglacial aquatic features that are now known to exist below Antarctic ice. The subglacial brine of Blood Falls provides unique access to subglacial samples for biological and chemical analyses.

Taylor Glacier, an outlet glacier of the East Antarctic Ice Sheet, flows into the Taylor Valley, which is part of the ice-free region of Antarctica known as the dry valleys. These valleys represent the coldest, driest desert on our planet. The Taylor Glacier has played an important role in carving out the valley landscape as it advances and retreats over geological time in response to climate change. During the warmer climate of the Tertiary, the length of the Taylor Valley was a deep fjord, submerged with marine water. A pocket of marine water was covered during an advance of the Taylor Glacier, apparently trapping the marine water below the glacier. Episodically, this marine brine is released to the surface at Blood Falls. It is not

WHAT CAUSES THE COLOR OF BLOOD FALLS?—IRON OXIDE

The rich red color of Blood Falls is attributed to oxidized iron. The process of staining the Taylor Glacier red is similar to the process of rust formation. The brine below the glacier is devoid of dissolved oxygen, and the iron is chemically reduced, in the form of ferrous iron (Fe^{2+}). When the brine emerges from the glacier, it interacts with the atmosphere, and the reduced iron is oxidized, becoming ferric iron (Fe^{3+}). The source of this iron is believed to have come from the bedrock below the glacier. Although samples of subglacial bedrock have not been collected, iron is the fourth most common element in the earth's crustal material. As the glacier advances and retreats, it grinds the bedrock into smaller pieces, liberating minerals and increasing the surface area for microbial interactions. Some of the microorganisms discovered in the brine are capable of using bedrock minerals in their energy metabolism, for example, respiring iron in the absence of oxygen in a process called iron reduction.

Jill Mikucki

exactly clear what causes the release of brine; however, it is likely connected to the glacier hydrological regime. The brine below the glacier might exist as a subglacial lake or as salty saturated sediments. Scientists will have to drill through the thick (approximately 1,500 ft. [450 m]) glacial ice and collect samples from the ancient marine source to fully understand this unique subglacial system.

Blood Falls has been a scientific curiosity for more than a century. Members of Robert Falcon Scott's 1911 expedition, which was led by the geologist Griffith Taylor, first discovered Blood Falls. These scientists originally thought the red color on the glacier was due to red-pigmented algae. It was not until the 1960s that scientists conducted chemical analyses on samples collected from Blood Falls and discovered that the color was due to iron. They also learned that Blood Falls was extremely saline, approximately two to three times saltier than seawater. Over the decades, scientists have continued to study this feature and have determined that the salt composition is similar to the composition of seawater. The brine is also extremely cold (−5 to −7°C or −23°F to 20°F). The brine remains liquid despite these subfreezing temperatures, because salts depress the freezing point of water. More recently, scientists began examining the brine for the evidence of life. They discovered that approximately 100 million microbial cells exist in every liter of the brine from Blood Falls.

The microbial residents of Blood Falls share similarities in their genomic material to marine organisms from other cold environments, such as cold marine sediments. These organisms have several interesting properties that allow them to survive and grow below the glacier. Many of these microorganisms are capable of growth at the subzero temperatures in Blood Falls and are considered psychrophiles. Psychrophiles are cold-loving microorganisms that prefer to grow at low temperatures (at or below 15°C or 59°F). These microorganisms have unique adaptations that allow them to survive at permanently cold temperatures such as modifications to their cell walls that promote fluidity or changes to their enzymes that allow them to manipulate substrates better in the cold. Other organisms found in Blood Falls are able to use iron instead of oxygen when they respire or breathe. Still others are able to fix inorganic carbon into cellular material in a process called chemosynthesis. Unlike photosynthesis, which converts sunlight into usable energy, chemosynthesis uses chemical energy. This process may play a role in supporting this microbial community despite being isolated from the surface, and sunlight, for perhaps millions of years.

The existence of this active marine ecosystem below the Taylor Glacier demonstrates that life can survive beneath thick glacier ice for hundreds or possibly millions of years. This fact intrigues scientists for several reasons. The Blood Falls ecosystem can provide insight into how life on earth was able to survive past global glaciation events, the so-called snowball earth events. Blood Falls can also provide an analog to possible extraterrestrial ecosystems such as what may exist below the polar ice caps of Mars. Perhaps the ice cover is a protective layer from the harsh surface conditions of Mars. The psychrophiles that have acquired unique traits to survive in Blood Falls, such as cold-adapted microbial compounds, are of interest to modern biotechnical industries.

Jill Mikucki

See also: McMurdo Dry Valleys of East Antarctica; McMurdo Dry Valleys of East Antarctica, Biology of

Further Reading

Lyons, W., K. Welch, G. Snyder, J. Olesik, E. Graham, G. Marion, and R. Poreda. "Halogen Geochemistry of the McMurdo Dry Valleys Lakes, Antarctica: Clues to the Origin of Solutes and Lake Evolution." *Geochimica et Cosmochimica Acta* 69 (2005): 305–23.

Mikucki, J., C. Foreman, B. Sattler, W. Lyons, and J. Priscu. "Geomicrobiology of Blood Falls: An Iron-Rich Saline Discharge at the Terminus of the Taylor Glacier, Antarctica." *Aquatic Geochemistry* 10 (2004): 199–220.

Mikucki, J., and J. Priscu. "Bacterial Diversity Associated with Blood Falls, a Subglacial Outflow from the Taylor Glacier, Antarctica." *Applied and Environmental Microbiology* 73 (2007): 4029–4039.

Bowhead Whale

The bowhead whale (*Balaena mysticetus*) is a large baleen whale and is the only mysticete endemic to the Arctic. The bowhead whale has a nearly circumpolar distribution in the Northern Hemisphere and is able to live in polar waters year-round since this species is morphologically and physiologically adapted to the extreme Arctic environmental conditions (e.g., cold water, sea ice cover, and scarcity of food). There are four recognized bowhead whale populations in the world: Sea of Okhotsk (Russian Federation), Spitsbergen (Svalbard-Barents and Kara Sea) (Norway, Greenland, Russian Federation), Bering-Beaufort-Chukchi Seas (Alaska, Canada, Russian Federation), and the Eastern Canada-West Greenland population (Canada, Greenland [Denmark]). Bowhead whales live in association with sea ice throughout their range. Sea ice strongly influences the seasonal distribution of bowhead whales as they undergo long seasonal migrations between their wintering and summering grounds. Bowhead whales tend to select areas of lower ice concentration and thickness during winter, likely to reduce risks of ice entrapment, while the opposite is observed during summer, probably to increase feeding opportunities near the productive marginal sea ice zone and reduce exposure to predators such as killer whales (*Orcinus orca*).

Bowhead whales are dark in color with a white chin and their body is shaped like a barrel. They have no dorsal fin and a large head that allows them to break through heavy ice cover (up to 17 inches [45 cm] thick). Their head comprises up to 35 percent of their body length, and their skull resembles the shape of the bow of a ship. One of their greatest adaptations to life in cold waters is perhaps the thickness of their blubber. They have the thickest blubber among all whale species, which can reach up to 20 inches (50 cm) thick in certain areas of their body. Bowhead whales also have the longest baleen plates (up to 45 ft. [14 m]). In terms of body size, calves are usually 13–16 ft. (4–5 m) long at birth and weigh around 2,000 pounds (900 kg). Adult bowhead whales measure between 45 and 59 ft. (14–18 m) and weigh between 150,000 and 200,000 pounds (75–100 tons). Bowhead whales are long-lived animals, and recent data support a life span of more than 200 years. Bowhead whales have a delayed onset of sexual maturity, a low fecundity, and a long inter-birth interval. Their sexual maturity is acquired at 25 years, and a female can produce a calf every three or four years following a gestation period of nearly 14 months. Bowhead whales are specialist feeders on zooplankton, and they have three known feeding modes: skim feeding near the surface, in the water column, and near the seafloor. Their main preys are calanoid copepods, euphausiids, and mysids, as well as other invertebrates.

Commercial whaling severely depleted bowhead populations worldwide during the fifteenth to nineteenth centuries. The abundance of bowhead whales prior to commercial harvesting was estimated to be 30,000–50,000, and the population was depleted to near extinction by 1920. Following the end of commercial exploitation, bowhead whale populations have been slowly recovering, but the numbers of whales are still far from what they were prior to the fifteenth century. The populations of the Sea of Okhotsk and Spitsbergen are endangered and critically endangered, while those of the Beaufort-Bering-Chukchi and the Eastern Canada-West Greenland have been assigned the status of *special concern* by the Committee on the Status of Endangered Wildlife in Canada. Climate change, through deterioration of their habitat, and increase in human activities within their distribution range via shipping, noise, pollution, and industrial development (oil and gas exploration and exploitation) are all posing threats to the recovery and preservation of this unique Arctic species.

Corinne Pomerleau

See also: Beluga Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Northern Bottlenose Whale; Southern Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Ferguson S., L. Dueck, L. Loseto, and S. Luque. "Bowhead Whale (*Balaena mysticetus*) Seasonal Selection of Sea Ice." *Marine Ecology Progress Series* 411 (2010): 285–97.

Foote, A., K. Kaschner, S. Schultze, C. Garilao, S. Ho, K. Post, T. Higham, et al. "Ancient DNA Reveals That Bowhead Whale Lineages Survived Late Pleistocene Climate Change and Habitat Shifts." *Nature Communications* 4 (2013): 1677.

Moore, S., and R. Reeves. "Distribution and Movement." In J.J. Burns, J.J. Montague, and C.J. Cowles, eds. *The Bowhead Whale.* San Francisco: Society for Marine Mammalogy, 1993, pp. 313–86.

Bransfield, Edward (1785–1852)

Edward Bransfield was born in Ballinacurra, County Cork, Ireland, and is best known for discovering Antarctica. Little is known about his family and or his background, but the Bransfields had a respectable reputation and were catholic. Bransfield attended a local Hedge School.

In 1803, at the age of 18 years, Bransfield was taken from his father's fishing boat and coerced into service for the British Royal Navy on the *Ville de Paris* as a seaman. During this assignment, he befriended William Edward Parry (1790–1855). In 1805, Bransfield's diligence and skill resulted in him being assigned to the *Royal Sovereign*, which had seen service in the Battle of Trafalgar (1805). Edward rose to the position of an able seaman in 1806, the second master's mate in 1808, and midshipman in 1808. He worked also as a clerk in 1809 and again a midshipman in 1811. Edward was promoted to the rank of second master in 1812. The same year, he was elevated to the post of the acting master of the *Goldfinch*, under the Cherokee, commanded by William Cornwallis (1744–1819). He had also participated in the Bombardment of Algiers in 1816. Later, he was made the master of the *Andromache* in September 1817, under the command of Captain W.H. Shirreff, and raised to the position of the new Pacific Squadron of Valparaíso in Chile under the Royal Navy.

In 1819, Captain Shirreff appointed Bransfield as the man in charge of a mission, along with two midshipmen, a surgeon, and William Smith as pilot, to explore South Shetland Islands. Through the Southern Ocean, they reached King George Island. Moving ahead, and crossing the Bransfield Strait on January 30, 1820, Bransfield saw the northeastern view of the Antarctic mainland, which is known as the Trinity Peninsula today. On the way, he had also found two high mountains, covered with snow and, later, discovered Elephant Island and Clarence Island. After the Arctic mission, he handed over the charts and records of the exploration to Captain Shirreff for submitting these to the Admiralty. The original journals are lost with the passage of time, but the charts are available with the Hydrographic Department in Taunton, Somerset. On October 31, 1852, he passed away and was buried in Brighton, England.

Ravindra Pratap Singh

See also: Amundsen, Roald Engebrecht Gravning (1872–1928); Klënova, Mariya Vasilevna (1898–1976)

Further Reading

Gurney, A. *Below the Convergence: Voyages Towards Antarctica 1699–1839.* London: W. W. Norton Co Ltd., 1977.

Smith, M. *Great Endeavour—Ireland's Antarctic Explorers.* Sanford, NC: Collins Press, 2010.

British Antarctic Expedition (1910–1913)

In September 1909, Captain Robert F. Scott (1868–1912) announced that he would lead his second Antarctic expedition. His program, like the one during his 1902–1904 expedition, included exploration and science, along with a run south, this time using mechanized sledges, ponies, dogs, and man-hauling. When Scott's ship, the *Terra Nova*, stopped at Melbourne, Australia, in October 1910, Scott picked up a telegram from the Norwegian explorer Roald Amundsen (1872–1928), indicating that he was also making a bid for the pole.

The *Terra Nova* took 21 days to get through the pack ice, and Scott was unable to land at his first choice to winter (Cape Crozier), or his second choice, off Hut Point. Finally, on January 4, 1911, the *Terra Nova* approached Cape Evans on Ross Island, where a base was set up.

During the first winter, Dr. Edward "Bill" Wilson, Lieutenant Henry "Birdie" Bowers, and Apsley Cherry-Garrard (assistant zoologist) undertook a journey from June 27 to August 1, in which they endured the harshest polar conditions ever experienced

CHERRY-GARRARD, APSLEY (1886–1959)

Apsley Cherry-Garrard was a British writer, Antarctic explorer, and survivor of Robert Falcon Scott's ill-fated *Terra Nova* Expedition of 1910–1913. Born in Bedford, England, Cherry-Garrard inherited a substantial estate upon the death of his father in 1907.

At the age of 24, Cherry-Garrard applied to join Scott's *Terra* Nova Expedition, but was rejected twice due to his lack of scientific training and poor eyesight. Cherry-Garrard later secured a place by donating £1,000 toward expedition expenses, joining as assistant biologist.

His role in the expedition was primarily one of support; he was not chosen to accompany Scott on his final journey toward the South Pole. Instead, Cherry-Garrard and several others spent part of the austral summer of 1911–1912 laying supply depots along the expected route of Scott to and from the South Pole. As the austral summer drew to an end in March 1912, Cherry-Garrard and dog handler Dmitri Gerov were forced to leave One Ton Depot to return to base camp. Robert Scott and his polar party perished 19 days later only 11 miles from the depot. Cherry-Garrard was one of several expedition members who found the remains of Scott and his men frozen to death several months later. Upon his return to Britain, he wrote his well-known account of the expedition, *The Worst Journey in the World*.

David Raley

by humans. Traveling to the Emperor Penguin rookery at Cape Crozier to collect eggs, Wilson hoped the penguin embryos would provide evidence of a link between reptilian scales and feathers; later examination did not provide any connection.

Three parties made up the main land operations over two years: Lieutenant Victor Campbell was to explore King Edward VII Land with his Eastern Party; Geologist Thomas Griffith Taylor was to lead the Western Party in the glacier region west of McMurdo Sound; and Scott's Southern Party was to lay supply depots along the proposed route to the pole, and later three groups made up the party heading south.

The Eastern/Northern Party

Campbell's six-man Eastern Party became the Northern Party through a series of difficult circumstances and nearly met with disaster. In January 1911, the party sailed in *Terra Nova* and was supposed to explore King Edward VII Land, but ship could not find a suitable landing place, so steamed westward along the edge of the shelf for the Bay of Whales. However, in the first week of February, Amundsen's *Fram* was found in that area, and Campbell did not want to establish his base so

Located on a point near what is now McMurdo Station in Antarctica, this shelter was used by Robert Falcon Scott in Antarctica before he departed on his fatal trip to the South Pole. The hut at Cape Evans, and all of the supplies inside, have been preserved as a historical monument to the explorer. (National Oceanic and Atmospheric Administration)

close to the Norwegians. *Terra Nova* sailed to Cape Evans to report on Amundsen and afterward went north to Cape Adare, Victoria Land, putting the Northern Party ashore on February 17.

After attempting to survey previously unexplored coastline west of North Cape and naming Oates Land, the ship left to spend the first of two winters refitting at Lyttelton, New Zealand.

Campbell and his men conducted exploratory and scientific work, and constructed a winter hut that accompanied the two huts left behind by Borchgrevink's 1898–1900 expedition. On January 4, 1912, *Terra Nova* returned and picked up the party, and carried it farther south to Terra Nova Bay. Here the party was disembarked with six weeks of sledging rations, two weeks of pemmican, and minimal rations for four weeks. The men made a survey and conducted a geological study of the area around Mount Melbourne and were supposed to meet the ship around February 18, but *Terra Nova* never arrived. The ship had tried several times to penetrate the pack ice 30 miles (48 km) offshore, but had to abandon the attempt.

The party cut an ice cave in the snowdrift of a rocky outcrop they named Inexpressible Island, supplemented their meager food supply as best they could with seals and penguins, and spent the winter in darkness. Only three weeks before the weather would allow the party to leave its ice cell behind in early September, the men were struck with inflammation of the small intestine (enteritis), which nearly killed Browning and Dickason. Leaving on September 30, the party made the journey to Cape Evans, arriving on November 7.

The Western Party

Taylor's four-man Western Party was landed by *Terra Nova* on January 27, 1911, at Butter Point (at the mouth of Ferrar Glacier), with the task of exploring the area between Dry Valley and Koettlitz Glacier. Taylor met up with Scott's depot-laying party at Hut Point and made the journey across the sea ice, returning to Cape Evans on March 13.

Taylor set out again in November on a new western journey with another team, beginning his topographical work at Cape Bernacchi. *Terra Nova* was supposed to pick up the party at Granite Harbor on or about January 15, 1912, but was prevented by ice offshore. The men moved to the more accessible Cape Roberts for three weeks, but the ship still could not reach them.

In early February, the party was living off reduced rations, and the possibility of having to be forced to winter at Cape Roberts was becoming all too real. However, Taylor decided to go southward along the coast to find an easier place for *Terra Nova* to pick them up. By February 13, the ship was able to come close enough at the mouth of Koettlitz Glacier. The ship then tried to rescue Campbell's party before heading back to base, which was reached on February 25.

The Southern Party

Scott set off in the first week of February 1911 to lay supply depots along the proposed route to the pole, hoping to lay a major one at 80º S. Due to weather conditions and the ponies' inability to cope, by February 17, Scott decided to establish the major One Ton Depot (70º 28' 30" S) over 30 miles (48 km) further north than he had wanted. It would prove to be a crucial shortfall. On the way back, Scott waited for Taylor's Western Party at Hut Point, and they returned to Cape Evans by mid-March.

On October 24, the first of three southern groups departed, aiming for a rendezvous (80º 32'S). The motor sledge team left camp, but the machines soon broke down, and the team reverted to man-hauling. Scott followed up with ponies on November 1 and afterward came two dog sledges. Everyone met up at the rendezvous on November 21, and one month later, the top of the Beardmore Glacier was reached, giving way to the polar plateau; now there were only three sledge teams, and one more was sent back.

On January 4, 1912, the final Pole Party was set at five men, one more than the original plan of four. Since Scott decided to take an extra man along, this meant a recalculation of food and weight, and a more crowded than usual tent on the trail. Scott chose Dr. Wilson, Lieutenant Bowers, Captain Lawrence Oates, and Petty Officer Edgar Evans. Five days later, Shackleton's 1909 Farthest South was surpassed, but jubilant expectations were shattered on January 16 by a marker flag left by the Norwegians. The following day, Scott and his men stood at the South Pole, where they found the tent and messages left by Amundsen.

With an 800-mile trek back to Cape Evans, Scott left the pole on January 18. Initially, the party made good progress, but as Scott approached the summit of the Beardmore, two of the men, Wilson and Evans, were suffering particularly badly, the latter having received a concussion after a bad fall. The effects of weather and the limited sledge diet had taken their toll. Evans made it to the bottom of the glacier, but died in his sleep on February 17. A month later, not wishing to continue to be a hindrance to his comrades' chances for survival, Oates sacrificed his life by walking out of the tent during a blizzard.

In the meantime, on February 26, the assistant zoologist Apsley Cherry-Garrard and the Russian dog driver Dmitri Gerov departed from the coast with two dog teams to deposit extra rations for the Pole Party at One Ton Depot. They arrived on March 4, but not finding Scott, they waited six days and then amid deteriorating weather and diminishing supplies made a turn for home—at this time the desperate Pole Party was fewer than 70 miles (110 km) away. One more attempt to reach Scott was made through the man-hauling trip of Surgeon Edward L. Atkinson and Petty Officer Patrick Keohane, but they were unsuccessful.

By March 19, Scott, Wilson, and Bowers had struggled to within 11 miles (18 km) of One Ton Depot—and safety—until a ferocious blizzard trapped them in their tent. Scott's last journal entry was 10 days later. Atkinson led a sledge party that found the bodies of the three men that November. *Terra Nova* reached Cape Evans on January 18, 1913, and sailed for Lyttelton eight days later, arriving on February 12.

Glenn M. Stein

See also: British Arctic Expedition (1875–1876); Heroic Age of Antarctic Exploration (ca. 1890s–1920s); Ross Sea; Shackleton, Ernest (1874–1922)

Further Reading

Amundsen, Roald. *The South Pole: An Account of the Norwegian Antarctic Expedition in the "Fram" 1910–1912.* 2 vols. London: John Murray, 1912.

Cherry-Garrard, Apsley. *The Worst Journey in the World: Antarctic 1910–1913.* London: Constable and Co., 1922.

Scott, Robert F. *Scott's Last Expedition.* 2 vols. London: Smith, Elder and Co., 1913.

Wilson, Edward. *Diary of the* Terra Nova *Expedition to the Antarctic 1910–1912.* London: Blandford Press, 1972.

British Arctic Expedition (1875–1876)

The British Arctic Expedition, led by Sir George Strong Nares (1831–1915), was a geographic and scientific exploration to find an open polar sea, reach the North Pole, and explore the coasts of Greenland and adjacent lands. Two ships (the HMS *Alert* and the HMS *Discovery*, captained by Henry Frederick Stephenson) sailed from Britain with 120 men. They wintered off the northern coast of Greenland and then sent out several sledge parties the following summer. Scurvy outbreaks and outdated equipment caused disaster, and the expedition returned to Britain in the fall of 1876. Although the expedition failed to reach the North Pole, they explored and mapped the coasts of Greenland and Ellesmere Island and collected scientific data and photographs of the region.

British Arctic exploration stalled after the loss of the Franklin expedition in 1847. By 1874, the political climate had shifted, and the government agreed to finance the new expedition, organized by the Arctic Committee of the Admiralty, as an exploratory and scientific mission. The ships sailed from Portsmouth, England, on May 29, 1875.

The ships traveled up the west coast of Greenland through Baffin Bay, then through the channel between Greenland and Ellesmere Island (now Nares Strait) to the Lincoln Sea. The route supposedly would lead to the mythical open polar sea, an ice-free region surrounding the North Pole. In late August 1875, the ships found overwintering locations. The *Discovery* sheltered in Lady Franklin Bay off Hall Basin, while the *Alert* went a further 80 km around the tip of Grant Land before retreating to a bay in Robeson Channel. Though he doubted any chance of a successful pole attempt upon seeing the ice-covered terrain, Nares followed orders and began laying depots in preparation for the next summer. The crews were kept busy all winter by constructing an ice rink and holding musical theater, evening classes, and other events.

In March 1876, dog-sledging parties set out from the *Alert* to contact the *Discovery* 80 km away. They returned a few days later with severe frostbite and exhaustion after only covering 26 km. The next party set out a few weeks later in better weather and reached the *Discovery*. The poor success with dog sledges convinced them that a man-hauling sledge was a better method.

Exploratory sledge teams headed out in early April. Commander Albert Markham and Lieutenant Alfred Parr led 15 men in two sledges with boats and three support sledges toward the North Pole. Scurvy, heavy equipment, and terrain slowed the team, which stopped 400 miles (640 km) short of the pole in mid-May (achieving the furthest north point of any expedition thus far at 83° 20' 26" N). Parr went back for help, walking for 24 hours without a break. Pelham Aldrich and Lieutenant George Giffard started out with the Markham party with another sledge party and turned west to Grant Land with eight men and two sledges.

A third expedition led by Lieutenant Lewis Beaumont and Dr. Richard Coppinger later went east to explore northern Greenland. These teams also developed scurvy and were rescued in June.

Aside from scurvy, the sledge teams were slowed by old-fashioned equipment. Sledges were heavy and difficult to pull through deep snow and pressure ridges. Paths had to be cut with shovels and pick axes. Clothing absorbed sweat, which then froze, making the clothes stiff enough to require beating with axes to flex the knees. In bad weather, teams had to spend days in thin tents in communal sleeping bags; clothes would thaw and saturate bags, which would then freeze and increase sledge weight. Each team lost men to exhaustion and scurvy. Realizing that the remaining men could not survive another winter, Nares retreated southward in late summer 1876 as soon as all sledging parties returned, arriving back in Portsmouth in November.

The expedition was initially greeted with acclaim. Nares was honored, and the expedition was recognized for its scientific and exploratory contributions. Public and press opinion later turned against Nares for the failure to reach the pole and the prevalence of scurvy. An official inquiry blamed Nares for failing to carry out orders correctly to prevent the disease. Though lime juice was included in sledge provisions, it had been distilled in copper pans, which destroys vitamin C, but this was not understood for years.

Altogether, they explored around 300 miles (480 km) of the northern Ellesmere Island and northern Greenland coastlines, which were previously undocumented by Europeans. They disproved the open polar sea theory by documenting the frozen Arctic Ocean. Scientific samples were taken, and northern indigenous peoples and landscapes of what became Canada's Northwest Territories and Nunavut were documented in photos.

Elizabeth Bella

See also: British Antarctic Expedition (1910–1913); Canadian Arctic Expedition (1913–1918); First German North Polar Expedition (1868)

Further Reading

Deacon, M. "George Strong Nares (1831–1915)." *Arctic* 38, no. 2 (1985): 148–49.

Hattersley Smith, G. "The British Arctic Expedition 1875–76." *The Polar Record* 18, no. 113 (1976): 117–26.

Nares, Captain Sir G.S. *Narrative of a Voyage to the Polar Sea during 1875–6 in H.M. Ships* Alert *and* Discovery. Reprint ed. London: Read Books, 2009.

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Canadian Arctic Archipelago

The Canadian Arctic Archipelago (or just called the "Arctic Archipelago") is a collection of around 36,500 islands located in Northern Canada. The archipelago is considered the world's second-largest high-Arctic landmass (Greenland being the first). The numerous islands are separated by many waterways, straits, and channels making up the Northwestern Passages. The collection of islands is predominately covering all of the Nunavut and a section of the Northwest Territories. This archipelago stretches east to west about 1,500 miles (2,400 km) and about 1,200 miles (1,900 km) north to south. Cape Columbia (83° 6′ 41″N 69° 57′ 30″W) on Ellesmere Island is the northernmost point of the archipelago.

The Arctic Archipelago is bordered by the Arctic Ocean in the north, the Beaufort Sea to the west, Baffin Bay, the Davis Strait, and Greenland to the east, and the Canadian mainland and Hudson Bay to the south. The archipelago covers an area of 550,000 square miles (1,425,000 sq. km). The British claimed the Foxe Basin, Hudson Bay, and Strait area of the Arctic Archipelago based on the Northwest Passage explorations of Martin Frobisher and Henry Hudson. Frobisher interacted with the Inuit inhabitants during his explorations. Vikings from Greenland are believed to have visited the area prior to the British. In 1894, Britain conveyed the area to Canada, where it was labeled the Provisional District of Canada or the District of Canada. In 1999, this district was adjourned with the creation of Nunavut. The majority of the Canada Arctic Archipelago is uninhabited and consists of a number of relatively small islands. There are 94 islands that are larger than 50 square miles (130 sq. km). Important islands over 3,900 square miles (10,000 sq. km) include Axel Heiberg, Baffin, Banks, Bylot, Devon, Ellesmere, Melville, and Somerset.

Axel Heiberg Island

Axel Heiberg Island (79° 26′N 90° 46′W) is located west of Ellesmere Island and separated by the Nansen and Eureka Sounds. It covers an area of 16,671 square miles (43,178 sq. km). It is part of the Sverdrup Islands, which include the islands Axel Heiberg, Ellef Ringnes, Amund Ringnes, Cornwall, Graham, Meighen, King Christian, and Stor. McGill University has a seasonal Arctic Research Station (79° 26′N 90° 46′W) on Axel Heiberg Island. The island has forest fossils dating back 56–33.9 mya to the Eocene.

Baffin Island

Baffin Island (69° N 72° W) is the largest island in Canada covering an area of 195,928 square miles (507,451 sq. km) making it the fifth largest island on the earth. South of the Baffin Island is Hudson Strait, Foxe Basin, and the Gulf of Boothia. East is Davis Strait and Baffin Bay. In between Baffin Island and Devon Island is the Lancaster Sound. The highest elevation is Mount Odin at more than 7,000 ft. (2,100 m) tall. There is an ice cap, called Barnes Ice Cap, roughly in the center of Baffin Island. Barnes Ice Cap covers an area of more than 2,300 square miles (6,000 sq. km). There are two large lakes on Baffin island, which are Nettilling Lake (66° 30′N 70° 50′W) and Amadjuak Lake (64° 55′N 71° W). Baffin Coastal Tundra dominates the northeastern coast of Baffin Island (70° 25′N 68° 75′W) and corresponds with the Baffin Island Coastal lowlands ecoregion of the Arctic Cordillera ecozone. Clyde River (70° 28′N 68°35′W) or Kanngiqtugaapik (in Inuktitut) is the largest village with a population of approximately 800 people mostly Nunatsiarmuit (meaning the people of the beautiful land), an Inuit subgroup. There are more than 10,000 people living on the island, with the almost three quarters being Inuit. The three largest cities are the capital of Nunavut "Iqaluit," and the cities of Pangniqtuuq and Pond Inlet. Only Pond Inlet (72° 41′N 77° 57′W) is located in above the Arctic Circle of the these three cities.

An ancient Inuit inukshuk serves as a landmark for seafarers in a fjord of Baffin Island, Nunavut, Canada. This inukshuk is estimated to be at least one thousand years old. (Shutterstock.com)

Banks Island

Banks Island (73° N 121° 30′W) is located in the Northwest Territories of Canada and lies west of Victoria Island and is separated by the Prince of Wales Strait, the Amundsen Gulf (south), and the Beaufort Sea on the western side. On the northwest side are Melville and Prince Patrick Islands that are separated by the M'Clure Strait. Banks Island covers an area of more than 27,000 square miles (70,000 sq. km). It the 24th largest island on the earth measuring 240 miles (380 km) long and 180 miles (290 km) wide. The highest elevation is Durham Heights at more than 2,400 ft. (730 m) tall. There are just more than 120 people on Banks Island all of which are located in the village of Sachs Harbor (71° 59′ 8″N 125° 14′ 53″W). The island is home to around 65 percent of the earth's lesser snow goose (*Chen caerulescens caerulescens*) and the majority of the earth's musk oxen population.

Bylot Island

Bylot Island (73° 16′N 78° 30′W) is located north of Baffin Island and the Eclipse Sound. To the northeast is Lancaster Sound, east is the Navy Board Inlet, and to the northwest is Baffin Bay. Bylot Island covers an area of more than 4,200 square miles (11,000 sq. km). In 1999, Bylot Island and the Bylot Island Migratory Bird Sanctuary (73° 14′ 58″N 78° 35′ 15″W) were included in the Sirmilik National Park. Bylot Island precipitation is around 37 inches (95 cm) in the summer months, and snow accumulation in the winter months is around 10 inches (26 cm). The amount of precipitation contributes to a diverse flora population of more than 350 different plants. It is home to 74 species of birds, such as the thick-billed murres, black-legged kittiwakes, Arctic skua, king eider, little auk, old-squaw, northern fulmar, gyrfalcon, ruddy turnstone, red-necked phalarope, Iceland gull, snowy owl, and snow bunting. There are also about 20 mammals, such as polar bears, ermine, Arctic fox, Arctic hare, brown and collared lemmings, walrus, and seals (e.g., bearded, harbor, harp, hooded, and ringed).

BYLOT ISLAND MIGRATORY BIRD SANCTUARY

The Bylot Island Migratory Bird Sanctuary (MBS) (73° 14′ 58″N 78° 35′15″W) is located on Bylot Island (73° 16′N 78° 30′W) and is part of the Canadian Arctic Archipelago. Bylot Island is located north of Baffin Island and the Eclipse Sound. To the northeast is Lancaster Sound, east is the Navy Board Inlet, and to the northwest is Baffin Bay.

The Bylot Island MBS is the second largest MBS in Canada. The largest MBS is Queen Maud Gulf MBS. On January 1, 1966, the Canadian government established Bylot Island as a marine, intertidal, and subtidal conservation area. In 1999, Bylot Island was included in the Sirmilik National Park. Under the International Union for Conservation of Nature, the Bylot Island MBS is categorized as a Category IV or a habitat/species management area. The Bylot Island MBS has a total land area of 1,263,500 hectares (3,122,176 acres) and has a marine, intertidal, and subtidal area of about 580 square miles (1,500 sq. km).

Bylot Island average yearly temperature is 5.9°F (−14.5°C), with summer temperatures averaging 40°F (4.5°C) and winter temperatures averaging −27°F (−32.8°C). Precipitation is around 37 inches (95 cm) in the summer months, and snow accumulation in the winter months is around 10 inches (26 cm). The amount of precipitation contributes to a diverse flora population of more than 350 different plants. It is home to 74 species of birds, such as the thick-billed murres, black-legged kittiwakes, Arctic skua, king eider, little auk, old-squaw, northern fulmar, gyrfalcon, ruddy turnstone, red-necked phalarope, Iceland gull, snowy owl, and snow bunting. There are also about 20 mammals, such as polar bears, ermine, Arctic fox, Arctic hare, brown and collared lemmings, walrus, and seals (e.g., bearded, harbor, harp, hooded, and ringed).

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Devon Island

Devon Island (75° 08′N 87° 51′W) is located in the Qikiqtaaluk Region, Nunavut, Canada. It is surrounded by Ellesmere Island to the north, Baffin Bay to the west, the Lancaster Sound and Bylot Island to the south, Cornwallis Island and Wellington channel to the east, and the Norwegian Bay to the northwest. At more than 21,000 square miles (55,000 sq. km), Devon Island is considered the largest uninhabited island in the world. There are several small mountain ranges on Devon Island, including Cunningham, Haddington, and Treuter Mountains. The Treuter Mountains are part of the Devon Icecap.

Ellesmere Island

Ellesmere Island (79° 50′N 78° W) is located in the Qikiqtaaluk region, Nunavut, Canada. Cape Columbia (83° 6′ 41″N 69° 57′ 30″W) on Ellesmere Island is the northernmost point of Ellesmere Island and the Canadian Arctic Archipelago. Ellesmere Island covers an area of more than 75,000 square miles (196,000 sq. km). It is the 10th largest island on the earth measuring 520 miles (830 km) long and 400 miles (645 km) wide. The highest elevation is Barbeau Peak at more than 8,583 ft. (2,616 m) tall. The largest populated area on Ellesmere Island is Grise Fiord (76° 25′ 3″N 82°

53′ 38″W) with just more than 110 people. Around 20 percent of the island is part of Quttinirpaaq National Park.

There are two large ice fields on Ellesmere Island, which are Manson and Svdp (south) and Prince of Wales (eastern side). On the northern coast are the Agassiz Ice Cap and the Ellesmere Ice Shelf. Originally, the Ellesmere Ice Shelf (82–83° N 64–90° W) was located from Point Moss to Nansen Sound on the northern coast of Ellesmere Island in Nunavut, Canada. It was called the Ellesmere Ice Shelf because when discovered, it was a single continuous ice mass. The Ellesmere Ice Shelf no longer exists as single continuous ice mass. Over the past hundred years, more than 90 percent of the Ellesmere Ice Shelf has collapsed and continues to fragment with each passing year. By the twenty-first century, the remaining Ellesmere ice shelves had shrunk to just under 350 square miles (900 km). The remaining ice shelves were the Ayles, Milne, Markham, Serson, Petersen, and Ward Hunt.

Melville Island

Melville Island (75° 30′N 111° 30′W) is split at the 110th meridian west between Nunavut (east) and the Northwest Territories (west). The island measures from 165 to 212 miles (265–341 km) in length and 130 to 181 miles (210–292 km) wide. Melville Island is the 33rd largest island in the world and covers an area of more than 16,000 square miles (42,000 sq. km). It is an inhabited island, but has a diverse mammal population that includes Arctic fox, Arctic wolves, musk oxen, caribou (Peary), lemmings, and ermine. There is only sparse vegetation on the island.

Somerset Island

Somerset Island (73° 15′N 93° 30′W) is located between Prince of Wales Island and Baffin Island. To the east is the Peel Sound and the west is Prince Regent Inlet. South of Somerset Island is Boothia Peninsula, which are separated by the narrow 1.2-mile (2-km) wide and 15-mile (25-km) long Bellot Strait, while north of Somerset Island is bordered by the Barrow Strait. The uninhabited Somerset Island is approximately 9,500 square miles (24,800 sq. km). Archaeological evidence suggests that the Thule people have inhabited the island since at least AD 1,000. In 1937, the Hudson Bay Company established a trading post at Fort Ross. Fort Ross was located on the southeastern end of Somerset Island on the Bellot Strait. Fort Ross was the last fort of the Hudson Bay Company and closed in 1948. After the closing of Fort Ross, Somerset Island was uninhabited.

There are two major disputes of the Canadian Arctic Archipelago. The Hans Island (80° 49′N 66° 27′W) dispute is between Canada and Denmark (started in 1973) over the ownership of a small area in the Nares Strait that includes Hans Island. At dispute are claims to the fishing areas, management, and jurisdiction over the Northwest Passage. Since 2012, both countries are negotiating, and it is suspected that Hans Island will be divided roughly in half between the countries. Claims to and the jurisdiction over the Northwest Passage are presently disputed. The dispute is primarily between the United States and Canada. The United States along with most maritime nations acknowledges that Canada owns the Northwest Passage; however, the dispute is over whether the Northwest Passage is Canadian internal waters or an international strait that would allow for the free passage without Canadian consent for all international maritime vessels.

Andrew J. Hund

See also: Arctic Ocean; Foxe Basin; Greenland; Hans Island Dispute; Lomonosov Ridge Claims; Northeast Greenland National Park; Tuktut Nogait National Park; Vuntut National Park of Canada

Further Reading

Aiken, Susan G., et al. "Flora of the Canadian Arctic Archipelago: Descriptions, Illustrations, Identification, and Information Retrieval." Ottawa: NRC Research Press, National Research Council of Canada, 2007.

Bouchard, Giselle. *Freshwater Diatom Biogeography of the Canadian Arctic Archipelago.* Ottawa: Library and Archives Canada/Bibliothèque et Archives Canada, 2005.

Rae, R. W. *Climate of the Canadian Arctic Archipelago.* Toronto: Canada Department of Transport, 1951.

Canadian Arctic Expedition (1913–1918)

The Canadian Arctic Expedition was the first entirely Canadian Arctic scientific expedition, led and organized by Vilhjalmur Stefansson (1879–1962), a Canadian-born Icelandic anthropologist. The expedition experienced setbacks including loss of the flagship *Karluk* and subsequent crew being stranded and starving. Despite the hardships, the expedition was considered a success due to the collection of thousands of specimens of animals, plants, fossils, minerals, photographs, film, and cultural artifacts, and for mapping new lands for Canada.

The expedition was originally sponsored by the U.S. National Geographic Society but was taken over by the Canadian government to strengthen Canada's claim to sovereignty in Arctic islands. The change shifted the expedition's emphasis toward geographical exploration rather than solely ethnological and scientific studies. The American sponsors withdrew subject to the condition that expedition rights would be reclaimed if Stefansson failed to depart by June 1913. Subsequent criticism of the expedition points to rushed planning and poor attention to food and equipment details by Stefansson.

The expedition was divided into a Northern Party on the *Karluk* led by Stefansson, and a Southern Party on the schooners Mary Sachs which was Alaska led by Rudolph M. Anderson (1876–1961). Besides looking for new land, the Northern

Party's program included meteorological, oceanic, and biological investigations. The Southern Party's purpose was anthropological studies and survey in the islands off the northern Canadian coast to document geography, geology, resources, wildlife, and people of the region, with particular attention to copper deposits and trade routes.

The ships set out from Nome in June 1913. They encountered rough conditions almost immediately. The smaller ships navigated north to Collinson Point, Alaska, where they overwintered. The flagship *Karluk* was trapped in sea ice and sank in January 1914 after drifting for months in the Beaufort and Chukchi seas toward Siberia. Stefansson left the *Karluk* with a hunting party of five after the boat had been stuck for a month. Two days later, a violent storm propelled the *Karluk* on a rapid new trajectory, permanently separating Stefansson and his party from the ship.

The *Karluk* crew initially set up camp on the ice. Four men died after independently leaving the camp to travel toward Russia. Four more reached Herald Island but died there of uncertain causes, possibly from fumes from a faulty stove; their fate was unknown until 1924 when their remains were discovered. After reaching Wrangel Island with the remaining crew, Bartlett and Kataktovik, one of the expedition's Alaskan Inupiat hunters, set out on a harrowing journey to the Russian mainland, then to Alaska to arrange a rescue. The USS *Bear* reached the survivors in the fall of 1914. Three more had died of a starvation diet based on faulty pemmican, and one crew member (Breddy) died of a gunshot wound, either self-inflicted or murdered for stealing food.

Stefansson and his group eventually reached the Mary Sachs. Here assembled the Northern Party with local hires and purchased two more small schooners, the North Star and the Polar Bear. Exploration continued until 1918. They discovered land previously unknown even to the Inuit, the only lands in Arctic exploration documented by a solely Canadian expedition. They also remapped significant errors in prior maps. At the expedition end, the schooner North Star was given as payment to Natkusiak, a hunter and a key crew member, while the Polar Bear ended her career in Siberia. Historians have divided views on Stefansson's decision to leave the *Karluk*. Survivors were critical of his indifference to their ordeal and the loss of life. He was not officially censured for his actions and was publicly honored for his expedition results despite the Canadian government's reservations about its overall management.

The Southern Party completed detailed mapping of the Arctic coast from Alaska to Bathurst Inlet, as well as the East Channel of the Mackenzie River. Regular soundings of ocean depth during ice trips established polar continental shelf information. The schooner Mary Sachs was left in what is now the town of Sachs Harbor, forming a new settlement point. The Alaska returned to Nome in 1916, with thousands of specimens of animals, plants, fossils, rocks, artifacts from the Copper Inuit and other cultures, and more than 4,000 photographs and 9,000 ft. of movie film. The material has been applied to countless scientific projects, publications, films, and exhibits. A number of books have detailed the *Karluk* disaster and overall expedition events. Changes in the culture and demography of the region came as expedition employees stayed in the region and brought others to the area. Trading for artifacts introduced new tools, guns, and various utensils to Inuit people, and fox trapping was established as a local industry and lifestyle.

Elizabeth Bella

See also: British Antarctic Expedition (1910–1913); British Arctic Expedition (1875–1876); First German North Polar Expedition (1868)

Further Reading

McDiarmid, F. "Geographical Determinations of the Canadian Arctic Expedition." *The Geographical Journal* 62 (1923): 293–302.

McKinlay, W. *The Last Voyage of the Karluk: A Survivor's Memoir of Arctic Disaster.* New York: St. Martin's Press, 1999.

Niven, J. *The Ice Master: The Doomed 1913 Voyage of the Karluk.* New York: Hyperion, 2000.

Caribou

Caribou (*Rangifer tarandus*) are northern herbivores and a Holarctic species of deer, living in Arctic and subarctic tundra and taiga. Caribou migrations, still occurring in North America, are a spectacular characteristic of this species as herds can travel up to a thousand miles from more southern winter ranges to northern calving grounds. For millennia, caribou have served as a critical source of protein and clothing to northern subsistence hunters. Now, caribou herds in the north are threatened by air pollution, thawing permafrost, shrinking acreage, and climate change impacts to lichen and other nutritional plants.

The caribou originated more than 400,000 years ago, as indicated by the fossil record, in northern Asia or eastern Alaska. Called reindeer in Europe and "tuktu" by the Inuit, they are described as a large Arctic deer, a ruminant mammal of the Cervidae family. Scientists generally organize this two toed, hooved, antlered animal with a four-chambered compartmentalized stomach into three groups or subspecies: woodland caribou (*R. tarandus fennicus*, *R. tarandus caribou*, *and R. tarandus dawsoni*); barren-ground caribou (*R. tarandus groenlandicus*); and Peary caribou (*R. tarandus pearyi*). A fourth type, Grant's caribou (*R. tarandus granti*), live in Alaska and are very similar to barren-ground caribou. Woodland caribou live in boreal forested areas and are generally a little larger and darker than the tundra-residing barren-ground caribou. Peary caribou live their lives on Canada's Arctic Islands and are a smaller animal with an almost white coat.

The caribou's natural habitats are tundra and taiga ecosystems, including alpine tundra. The tundra was considered barren by early biologists but in fact provides sedges, grasses, lichens, and herbs. Lichens are an extremely important winter resource for these nomadic animals, which have the ability to generate nutrients and energy from these low-nutrient and difficult-to-digest organisms. Lichens are able to grow under snow in severe weather and on dying branches in the taiga. The nomadic existence of caribou herds allows them to find the slow-growing reindeer lichens, and this wandering behavior also enables the lichen to regenerate, thus preventing overgrazing. Currently, the largest herds are found on Alaska and Canada's mainland. In summer, sedges, grasses, and berries enable caribou to build up energy reserves.

The term "reindeer" is commonly used to denote semidomesticated animals, whose herd movements are largely directed and controlled by people. These semidomesticated animals are smaller, tamer, and can vary in shades of color from brown to white. These reindeer have been selected, over centuries, for their ability to produce meat. Fossils show signs of caribou hunters dating back thousands of years. Peoples of Asia and northern Europe chose to stay close to specific herds year-round and direct the animals toward quality winter, summer, and calving grounds as well as protect them from common predators.

Caribou are well adapted to the tundra and marshy wetlands by having very large, wide hooves that allow them to travel more easily over snow and soft ground. The large dewclaws also provide stability. Caribou use their front hooves to dig away snow to locate lichens, a behavior called "cratering." This behavior has led some northern people to call caribou "the digging ones" or "snow shoveler." Another important adaptation is their thick two-layered coat with hollow hairs that can trap air and provide increased insulation. The caribou's vascular system acts as a heat exchanger between cold deoxygenated blood (veins) and warm oxygenated blood (arteries) contributing to the conservation of heat. A fine network of veins in the nasal passages surrounds the arteries and reduces heat loss in the extremities. A very unusual adaptation in caribou is the presence of antlers in females and the young, even in the winter.

Caribou calves are born during a short period of time in the spring on the calving grounds. Bull caribou live about 10 years, and a general rule for mammals, females live a few years longer. Caribou lifespan and reproduction can be affected not only by the changing lichen cover but also by air pollution. Some pollutants transported to the north kill lichens while others such as mercury are absorbed through the food chain, affecting their physiology and biochemistry.

Lawrence K. Duffy

See also: Arctic Fox; Arctic Ground Squirrel; Arctic Hare; Arctic Seabirds; Arctic Wolf; Dogs in the Arctic; Lemmings; Musk Oxen; Polar Bear; Wolverine

Further Reading

Duffy, L., et al. "Mercury in the Hair of Large Alaskan Herbivores: Routes of Exposure." *Alces: A Journal Devoted to the Biology and Management of Moose* 37 (2001): 293–302.

Quinlan, S. *Caribou.* Minneapolis: Carolrhoda Books, Inc., 2005.

Cartography of the Arctic

The mapping of the Arctic was a subject of speculation since antiquity, and the immense difficulties involved in reaching and exploring the polar regions meant that the true nature of their geography and therefore their cartography was finally resolved only during the twentieth century.

The earliest maps including reference to the Arctic were known as "zonal maps." They represent attempts made during late classical times to organize strictly limited knowledge of the world. Zonal maps were little more than diagrams in which the global disk was divided into habitable temperate regions and uninhabitable regions, including frigid zones in the far north, which they knew existed, and the far south, the existence of which they inferred.

The developing medieval worldview was quite different from the modern one and is exemplified by the type of world map known as *mappae mundi.* In effect, they were compendia of current information based on classical knowledge, the Bible, travelers' tales, and some natural history, all set within a Christian context that placed Jerusalem at the center of the map, which was often oriented to the east. This worldview only just included the Arctic, as can be seen in the famous Hereford *mappae mundi* (ca. 1290), which depicts a small Norwegian figure on a ski at the very edge of the known world, just inside the encircling ocean.

In about 1360, an English friar, Nicholas of Lynn, reputedly sailed from Norway to a coast where the sea froze in winter, which may have been Greenland. He reported that the North Pole was a magnetic rock in the middle of a whirlpool surrounded by mountainous lands and channels through which the sea was drawn in. It may be that the magnetic rock owed something to the workings of the magnetic compass, and the whirlpool was perhaps connected to the maelstrom believed to lie off the Arctic coast of Norway. Whatever the truth, Nicholas's account had a great effect on Arctic cartography. The earliest extant globe, for example, made by Martin Behaim in Nuremburg in 1492, clearly followed Nicholas's concept though, with Greenland depicted as an extension of Norway, and as late as 1595, Gerard Mercator considered it appropriate to reproduce the same concept in even greater detail in his atlas.

The persistence of such concepts was assisted in 1558 by the publication of an account of an Arctic voyage reputedly made about 1380 by two Venetian brothers, Niccolo and Antonio Zeno. As well as describing their visit to Greenland and the mythical island of Frisland or Frislandia, the account included a map showing

Greenland as extending in a great arc north of Iceland and joining Norway. The Zeno map, possibly originating in the medieval concept that all lands must be united since all civilization originated from a common center, served to confuse generations of future Arctic cartographers and explorers.

The medieval image of the world began to undergo radical change in the late fourteenth century, when Turkish pressure on Constantinople resulted in the emigration of Byzantine scholars to Italy. They took with them Greek manuscripts, including Ptolemy's *Geographia.* By 1427, less than 20 years after the first Latin translation, a copy of the *Geographia* was made in France to which was appended a map of the northern lands by the Danish geographer Claudius Clavus—the first modern map to be added to a Ptolemaic manuscript. All the early editions of the *Geographia* were copied by hand, text and maps alike, and various changes were introduced. In 1466, a copy of the world map showed Greenland west of Norway; by 1468, it had been moved to the north. The first printed edition was published in Bologna in 1477; by the famous Ulm edition of 1482, a northern extension representing Scandinavia had been added. The sea beyond is simply *mare glaciale*, and there is no Siberian coast. Much geography at this time was hypothetical, and cartographical progress was in consequence uneven. Martin Waldseemüller's 1507 world map, for example, depicts the Arctic coast of Eurasia joining Scandinavia with the Far East. In about 1504, a chart of the North Atlantic by Pedro Reinel appeared, the first to show the direction of the North Magnetic Pole. In 1569, Mercator showed two magnetic poles—one on an island in the Strait of Anian (roughly Bering Strait) and the other farther to the northwest, stating in an explanatory note that he believed the true magnetic pole lay somewhere between these two positions.

Actual exploration of the Arctic began in the mid-sixteenth century, when English and Dutch navigators began to search for the Northeast and Northwest Passages to Cathay and the Spice Islands. There was by now general agreement among cartographers that northeastern Asia and northwestern America were not connected and that the polar lands were separated by sea from both. The Arctic Ocean was believed to be largely ice free and appeared to offer a short route to the Far East and its luxury products. It may have been this concern that led cartographers at an early date to draw maps on a polar projection—a bird's eye view of the circumpolar lands centered on the Pole itself, for example, John Dee's map of about 1582.

One of the earlier English expeditions to investigate the Northeast Passage was that of Stephen Borough in 1556–1557, whose brother William compiled a chart depicting the route from North Cape to the Kara Sea. By the time Abraham Ortelius's world map was published in Amsterdam in 1587, the Siberian coast was depicted and Novaya Zemlya had appeared. However, beyond Iceland and Greenland—now roughly in the right positions—and stretching right across the world lies a vast polar continent, *Terra Septemtrionalis Incognita*, mirroring the contemporary concept of a great southern continent (*Terra Australis Incognita*). The Dutch also explored the Northeast Passage, and the map compiled by Willem Barents on the basis of his voyages in the 1590s was published posthumously by Cornelius Claesz in 1598 in a polar projection that combined Barents's discoveries of Spitsbergen and Bear Island with existing knowledge of the Arctic, including Davis Strait, the northwest coast of Novaya Zemlya, and the supposed position of the magnetic pole in the Strait of Anian. Later Dutch cartographers improved upon mapping of the Svalbard Archipelago on the basis of discoveries, particularly to the north and the east, reported in the seventeenth and eighteenth centuries by Dutch whalers.

A landmark event in Arctic cartography was the Great Northern Expedition of 1733–1743, launched by Tsar Peter the Great and led by Vitus Bering. Seven detachments, almost 1,000 men in all, set out by ship and dog sledge to explore and map a possible Northeast Passage, the Eurasian Arctic coast, the Bering Strait, and Alaska—which was a Russian possession until 1867. By the time these surveys were completed, often in conditions of the greatest hardship, almost the entire Arctic coastline of mainland Russia had been explored. Maps compiled in the field were sent back to the St. Petersburg Academy of Sciences to be collated, redrawn, and engraved. Initially, efforts were made to keep these maps secret, but doing so proved impossible, and they were published in the great Russian atlas of 1745, to be revised as further surveys were carried out subsequently.

The mapping of the North American Arctic, with its labyrinth of islands and straits, proceeded more slowly. Charting of the Hudson Bay region began with the seventeenth-century English voyages in search of the Northwest Passage. The Arctic coast was first depicted in 1772 on Samuel Hearne's map showing the Coppermine River to the Arctic Ocean (published in 1795). Between 1818 and 1838, British naval and Hudson's Bay Company expeditions continued the process, the pace accelerating during the period of the search for Sir John Franklin's lost expedition (1847–1859), when many islands were surveyed for the first time. Vilhjalmur Stefansson's discovery and survey of the last unknown islands between 1913 and 1918 concluded the outline mapping of the region.

The first recorded European—as opposed to Inuit—maps of Greenland were those compiled in 1605 by James Hall, pilot of John Cunningham's Danish expedition. Hans Egede's map of southern Greenland in 1737 significantly omitted Frobisher's Strait, which earlier cartographers show cutting across south Greenland as a result of circumstances described in the entry for Martin Frobisher. Despite Egede's insisting that it did not exist, "Frobisher's Strait" continued to be depicted there rather than on Baffin Island by many maps into the nineteenth century.

Arctic cartography has continued to develop into modern times, as the more inaccessible regions were finally reached by explorers: Severnaya Zemlya, for example, discovered in 1913 and not surveyed until 1930–1932 by Georgiy Ushakov; and East Greenland, mapped by a succession of Danish expeditions from 1884 when Ammassalik was first reached by Gustav Holm. Aircraft and, more recently, satellites have led to significant improvements in accuracy, particularly in the portrayal of interior detail.

David Clammer

See also: Arctic Circle; Bering, Vitus Jonassen (1681–1741); British Arctic Expedition (1875–1876); Canadian Arctic Expedition (1913–1918); Continental Shelf Claims in the Arctic; First German North Polar Expedition (1868)

Further Reading

Bagrow, L. *History of Cartography.* London: C. A. Watts, 1964.

Lainema, M., and J. Nurminen. *Ultima Thule: Arctic Explorations.* Helsinki, Finland: John Nurminen Foundation, 2001.

Parry, W. E. *Journal of a Voyage for the Discovery of a North-West Passage from the Atlantic to the Pacific: Performed in the Years, 1819–20, in His Majesty's Ships Hecla and Griper, under the Orders of William Edward Parry; with an Appendix Containing the Scientific and Other Observations.* London: John Murray, 1821.

Chamisso Wilderness

The Chamisso Wilderness is managed under the U.S. Fish and Wildlife Service and is part of the National Wilderness Preservation System. In 1975, the U.S. Congress under Public Law 93–632 designated 455 acres (184 hectares) as a wilderness area and officially established the Chamisso Wilderness (66° 13′N 161° 49′W). Prior to the Congressional designation, the areas of the Puffin and Chamisso Islands and a few nearby rocky islets were established as a wildlife refuge on December 7, 1912. In 1980, the Chamisso Wilderness became part of the Chukchi Sea Unit of the Alaska Maritime National Wildlife Refuge.

Chamisso Island (66° 13′N 161° 49′W) and Puffin Island (66° 13′N 161° 51′W) are located in the Kotzebue Sound off Spafarief Bay and at the mouth of Eschscholtz Bay. Chamisso Island is a small almost arrowhead-shaped island about 1.5 miles long and 0.125 miles wide. The highest elevation of the island is around 225 ft. above sea level. The island's vegetation is a beach zone, bogs, and tundra. The beach zone consists of a long sandy spit and low-lying beach area. There are a few marshy bogs and the terrain above the sandy beaches is mostly tundra. There are about a 40 different plant species on the island. The primary bird species of Chamisso Island is horned puffins. The island was named after German poet and botanist Adelbert von Chamisso (1781–1838), who was the first European to reach the island in 1816.

Two miles away from Chamisso Island is Puffin Island. Puffin Island is smaller than Chamisso Island and is primarily a steep rock. Puffin Island has a higher population of nesting birds than Chamisso, and its terrain provides excellent nesting habitat for birds, especially horned puffins, black-legged kittiwakes, and murres (common and thick-billed). Around 25,000 seabirds nest on Puffin Island, while 3,000 nest on Chamisso Island. There are about a dozen different plant species on the island, which are mostly different grass species. Puffin Island was named by English Naval Officer Frederick William Beechey (1796–1856) in 1831.

Prior to Adelbert Chamisso and Captain Beechey's arrival, the local Inuit/Eskimo population had been utilizing the islands for subsistence activities for hundreds of years. Both islands are still used by the local Eskimo population for subsistence activities, where they gather mostly kittiwake and murre eggs. Beyond the bird populations, the islands are most uninhabited. The islands are available for recreation purposes, such as camping, hiking, bird-watching, and kayaking, as are all federal lands listed under the National Wilderness Preservation System. The islands frequently experience rough seas resulting in boating being risky.

Andrew J. Hund

See also: Arctic National Wildlife Refuge (ANWR); Climate Change and Invasive Species in the Arctic

Further Reading

Von Chamisso, Adelbert. *A Voyage around the World with the Romanzov Exploring Expedition in the Years 1815–1818 in the Brig* Runk, *Captain Otto von Kotzebue.* Translated and edited by Henry Kratz. Honolulu: University of Hawaii Press, 1986.

Chinstrap Penguin

The chinstrap penguin (*Pygoscelis antarctica*) is a medium-sized penguin that nests on the Antarctic Peninsula and islands in the circumpolar region of the subantarctic, including the southernmost islands in all three major oceans. Birds grow to 27 inches (68 cm) in length, although weight is highly variable due to both sex and breeding cycle, ranging from 6.5 to 13 pounds (3–6 kg). By the end of the breeding cycle in March, adults have run through most of their fat reserves and spend the rest of the year building up weight for the next breeding cycle, which begins in November.

As with all other penguin species, the chinstrap is flightless although with flippers built for swimming underwater. It is black above and white below with a black bill and diagnostic narrow black band running from crown to chin, appearing like a helmet chinstrap. When combined with reddish-brown eyes and white edgings to black flippers, the chinstrap penguin is one of the most easily recognizable. There is no sexual dimorphism in plumage.

The chinstrap is classified as a species of least concern, with a global population of over 15 million birds. Both population and range were thought to expand during the 1960s due to increased commercial whaling, which served to remove much of their competition for krill. To find food, which also includes fish and shrimp, chinstraps have been known to swim up to 100 miles (160 km) in a day. Their main predator is the leopard seal.

Like the Adélie and emperor penguins, the chinstrap is one of the three truly Antarctic penguins. But unlike the Adélie and emperor penguins, the chinstrap penguin does not breed away from the Antarctic Peninsula. Similar to its cousins, the chinstrap has evolved a highly developed defense system against cold temperatures. Blubber provides insulation, and blood vessels in the feet and flippers aid in the retention of body heat. The density of body feathering, second in the bird world only to the emperor penguin, provides a watertight seal keeping the frigid waters from coming into direct contact with skin. Although they do not breed in the slightly warmer waters of the northern subantarctic region, beach-wrecked birds in heavy molt have been found as far north as Tasmania and New Zealand.

The chinstrap has the dubious reputation of being the most pugnacious and aggressive species in the penguin family. Despite their unique look, there are very few depictions of this species in popular culture. An exception to this is the bizarre case of Roy and Silo, two male chinstraps that improbably found themselves at the forefront of the culture wars during the early part of the new millennium. After forming a pair bond at the Central Park Zoo in New York, these two males successfully hatched and raised a chick from an egg placed in their exhibit. A 2005 children's book based on this episode, *And Tango Makes Three*, found itself subject to censorship and bans due to perceptions that the book served as a metaphor condoning homosexuality and same-sex child rearing.

Andrew J. Howe

See also: Adélie Penguin; Emperor Penguin; Gentoo Penguin; King Penguin; Macaroni Penguin; Rockhopper Penguin

Further Reading

Bustamante, J., and R. Marquez. "Vocalizations of the Chinstrap Penguin *Pygoscelis antarctica.*" *Colonial Waterbirds* 19, no. 1 (1996): 101–10.

Jan, R., and E. Taylor. "Thermal Insulation of the Down and Feathers of Pygoscelid Penguin Chicks and the Unique Properties of Penguin Feathers." *The Auk* 103, no. 1 (1986): 160–68.

Juan, A. Amat, Luis M. Carrascal, and Juan Moreno. "Nest Defense by Chinstrap Penguins *Pygoscelis antarctica* in Relation to Offspring Number and Age." *Journal of Avian Biology* 27, no. 2 (1996): 177–79.

Chukchi

The Chukchi are an indigenous group inhabiting the Chukotka Autonomous Okrug in the northeastern part of Russian Far East. It is a region with a severe climate with winter temperatures dropping as low as −58°F (−50°C) and summer temperatures averaging around 50°F (10°C). The Chukchi population is approximately 16,000 with most (12,800) living in the territory of Chukotka. About 1,500 Chukchi live in Kamchatka and 250 in the Magadan in the south, while 600–700 live in the Nizhnekolymsk. Scattered minor groups live elsewhere, including Saint Petersburg, Russia.

Historically, the Chukchi population were nomads with a coastal population called the Maritime Chukchi (self-designation *anqa'lït* "coastal men") and interior Reindeer Chukchi (self-designation *av ulat* "reindeer men"). This division is due to their means of subsistence. The coastal dwellers are whale and walrus hunters, while those living on the tundra are reindeer nomads. They speak the same dialect (although some lexical differences exist), intermarriage is common, and very few cultural differences exist. The Maritime Chukchi are believed to be ancestors of Chukchi who mixed and assimilated the Yup'ik hunters who earlier lived in the area.

The Chukchi came in contact with Russians in the early seventeenth century when Cossacks and fur traders began to visit the area. A fortress and trading post was founded at Nizhnekolymsk in 1644 and in Anadyrsk near their settlements in 1649, but the natives had a wary approach toward the Russians, which minimized contact. In the year 1700, the Chukchi numbered approximately 6,000. Russian Cossack units' attempts to conquer the Chukchi-inhabited areas during the

Chukchi in traditional clothing leads with dog harness. (Shutterstock.com) eighteenth century met with fierce resistance. In a battle in the spring of 1747, the Chukchi defeated a Cossack regiment headed by Dmitry Pavlutsky, who himself was killed. The Czarist administrative influence was therefore nominal for a long time. Early written records of the Chukchi date back to 1716, when Ambjörn Molin, lieutenant in a Swedish cavalry regiment, traveled in their areas and reported on their way of life. They are described in 1755 in a travelogue by the Russian explorer Stepan Krasheninnikov.

When whaling ships began to visit the area from the end of the eighteenth century and onward, the contacts between the Chukchi and the outside world expanded. Trade products were brought with these ships. Russian Orthodox missionary works began in the early nineteenth century, which increased contacts. Ferdinand von Wrangel, who had led a Russian expedition, reached their area in the 1820s and provided some information about them to the other world. At the end of the 1870s, the numbers of Maritime Chukchi were estimated at around 3,000 persons, distributed over a vast area from the Bering's Strait to Cape Shelagsky, a stretch of almost 775 miles (1,250 km). When the Swedish Vega expedition had to stay a winter outside Pilgykey in 1878–1879, the crew was visited by neighboring Chukchi hunters. The scholars on board conducted a unique fieldwork among them during the long winter stay, researching their language, material culture, and religion, and the botanist F.R. Kjellman made a methodologically exemplary ethnobotanical field survey. Their art, which was also studied, included traditional walrus ivory carved works. Being in exile, ethnographer Vladimir Bogoraz was able to conduct in-depth fieldwork over the next decade and collected rich ethnographical data. In 1900, he was invited to join the Jessup North Pacific expedition, which made it possible for him to continue the fieldwork. His results were published in four large volumes. In the winter of 1919–1920, the Norwegian oceanographer Harald Sverdrup traveled with Chukchi reindeer herders and later wrote a book about them.

Traditional Way of Life

To survive in this remote and harsh environment, the Maritime Chukchi were almost exclusively dependent on hunting and fishing, especially the hunting of marine mammals, such as bowhead whales, walruses, and seals. The polar bear was also among their prey until 1956 until Soviet government banned its harvesting. Whales and walruses were hunted in walrus-hide canoes. During the summer season, they also caught a lot of birds and gathered eggs on the cliffs. Chukchi fed and still feed their dogs with walrus meat. Fish were used as a kind of supplementary dog food, although they also caught cod for their own consumption. The endemic freshwater small fish, *Dallia delicatissima*, found in small tarns in their settlement area was regarded as a delicacy among the Chukchi. Observations in the late nineteenth century show that not only several kinds of seaweed were used as food, but also other plants and roots were gathered during the brief summer season and stored fermented in bags. The coast dwellers also bartered food (among other things, algae gathered in the wintertime) with their nomadic kinfolks, Reindeer Chukchi, in the interior. The nomadic reindeer herders kept quite large herds and used dogs for guarding the herds. In the early twentieth century, the wealthiest Chukchi owned herds numbering between 3,000 and 5,000 animals. Those households with smaller herds hunted some seals in the summer. The herds provided the Reindeer Chukchi with most food, including the fresh or fermented stomach contents from newly slaughtered reindeers. Their usual morning meal consisted of hot soup made from the contents of reindeer stomachs. However, this dish seems to have become less important after the introduction of tea. Bird-hunting also provided food for the reindeer nomads.

The winter season lasted from 9 to 10 months. During the brief summer from the end of June to September, hunting season is very active and provides most of the game for the winter. Pacific walruses and polar bears were hunted with ingeniously constructed spears, while seals were captured with large-mesh nets made of walrus hide. The Chukchi lived all year-round in skin tents (*yarangas*), made of walrus-hide and reindeer skins. The Maritime Chukchi used dogs as draft animals during spring hunting on the ice and traveling to their neighbors. The Chukchi dogs were considered as good though slow draft animals, and were capable of long-continued exertions.

Modern Way of Life

By the late 1920s, about 70 percent of the Chukchi were still nomads; however, after 1929, they were collectivized under the Soviet Union and made to settle. In the 1950s, the Chukchi's ancestral land was used for gold, tin, tungsten, and coal mining operations and oil discoveries threatening subsistence ways of life. The atmospheric nuclear tests of the late 1950s and early 1960s on Novaya Zemlya and the nuclear fallout affected also Chukotka and its inhabitants, who, for instance, have an increased cancer mortality rate. Also, heavy metals have passed through the food chain and are damaging the local populations that rely on subsistence foods. The Chukchi have also had high prevalence of tuberculosis and cirrhosis. Climate changes and the permafrost melting are a new threat toward the Chukchi way of life.

Whaling is still important for the Maritime Chukchi; they are allowed to harvest a certain number of gray and bowhead whales each year under a five-year block quota by the International Whaling Commission. Walruses and seals have an important role in their diet. Many traditional habits are still practiced, including food habits, local religion, and lifestyles.

After the breakup of the Soviet Union, there has been an increased interest in their area and in their lifestyle in the Arctic. Scholars from all over the world are coming to Chukotka, but there is also a growing tourist industry, which may be beneficial for their future. Local museums with a lot of traditional Chukchi artifacts exist in Anadyr and in the Uelen village. Mining continues to be important to the local economy. The large coal reserves of Chukotka are of interest for foreign developers, such as China.

The Chukchi Language

The Chukchi belongs to the Chukchi-Kamchatkan group of Paleosiberian languages (related to Alutor, Itelmen, and Koryak languages) and is considered an endangered language. The United Nations Educational, Scientific, and Cultural Organization list the Chukchi language as severely endangered with 7,742 fluent speakers. About one-third of the Chukchi speak their native language on a daily basis, while the other half speaks Russian. Most Chukchi are at least bilingual; only a few master only their native language, and these people are now in their 70s. An interesting observation is the existence of Chukchi gender dialects: women's language differs from the Chukchi men's variety in a number of ways. The Chukchi is also used by the neighboring now-almost-assimilated Kerek people (only four left), which were highly influenced by them. Also the reindeer-herding Chuvans living within Chukotka speak the Chukchi language. During the international whaling era from 1850 to around 1900, a Chukchi-English-Yup'ik-based pidgin was used in the contacts between the ship crews and the natives.

The written language was created in 1932 at the Leningrad Institute of Northern Peoples, using the Latin alphabet. A few school textbooks were published. In 1937, the Latin script was replaced by a Cyrillic alphabet. Currently, there are radio broadcasts in Chukchi, the regional newspaper *Krainy Sever* ("The Far North") has a page in Chukchi language, but the literature is still very sparse. There is an increasing interest in the revival of the culture and use of language in all domains of the local society.

With the breakdown of the Soviet Union, political mobilization also began among the indigenous peoples of Siberia. Contemporary Chukchi are politically quite active, and they also participate in several important international organizations, such as the International Whaling Commission, Alaska Eskimo Whaling Commission, Eskimo Walrus Commission, and U.S.-Russian polar bear meetings.

Ingvar Svanberg

See also: Chukchi Sea; Dolgans; Enets; Eskimos; Evenks; Evens; Inuit; Ket; Khanty; Koryak; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Bogoras, W. *The Chukchi. 4 vols.* Leiden, The Netherlands: E. Brill, 1904–09.

Bogoras, W. *The Chukchi Mythology.* Leiden, The Netherlands: E. Brill, 1910.

Kerttula, A. *Antlers on the Sea: The Yup'ik and the Chukchi of the Russian Far East.* Ithaca, NY: Cornell University Press, 2000.

Svanberg, I. "The Fortuitous Ethnobotanist on Ice: Frans Reinhold Kjellman (1846–1907) and His Field Work among the Maritime Chukchi at Pitlekay." In Ł. Łuczaj and I. Svanberg, eds. *Encounters with the Science of the Concrete: Pioneers in European Ethnobiology.* Uppsala, Sweden: Acta Universitatis Upsaliensis, 2013.

Chukchi Sea

The Chukchi Sea is a marginal sea of the Arctic Ocean and is located between the Beaufort (west) and East Siberian (east) Seas. It is named after the Chukchi people from the Chukotka Peninsula, who have traditionally used the sea and coastal regions for subsistence activities, such as hunting fur-bearing animals and marine mammals (whales, walrus, etc.), and reindeer herding. The Chukchi Sea is an ocean link between Siberian Rivers and ports in the Russian Far East, Canada, and the United States. The shallow Chukchi Sea has a highly productive seafloor that enables bottom-dwelling prey, such as fish, crustaceans, and mollusks, to thrive. The abundance of prey attracts many predators, such as seabirds, gray whales, walrus, and seals. The sea ice of the Chukchi Sea also provides denning area for polar bears.

The Chukchi Sea is bordered to the west by the De Long Strait near Wrangel Island (71° 14′N 179° 25′W), to the east by Point Barrow, Alaska (71° 23′N 156° 28′W), to the south by the northern limit of the Bering Sea (66° 33′N—the Arctic Circle), and to the north the Arctic continental slope. The northern boundary is sometimes determined as a line from the northernmost point of Wrangel Island to Point Barrow, Alaska (71° 20′N 156° 20′W to 179° 30′W). The total area of the Chukchi Sea is about 230,000 square miles (595,000 sq. km). The average depth is about 250 ft. (77 m) with more than half the Chukchi being less than 160 ft. (50 m) deep.

The Chukchi Sea is fed by the Pacific Ocean via the Bering Strait. There are three main currents in the Chukchi Sea, which are the Bering Sea Water, the Alaska Coastal, and Siberian Coastal Currents. The Bering Sea Water flows north and is fed or comprises the Pacific Ocean and Anadyr River. This current exits the Chukchi Sea via the Barrow Canyon, Central Channel, and Herald Canyon. The Alaska Coastal Current flows just off the coast of Alaska. The Siberian Coastal Current flows along the Siberian coast and is believed to exit into the innermost part of the Chukchi Sea. During the summer and fall, the Siberian Coastal Current is noticeable, while in the winter and spring, it is nonexistent or faint. The Chukchi is navigable four months (July and October) of the year. The remaining months of the year, the Chukchi is frozen. The flow or current of ice into the Chukchi moves along the Siberian coast in a southeastward direction.

Several rivers empty into the Chukchi Seas, such as the Amguema, Chegitun, Kavalina, Kobuk, Kokolik, Noatak, Ulik, Utukok, and Yeni-Veyem Rivers. Kotzebue Sound and Kolyuchin Bay are the largest inlets. Compared with other marginal seas, the Chukchi has a limited number of islands. The major islands in the Chukchi Sea are Herald, Kolyunshin, and Wrangel Islands. The main port of the Chukchi is Uelen (66° 9′N 169° 48′W), Russia. The International Date Line (IDL) generally runs along the 180th meridian, but it deviates in one place through the Bering Strait into the Chukchi Sea. The IDL deviates eastward through Bering Strait into the Chukchi Sea then deviates westward above the Wrangel Island back to the 180th meridian.

Located off the Alaskan coast, the Hope Basin is the key geological characteristic of the Chukchi seafloor. There are two submarine canyons, called the Herald and Barrow, which cut across the seafloor of the Chukchi Sea. The Herald canyon is about 295 ft. (90m) deep and starts around 70° N and continues northward roughly along the 175° W meridian. Part of the Barrow Canyon is in the Chukchi Sea. The Barrow Canyon starts out roughly west of Point Barrow, Alaska, runs parallel to the Alaska coast in a northeastward direction, and then enters the Beaufort Sea just north of Point Barrow. The depth of the Barrow Canyon ranges from around 160 to 330 ft. (50–100 m) deep.

Andrew J. Hund

See also: Arctic Basin; Arctic Ocean; Barents Sea; Beaufort Sea; Chukchi; East Siberian Sea; Kara Sea; Laptev Sea

Further Reading

Darian-Smith, K. *Australia, Oceania and Antarctica—Continents of the World.* London: Hodder Wayland, 2005.

Climate, Long-Range Investigation, Mapping, and Prediction (CLIMAP) Project

CLIMAP project was established in 1971 and ended in 1981. The project coincided with the International Decade of Ocean Exploration and was funded by the National Science Foundation. The objective of the CLIMAP research project was to determine ocean-ice–atmosphere factors that contributed to the global climatic changes from the past million years. The data collected for the study were fossil abundance from the seafloor sediment cores to create a climatological map of the earth during the Last Glacial Maximum (LGM) or approximately 18,000 years ago.

The original members of the CLIMAP project consisted of researchers from Oregon State University, the Lamont Doherty Geological Observatory, Columbia University, and Brown University. The focus of the original group was to study climate change that resulted from the most recent cooling period of 18,000 years ago in Antarctica, North Atlantic, and North Pacific. The researchers sought to reconstruct the sea-surface conditions and temperatures of the planet during the LGM and develop seasonal maps to understand the oceans response to the cooling period. Maps of vegetative zones across continents were also developed. Collectively, more than 100 researchers participated in the project. The scientists were focused on the origins of ice ages and how the planet responded to them. They believed that understanding the processes related to an ice age could possibly provide insight into predicting future climate changes.

The data collected during the project primarily focused on the LGM between 18,000 and 21,000 years ago and also included samples from the interglacial period dating back to 120,000 years ago. The CLIMAP data consist of 635 sediment cores that include micropaleontology files on geochemistry, plankton in marine sediments, rock and sediment layers (stratigraphy), microscopic skeletal plate of calcite that makes a protective cover over a number of ocean phytoplankton that are in a fossilized state (coccoliths), and ameba-like single-celled aquatic animals (radiolarian).

CLIMAP made several advances for the scientific community, such as the reconstruction of the earth's climate 18,000 years ago and provided estimates for how much the planet cooled since then. CLIMAP also provided a model by which to date ocean sediments. Modern scientists using climate models have not been able to replicate findings from the CLIMAP project. For example, modern climate models result in regions having lower temperatures than the CLIMAP project data revealed. The difference in findings between current climate studies and the CLIMAP project continues to provoke discussion among scientific circles. Resolution to the debate may require undertaking a resampling of the Pacific Ocean.

Andrew J. Hund

See also: Climate Change and Invasive Species in the Arctic; Climate Change and Permafrost; Climate Change in the Arctic

Further Reading

COHMAP Project. "Climatic Changes of the Last 18,000 Years: Observations and Model Simulations." *Science* 241 (1988): 1043–52.

National Academy of Sciences. *In an Ocean Quest—The International Decade of Ocean Exploration.* Washington, DC: National Academy of Sciences, 1969.

Climate Change and Invasive Species in the Arctic

Invasive species are known to cause vast ecological and economic damage. In the Arctic, a short growing season and low temperatures currently restrict establishment, growth, and reproduction of most invasive or nonnative species. Climate change is expected to increase potential habitat for invasive species. Invasions can displace native plant and wildlife populations, reduce habitat quality, and change ecosystem functions. Introduction pathways to Arctic regions have been deliberate or incidental. Predicting where species are likely to occur improves ability to plan prevention and treatment options.

Nonnative plant species compose less than 10 percent of the flora in the Arctic and are almost entirely restricted to disturbed areas near human habitation. Most are common nonnatives in low densities with limited invasive properties and are not currently considered to be a major threat to the ecology of the tundra biome. Approximately 20 nonnative vascular plant species are inventoried in the Arctic in the statewide Alaska Exotic Plant Information Clearinghouse, representing nine families. Species include a number of grasses, such as meadow foxtail (*Alopecurus pratensis* L.), smooth brome (*Bromus inermis* L.), and quack grass (*Elymus repens* [L.] Gould). Other species include forbs like lambs quarters (*Chenopodium album* L.), shepherd's purse (*Capsella bursa-pastoris* [L.] Medik.), white sweet clover (*Melilotus alba* Medikus), and bird vetch (*Vicia cracca* L. ssp. *cracca*). Distribution is mainly along the Dalton Highway (Haul Road) connecting Fairbanks to Prudhoe Bay, within villages, and along established trails and tracks.

Growing degree-days are increasing in the Arctic, and the total number of species is projected to increase. Nonnative species are currently a small component of the diversity and biomass of the region, but rising temperatures, increasing propagule pressure, and higher levels of disturbance may increase the proportion. Nonnative plant richness is higher in settlements with higher total temperature by growing degree-days, suggesting that a warming climate will facilitate establishment of new populations or an increased expansion of existing invasive populations.

Several factors contribute to higher invasion vulnerability in a warmer climate. Fire regime changes may result in large-scale wildfire, opening larger areas of bare ground to invasion. Increased insect and disease may affect native plant communities, causing niche gaps. Water may be more available as permafrost melts, and the active soil layer increases in depth, favoring invasive plants over low-water-adapted native tundra plants. Most significantly, higher rates of shipping, trade, traffic, and use of the Arctic region by humans will increase propagule pressure and cause repeated introductions. Existing known populations may expand as established species respond to slight increases in temperature.

Limitations to invasive species establishment in the Arctic include the climate itself, with low temperatures, limited growing degree-days, low moisture availability, and a short growing season. Competition from native plants, which often form a thick mat, may prevent establishment. Shrub abundance increases may reduce the amount of bare ground available. Many native plants have a large ecological amplitude, or tolerance to a wide range of environmental conditions, causing plastic (variable) growth forms. Native plants can better withstand harsh conditions by changing structure and function, improving competitive ability. The harsh climate may also drive the development of new genotypes (genetically different types), polyploids (plants with multiple copies of chromosomes), and genetically transient phenotypes (plastic growth forms), allowing adaptations to compete with invaders.

Large-scale ecological impacts may include changes in hydrology and drainage patterns, reductions in wildlife forage, or changes in pollination regimes leading to decreases in native berry production or other subsistence products. Fire regimes may change if large-scale infestations like quack grass become established. Economic impacts may be less direct or immediate, but are possible with aquatic invaders like elodea in waterways, restricting transportation. The European elodea species has been documented in Alaska and Canada, and the North American species in Europe, as an example of panarctic species transport.

Higher invasive diversity occurs in areas with a long settlement history and more extensive livestock use. Remote homestead sites, canneries, salteries, and whaling stations often had gardens and trees planted. Sites with warm microclimates, such as hot spring areas, can support more nonnative species than surrounding areas. Deliberate introductions have included lawn grass, ornamental flowers, vegetables and other crops, experimental gardens, and bank and roadside stabilization efforts. Incidental introductions have occurred through packing straw, other packing material, animal feed, potted plants, and crates that contain seeds, plant parts, live seedling, or insects and disease pathogens. Distribution to remote sites is facilitated by boat and aircraft use, or on transported gear. Natural distribution can occur with seeds or plant parts transported by wind, bird droppings, wildlife, rivers, or across sea ice or on ocean currents. Invasive marine species are brought in on shipping traffic, through ballast water exchanges and hull fouling organisms.

Range map scenarios spatially illustrate where species can occur in today's climate and where they can spread in future climates. Habitat shifts occur in response to climate change sensitivity, mobility, lifespan, and availability of suitable abiotic factors. Predictive range maps of current and potential future habitats depict invasive species ranges that exceed current known distributions, although most invasive species have limited habitat potential in the Arctic. Improved climate models and projections may enhance predictive modeling, leading to better predictions. Anticipating change facilitates adaptive management decisions on prevention and control options for invasions that may occur in the Arctic, to prevent future ecological or economic impacts.

Elizabeth Bella

See also: Arctic Botany; Arctic Shrub Range Expansion; Climate Change and Permafrost; Climate Change in the Arctic

Further Reading

Bella, Elizabeth M. *Invasive Plant Species Response to Climate Change: Bioclimatic Models of Current and Predicted Future Time Steps.* Anchorage, AK: HDR Alaska Inc. and US Fish and Wildlife Service, 2009. http://alaska.fws.gov/fisheries/invasive/reports.htm. Accessed January 8, 2014.

Carlson, Matthew L., et al. *Invasiveness Ranking System for Non-Native Plants of Alaska.* Anchorage, AK: USDA Forest Service, R10-TP-143, 2008.

Epstein, Howard E., et al. *Arctic Report Card: Update for 2012: Vegetation.* Washington, DC: SEARCH, NOAA, CAFF, and AMAP, 2012.

Climate Change and Permafrost

Permafrost is estimated to contain approximately 1,800 billion tons of carbon (1.8 Pg), which is twice the amount contained in the earth's atmosphere. Permafrost covers approximately 8.8 million square miles (23 million sq. km) or about 25 percent of the earth's land surface. In some places, permafrost can be more than 0.5 mile (1 km) deep and up to 500,000 years old. Thus, permafrost represents a major pool of carbon and could play an important role in global warming as Arctic temperatures increase. While it is known that permafrost characteristics differ across the Arctic in terms of depth, soil type, hydrology, and vegetation, it is not clearly understood what the impact of a warming Arctic will be. Future uncertainty is compounded by the fact that the majority of scientific study has taken place in the Alaskan Arctic, despite the bulk of the earth's permafrost being located in Siberia.

According to climate models, permafrost now and in the past has acted as a carbon sink, with more carbon taken in from the atmosphere through photosynthesis during the short Arctic growing season that is emitted through decomposition and respiration throughout the year. This can be observed in permafrost deposits, which commonly contain deeply buried plant remains that are tens of thousands of years old, but appear to be relatively fresh and not decayed. As climate warms, permafrost will thaw and become dryer, which will expose previously frozen organic material to sunlight and bacterial action, enhancing respiration and decomposition. This will have the effect of converting permafrost carbon to the greenhouse gases carbon dioxide and methane, promoting global warming. This is a *positive feedback* process in which warmer climate will lead to thawing permafrost, which in turn will lead to increasing greenhouse gases and even warmer climate. However, it also must be considered that a warming climate will produce a longer growing season, increasing photosynthesis. The overall carbon balance in a warming tundra is not well understood at this time, but current research warns that Arctic ecosystems could shift from being a carbon sink to being carbon-neutral, or even becoming a carbon source depending on the amount of warming that occurs.

Concern over the thawing of permafrost is especially acute because temperature increases in the Arctic over the past 100 years have been greater than any other area of the planet, with some parts of the Arctic experiencing more than twice as much warming as the global average. Borehole studies have observed that permafrost temperatures at 65 ft. (20 m) depth have increased 36–37°F (2–3°C) in the past two decades. Because of the large quantity of carbon locked up in permafrost and the prospect of even more extreme warming in the future, "carbon dioxide and methane emissions from thawing permafrost and warming wetlands of the Arctic have been referred to as a carbon bomb, and there is compelling evidence that the fuse is burning now" (Hansen 2004).

Estimates of future permafrost thawing vary and depend on the extent of future warming. Scientists assuming a high warming scenario of 36.5°F (2.5°C) by the year 2040 and 45.5°F (7.5°C) by 2100 estimated that 9–15 percent of the top 10 ft. (3 m) of permafrost will thaw by 2040 and that 47–61 percent will thaw by 2100. The estimated carbon release from this degradation would be 30 billion to 63 billion tons of carbon by 2040, reaching 232 billion to 380 billion tons by 2100. Predictions of Arctic permafrost degradation by 2100 ranging will be from 40 to 90 percent. Although the projections vary widely on the exact amount of thaw, there is agreement that the areal extent of permafrost will decrease and the active layer will deepen, leading to increasing production of carbon dioxide and methane.

In addition to releasing previously stored carbon, the melting of permafrost changes the physical landscape of the tundra. Warmer temperatures create taliks, a layer of unfrozen soil above the permafrost but below the seasonally frozen surface soil layer. Warming also leads to increased development of thermokarst features, which are local landslides, sinkholes, and other soil collapse due to the melting of ice and subsequent drainage of soil water from permafrost. Thermokarst lakes (or thaw lakes) are shallow water bodies formed by melting and are increasing in some areas.

While warming temperatures lead to melting soil ice and wetter conditions in some areas, they can also increase evaporation rates and result in drying tundra. A drying tundra can lead to increased microbial action, promoting the conversion of permafrost carbon to carbon dioxide and methane, and also causing wildfires. The 2007 Anaktuvuk River fire burned across more than 385 square miles (1,000 sq. km), which was more than twice the extent of wildfire in the Alaskan tundra in the past 50 years. Both fire and increasing microbial respiration transfer carbon from permafrost to the atmosphere, creating climate feedbacks that will promote future warming.

Yet another impact of warming climate is a biome shift, with the boreal forest biome moving north and the southern boundary of the tundra shifting northward, decreasing its overall size. Recent research suggests that the way in which this shift may take place is poorly understood, but analysis of satellite imagery indicates that the transition may not be a smooth process and instead may proceed abruptly, with unknown impact on biotic communities within the transition zones.

Bruce Taterka

See also: Climate Change and Invasive Species in the Arctic; Climate Change in the Arctic; Environmental Concerns, Arctic Mining Operations

Further Reading

Cory, R., B. Crump, J. Dobkowski, and G. Kling. "Surface Exposure to Sunlight Stimulates CO_2 Release from Permafrost Soil Carbon in the Arctic." *Proceedings of the National Academy of Science of the United States* (PNAS) 110, no. 9 (2013): 3429–34; published ahead of print February 11, 2013, doi:10.1073/pnas.1214104110. http://www.pnas.org/content/110/9/3429.full.pdf++html. Accessed January 8, 2014.

Edward, A., G. Schuur, and Benjamin Abbott. "High Risk of Permafrost Thaw. The Permafrost Carbon Network." *Nature* 32 (2011): 480.

Hansen, J. "Defusing the Global Warming Time Bomb." *Science American* 290, no. 3 (2004): 68–77.

Climate Change in the Arctic

Climate has continuously changed throughout the past millennia and been altered by the planetary system and associated cycles. Coupled with plate tectonics and other factors, climate has shaped the Arctic dramatically: on land, at sea, in the atmosphere, and on the ground. This had widespread global effects on the setup of tropical rainforests, ocean currents, the cryosphere, and the atmosphere. As a consequence, at different times throughout the earth's history, not only dinosaurs and tropical species lived in what is now referred to as the Arctic, but they also disappeared (winked out) again locally and on a broader scale. However, man-made climate change puts a different spin on the natural climate change now.

While climate cycles and earth processes are still ongoing, the human population has increased dramatically during the past 100 years and so has the global consumption of products and goods in the past 50 plus years. A major driver of this development was the industrial revolution, which triggered one of the biggest changes known for the globe since humans have been wandering the earth. These changes include intense use of natural resources, exploration, and extraction of fossil fuels, with subsequent contamination and pollution of the atmosphere as well as associated habitat changes. Through intensive use and burning of fossil fuels as well as deforestation, vast amounts of greenhouse gases (GHGs) are released into the atmosphere. Among other contributors, this leads to the greenhouse effect, which subsequently changes climate patterns and is known as climate change. Moreover, most GHG emissions have increased with economic growth and human activities, according to the IPCC 2007.

The view of Alaska's Muir Glacier in 1892. (Glacier Photograph Collection)

Due to the large scale of the human undertaking, humans have modified the entire globe, and this human footprint spans from the Arctic to the Antarctic, into the atmosphere, and well into the soil. Human effort and its related policies and procedures, such as unabated economic growth, and as promoted by global institutions like the World Bank, the World Trade Organization, and enforced by the United Nations Environmental Program have not changed things for the better. They indulge neoclassical economic policies, which are not adequate for the current time and for the well-being of the Arctic.

With such a situation, the earth and its atmosphere were overcommitted and are being pushed beyond their carrying capacity. Earth system processes and ecological services such as the global maintenance of weather patterns, related farming productivity, or wilderness areas were significantly compromised. While the global warming trend is clear, in the Arctic, the picture of climate change is still complex and extends far beyond the acknowledged and widely promoted loss of sea ice during the summer with record lows in 2007. Wang and Overland (2009) theorize that the Arctic could become entirely free of summer sea ice by 2050. This loss of sea ice together with other substantial changes in the cryosphere threatens entire

The view of Alaska's Muir Glacier in 2004. (Glacier Photograph Collection)

ecosystems and species habitats related to the Arctic, polar regions, and beyond. While the process of melting sea ice and glaciers in its entirety is rather complex, the overall outcome follows common sense (ice melts when warming). But the implications for the globe and humans are still hard to grasp. Ethically, climate change becomes a dilemma for native peoples living in the endangered regions, possibly creating climate change refugees or environmental migrants, due to the thawing permafrost, coastal erosion, melting glaciers, and melting pole caps. All these conditions are caused by elevated carbon level due to burning of fossil fuel. With such a fundamental decay of Arctic ecosystems, all the species, food webs, and ecological processes suffer as well. The Arctic is not able to continue to function well as the cooling chamber and climate driver for the earth (which maintains the balance between cold and warm systems that we know and evolved upon), and as we are used to.

With Arctic climate change, many administrative efforts have to be modified, such as building overarching Ministries of Climate Change. New federated governance structures need to be found. The current process of listing a few endangered species will have to change toward a massive administrative effort trying to maintain thousands of endangered species at huge costs (e.g., we currently lack Arctic Zoos and such an expertise). While *ex situ* storage of polar DNA in a single global institution is interesting to some people, as done in

Svalbard/Norway, it is not the same as having polar species alive in their wilderness setting. The earth as we know cannot be maintained from the lab and in the lab by humans. By now, the human race has proven to be rather bad at governing the Arctic, and it has to improve significantly in the future. While the Arctic ecosystem is heavily affected by climate change, no relevant proactive or achieving management has yet been established. For times to come, the Arctic makes for one of the most endangered habitats, with its fragile species, yet lacks a valid management scheme.

The notion that economy plays a big role in climate change can easily be seen by the fact that Arctic air quality loss is fueled from the outside (e.g., with international industrial centers such as the United States [east coast and west coast], Europe, and Asia [Asian Brown Cloud, black carbon]). Other circumpolar air quality issues are driven by the Norilsk smelter in Russia, which increases environmental contamination as Russia's economy is growing and with a high throughput. Despite these ongoing troubles with the North, lobbies are quick to exploit this situation. The increasing temperatures and retreat of sea ice allow for Arctic shipping routes, which make old dreams come true: a faster alternative for the Panama Canal, connecting Europe, Africa, and eastern North America with ports in China, Singapore, Japan, and Russia. Even more opportunities like a shipping route circling the entire Arctic may become possible in the foreseeable future. While this sounds tempting for economic reasons, it brings with it a wide variety of problems and impacts, starting with geopolitics and policing questions of the now open Arctic and extending to oil spill and safety issues, port and airport enlargements, and invasive species problems. Where do the unresolved problems end while the earth warms more and human population grows to 9 billion people till 2100, without any means to curb the man-made climate impact?

Climate change has resulted in species ranges shifting north, with some species being called "winners." But in reality, they are actually just removed from their natural niche and mostly consist of invasive species groups like weeds and diseases (parasites and rabies make for a classic representation of such winners). The risk of avian influenza and mosquito (vector-borne) illnesses might also increase.

Now, where does the Arctic go in times of climate change? Arguably, the next 15 years will be unlikely to see a relevant change of the ongoing situation, judging by the development and inertia of the recent past. The Kyoto protocol was insufficiently designed to start out with and has repeatedly missed its targets already (e.g., at the Copenhagen and at the Cancun meetings); nations like Canada promote its abandonment now. China, India, North America, and Europe make no relevant effort to reduce the consumption of goods either, and with a steadily growing world population, this consumption will not be likely to slow down any time soon, nor can carbon emissions be reduced much.

Like never before, a sustainable Arctic governance remains the core problem. No measure or policy has been successful so far in bringing the environmental destruction in Arctic ecosystems to a halt. The latest example indicating no positive change can be seen in the development of Canada's north: On December 4, 2012, Canada had 2.5 million protected rivers and lakes; just one day later, on December 5, 2012, only 82 protected rivers and lakes were left due to a new policy declaration. Overall, it appears that a fundamental change of command and institutional structure is required now to save the last bits and pieces of the Arctic, and the globe. While this sounds dramatic, the near future will decide whether we see a soft and proactive change or whether we experience an avoidable hard crash of mother earth as we know it.

Falk Huettmann and Moritz Schmid

See also: Climate Change and Invasive Species in the Arctic; Climate Change and Permafrost; Environmental Concerns, Arctic Mining Operations

Further Reading

Pachauri, R. K., and A. Reisinger, eds. *Climate Change 2007: Synthesis Report, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC, ISBN 92–9169–122–4, 2007. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_frontmatter.pdf. Accessed January 8, 2014.

Rosenzweig, C., D. Karoly, M. Vicarelli, P. Neofotis, Q. Wu, G. Casassa, A. Menzel, et al. "Attributing Physical and Biological Impacts to Anthropogenic Climate Change." *Nature* 453 (2008): 353–57.

Wang, M., and J. E. Overland. "A Sea Ice Free Summer Arctic within 30 Years?" *Geophysical Research Letters* 36 (2009): 2–5.

Coastal Erosion

A considerable risk posed to the coastal-living Inuit is erosion. For many years, the Intergovernmental Panel on Climate Change has noted the risks of coastal erosion due to the combined climate change effects of melting sea ice, permafrost thaw, storm surges, and waves. In the Arctic, there is evidence that the coastline has been retreating exponentially due to erosion for the past 50 years. The average rate of coastline erosion from the years 1955 to 1979 was calculated to be 22.31 ft. per/year (6.8 m/year), but from years 2002 to 2007, the average rate of coastline erosion was 44.62 ft. per/year (13.6 m/year), and from years 2007 to 2008, the average rate of coastal erosion was 82.02 ft. per/year (25 m/year). The Inuit, Inupiat, and Yup'ik villages of Tuktoyaktuk (Canada), Pangnirtung (Baffin Island, Nunavut), Newtok (Alaska), and Shishmaref (Alaska) have experienced the effects of increased coastal erosion. The increasing effects of coastal erosion will result in relocation and abandonment of Inuit homes and villages and may create climate change refugees.

Tuktoyaktuk, a predominantly Inuit city in Canada, borders the Beafort Sea. (Timothy Epp/Dreamstime.com)

In Canada, there are several areas experiencing coastal/shoreline erosion due to climate change. Tuktoyaktuk, a low-lying port city off the Beaufort Sea, with a mostly Inuit population of 860, is one such area. Factors that make Tuktoyaktuk particularly vulnerable to coastal erosion include thawing permafrost, storm surges, and decreased extent and duration of sea ice. Mitigation efforts to protect Tuktoyaktuk's shoreline have not withstood the effects of storm surges and waves. Without effective mitigation efforts, it is anticipated that Tuktoyaktuk will eventually have to be evacuated. The Inuit village of Pangnirtung in Nunavut is also experiencing coastal erosion along with other effects associated with climate change such as changes in wind patterns, seasonal changes, and ice trends. In several coastal Alaskan villages, raising temperatures due to climate change are causing a reduction in winter sea ice and the melting of permafrost. The loss of these natural protective coastal barriers results in further coastal erosion. Invariably, the effects of climate change including coastal erosion will have the most immediate impact on those who living near the coastline and practice a traditional subsistence livelihood. Unfortunately, these persons will need to evacuate and relocate their homes.

Shishmaref, an Inupiat village, on the Alaskan island of Sarichef is home to approximately 560 inhabitants and has been experiencing significant coastal erosion since early 2000s. Shishmaref is now facing the prospect of evacuation and relocation. The cost of the relocation project is estimated at $180 million. Newtok, an Alaskan city with a population of approximately 340 predominately Yup'ik inhabitants, has been experiencing serious erosion problems due to thawing permafrost, storm surges, and decreased extent and duration of sea ice coupled with the Ninglick River eroding the shoreline. The erosion crisis has resulted in plans to move the village nine miles away at an estimated cost of $130 million. Kivalina, a coastal village located approximately 130 miles (210 km) north of Shishmaref, is also facing the prospect of evacuation and relocation. The projected cost to move the three Alaskan villages of Newtok, Kivalina, and Shishmaref is $450 million.

The U.S. Army Corps of Engineers is attempting to mitigate the effects of erosion by building rock walls along the coasts of Shishmaref, Unalakleet, and Kivalina. The $41 million project is not a solution to the problem but is hoped to allow more time for relocation efforts. In 2003, the Government Accountability Office claimed that 86 percent or 184 out of 213 Alaskan Native villages are susceptible to flooding and erosion. The U.S. Army Corps of Engineers has projected that there are 26 additional Alaskan villages in immediate danger of significant erosion with another 60 more villages being added in the next decade. The estimated future costs associated with protecting Inuit, their lands, and livelihood in the Arctic will be substantial.

Andrew J. Hund

See also: Inuit Lawsuits over Climate Change

Further Reading

Crowley, P. Petition to the Inter American Commission on Human Rights for Dangerous Impacts on Climate Change. 2005. http://www.inuitcircumpolar.com/files/uploads/icc-files/FINALPetitionICC.pdf. Accessed January 8, 2014.

Hassol, Y. *Impacts of a Warming Arctic: Arctic Climate Impact Assessment.* Cambridge: Cambridge University Press, 2004.

Núñez, A. *Human Rights and Climate Change CIEL: The Inuit Case Study.* Washington, DC: The Center for International Environmental Law, 2007.

Colville River

The Colville River is located above the Arctic Circle. It is named after Edward Colville Griffith (1858–1914), who was responsible for surveying the area before the U.S. purchase of Alaska in 1867. It is on the northern side of the Brooks Range and drains most north-flowing rivers of the western Brooks Range into the Arctic Ocean. The Colville River is around 350 miles (560 km) in length. The course of the Colville is starts in the western side of the Brooks Range in the De Long Mountain area and in the southwest corner of the National Petroleum Reserve—Alaska (NPR-A). At its headwaters, the Colville River flows north and then travels east along the foothills of the Brooks Range. On its journey east, the Colville River runs parallel with the southeastern border of the NPR-A. The Colville River and its Brooks Range major tributaries of the Etivluk, Killik, Chandler, Anaktuvuk, and Itkillik Rivers are northern Alaska's major drainage system. At the native village of Umiat (69° 22′N 152° 08′W), the Colville again heads north, flows across a board tundra delta near the village of Nuiqsut (70° 12′N 151° W), and empties into the Arctic Ocean.

In 1977, the Colville River was the first of four areas in the NPR to be designated a special area. In 1999, the tributaries of Kikiakrorak and Kogosukruk Rivers were added as well as a 2-mile buffer zone on each side of the Colville River were added to the Colville River Special Area (CRSA). The Colville River and the tributaries are more than 300 miles in length and around 2.44 million acres. The CRSA is managed by the Bureau of Land Management. There are a several locations with collections of dinosaur and other fossils, dating back to the Cretaceous (145–166 mya). The CRSA is a critical nesting area for approximately 25 percent of Peregrine Falcon population in Alaska. The Colville River has unexploited oil and natural gas deposits. There are more than 20 year-round resident fish species in the Colville River.

Andrew J. Hund

See also: Indigirka and Kolyma Rivers; Khatanga, Lena, and Yana Rivers; Mackenzie River; Ob, Pechora, and Yenisey Rivers; Yukon River

Further Reading

Nigro, D., and R. Ritchie. "Colville River Cliff-Nesting Raptor Survey." Unpublished Report by the U.S. Department of Interior, Bureau of Land Management, Northern Field Office, Fairbanks, Alaska, 2003.

Common Raven

The common raven (*Corvus corax*), easily recognizable with its entirely black plumage and heavy bill, is a well-known bird in the circumpolar folk ornithology. It has coexisted with human beings since the dawn of humanity and played a significant role in religious traditions and local lore everywhere. This large member of the family Corvidae is an important being as a creator, bringer of culture, trickster figure, or a dangerous bird of omen in folk beliefs and myths all over the Northern Hemisphere.

The raven has a wide geographical distribution. It is actually the most widespread species within the Corvidae family, and it is to be found all over Eurasia, North Africa, and North America (although it is nowadays eradicated in many areas), and several subspecies (7–11) are recognized. The nominate form is found in the

Ravens are considered to be one of the smartest birds. (Shutterstock.com)

western Eurasia; *Corvus corax varius* resides in the Faroes and Iceland; the somewhat larger *Corvus corax kamtschaticus* in eastern Siberia and Kamchatka; and the largest subspecies *Corvus corax principalis* is distributed in eastern Alaska, Canada south to Oregon and Washington, and the coastal areas of Greenland. Further subspecies are found more south. Recent molecular–genetic investigations have shown that the common raven falls into two clades: a California one, which is found in the southwestern United States, and a Holarctic clade, distributed across the rest of the Northern Hemisphere. Although the birds from the two clades look alike, they are genetically distinct and began to diverge from each other about 2 mya. Existence of both clades in western North America suggests that the common raven may have colonized North America at least twice. A genetically distinct population also exists on the Canary Islands. In the Faroe Islands, an interesting black-and-white color morph existed earlier, locally known as *hvítravnur* "white raven." However, due to overhunting caused by a compulsory beak tax and demand on the museum trade in the nineteenth century, it is now extinct.

Ravens are extreme opportunistic generalist foragers and find nutrients in many different ways and of any kind, including food waste and carrion. In medieval European cities, it was a common scavenger. Even dead human bodies were left on the battlefield for the ravens as food. The same applies to the dead at execution sites. It was known as *Galgvogel* ("gallows bird") in medieval German. As a scavenger,

Raven on totem. (Andrew J. Hund)

it therefore has a bad reputation in many parts of Eurasia. They easily locate other predators' carcasses from the air, but they also eat berries, insects, small mammals, cereals, and food among garbage at human settings. They can kill smaller mammals themselves and are regarded as predators, disliked by, for instance, some Sámi reindeer herders and Faroese shepherds. It is still very disputed whether the birds actually can kill larger mammals or whether they just eat calves and lambs killed by fatalities.

In the wild, ravens have longevity of about 15–21 years, but life expectancy of up to almost 80 years has been recorded in captivity. Young birds often live in small flocks, but later in life, they form lifelong pairs. Each pair is defending a territory. They built their enormous nest on cliffs or in high trees far away from other pairs. Both parents take care of the chicks, usually four to seven in number, for almost six months.

It seems to have been a widespread practice all over the Northern Hemisphere to keep ravens as pet birds. It was easily tamed and could be taught to imitate human voices. This is described already from Roman times. In the Tower of London, the famous ravens have been kept in captivity for centuries still playing a prominent role in the national ideology of the country. It is also kept in many zoological gardens all over the Northern Hemisphere and breeds easily in captivity. Skansen Zoo in Stockholm was among the pioneers in breeding the raven in captivity in 1909.

People in the subarctic regions usually have a positive view of the raven. It appears as a major figure in the tales and creation myths of various circumpolar people, including the Sámi, Inuit, Yup'ik, Tlingit, Alutiiq, Na-Dene (Eyak, Koyukon, and Tlicho), Algonquian, and various Siberian indigenous people like the Sacha, Chukchi, Koryak, and Ainu. It also played an important role in the life of Norse people who settled in Greenland, Iceland, and the Faroes. Raven is associated with prophecy and magical flight in many areas. According to the French anthropologist Claude Lévi-Strauss, the raven obtained its mythical status because it was a mediator animal between life and death. Raven has been hunted for several reasons all over Eurasia and North America, and some people have even used the meat for food.

Ingvar Svanberg

See also: Arctic Loon; Arctic Seabirds; Arctic Skua; Arctic Tern; Gyrfalcon; Lapland Longspur; Red-Throated Loon; Snow Bunting; Snow Goose; Snowy Owl; Sooty Albatross; Wandering Albatross

Further Reading

Chowning, A. "Raven Myths in Northwestern North America and Northeastern Asia." *Arctic Anthropology* 1, no. 1 (1962): 1–5.

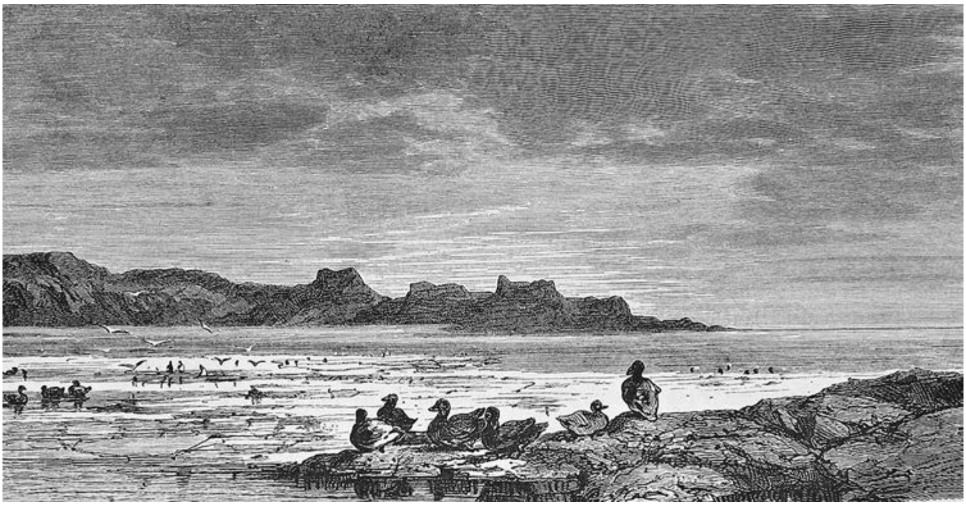
Heinrich, B. *Ravens in Winter*. New York: Vintage Books, 1991.

Omland, K., E.J.M. Baker, and J.L. Peters. "Genetic Signatures of Intermediate Divergence: Population History of Old and New World Holarctic Ravens (*Corvus corax*)." *Molecular Ecology* 15 (2006): 795–808.

Continental Shelf Claims in the Arctic

No country owns the North Pole or the Arctic Ocean region. The five coastal states of Canada, Denmark (Greenland), Norway, the Russian Federation, and the United States (Alaska) have been granted the management, jurisdiction, and governance over the Arctic Ocean under the United Nations Convention on the Law of the Sea (UNCLOS). This international agreement establishes exclusive economic zones (EFZs) that grants development rights over all natural resources in territorial waters and out to 200 nautical miles (230 miles; 370 km) including living resources. A claim to a continental shelf can include a natural prolongation or seabed that extends beyond the 200 nautical miles, but not further than 350 nautical miles (400 miles; 650 km). This provision allows the coastal states to have exclusive rights to and the harvesting of mineral resources to the end of the natural prolongation, but not exclusive rights over living resources beyond the limit of EEZ 200 nautical miles. UNCLOS does not establish the ownership of North Pole or the Arctic Ocean region, just jurisdiction authority over coastal states and mineral resources on the continental shelf.

UNCLOS treaty allowed coastal states 10 years from their date of ratification to extend their claim to the continental shelf. Four of the Arctic coastal states have ratified the treaty (i.e., Norway in 1996, Russia in 1997, Canada in 2003, and Denmark in 2004) with the United States holding out. Members of the U.S. Congress are reluctant to ratify the treaty because Part XI is viewed as being against national security interests and is economically disadvantageous to U.S. companies. The U.S. non-ratification has resulted in claims extending the continental shelf being undecided. When a coastal country makes a claim (deemed valid by the United Nations) to the continental shelf, they are granted exclusive rights to the seafloor and the resources held below.



Kennedy Channel old illustration, Arctic Sea passage between Greenland and Ellesmere Island. Created by Noel after Kane, published on Le Tour du Monde, Paris, 1860. (Shutterstock.com)

Canada

Canada ratified the UNCLOS in 2003 and has until 2013 to construct its extended continental shelf claim. As of December 2013, Canada has submitted an official claim with the United Nations Commission on the Limits of the Continental Shelf to extend its continental shelf. Since 2007, the Canada government has been active in asserting its control over Arctic waters by building a new military training center at Resolute Bay (74° 41′N 94° 49′W) and renovating a deepwater port at Nanisivik (73° 02′N 84° 32′W). The Canadian government also dispatched eight Arctic patrol ships to the area. Nanisivik was a former mining site. Resolute Bay is the second northernmost Canada Arctic town (the most northern inhabited town is Grise Fiord) and the coldest inhabited place on the planet with an average annual temperature of 2.5°F (−16.4°C). The Canadian government's renewed interest in the Arctic was in response to the Russian North Pole expedition Arktika 2007. The Arktika 2007 expedition explored the seafloor near the North Pole, collected flora and fauna samples, and deposited a Russian flag encased in a titanium tube.

The Canadian government contends that the Lomonosov Ridge is an extension of Ellesmere Island of the Canadian Arctic Archipelago. The Lomonosov Ridge is an unusual geologic structure that is around 35–200 miles (60–200 km) wide and stretches around 1,100 miles (1,800 km) from roughly Ellesmere Island of the Canadian Arctic Archipelago to the New Siberian Islands located between the between the East Siberian Sea and Laptev Sea and north of the East Siberian coast.

Most of the Lomonosov Ridge rises about 10,000–12,000 ft. (3,300–3,700 m) above the seafloor. The Lomonosov Ridge at its most shallow area or the closest it comes to the ocean surface is around 3,000 ft. (950 m).

Denmark

Denmark ratified the UNCLOS in 2004 and has time until 2014 to construct its extended continental shelf claim. Presently, the continental shelf claims made by Denmark include the Danish straits and the Danish portion of the sound. The straits include Great Belt, the strait between the main Danish islands of Zealand (*Sjælland*) and Funen (*Fyn*) Islands; a strait between Jutland and Funen (*Fyn*) called the Little Belt; and the Danish portion of the sound that was established under the Copenhagen Treaty of 1857. Under the Copenhagen Treaty, these are legally Danish waters. Greenland, a Danish province, is the location closest to the North Pole. The Denmark government contends that the Lomonosov Ridge is an extension of Greenland. In 2006, the Danish and Canadian governments cooperatively worked with the project called "Lomonosov Ridge Test of Appurtenance" or LORITA-1 for short. The focus of the research was to collect bathymetric, seismic, and gravity data to substantiate respective claims to the Lomonosov Ridge. During the International Polar Year (2006–2007), the Danish government along with scientists from multiple countries conducted a joint research project called "Lomonosov Ridge off Greenland" (LOMROG). To collect the data for UNCLOS continental shelf, the LOMROG project used the Swedish Icebreaker *Oden* and the Russian nuclear icebreaker NS 50 *Let Pobedy*. Additional studies have been conducted called LOMROG II in 2009 and LOMROG III in 2012. LOMROG III collected bathymetric, gravimetric, seismic, oceanographic, and rock sample data.

Norway

Norway ratified the UNCLOS in 1996 and had time until 2006 to construct its extended continental shelf claim. In 2006, Norway officially submitted their UNCLOS claim under article 76, paragraph 8, in accordance with the UNCLOS. The Norway claim presented their reasoning for extending the Norwegian seabed claim beyond the EEZ of 200 nautical miles into three areas. The three areas are in the Barents Sea called the "Loophole," the Norwegian Sea called the "Banana Hole," and the Western Nansen Basin in the Arctic Ocean.

The Barents Sea Loophole is a gap between Norway and Russian EEZs. It is also a gap between Svalbard and the Russian economic zones and is not a protected or managed fishery. It is a high seas or international waters. The area is around 24,000 square miles (67,100 sq km). Under the EEZ, the living resources beyond the 200 nautical miles are not included in coastal state jurisdiction. Thus, the Barents

Sea Loophole is an area that lacked fishery protection and management. In 1999, the countries of Norway, Iceland, and Russia signed the "Loophole Agreement," which resolved the dispute over nonregulated fishing in the loophole. The agreement granted Iceland fishing rights in the Norway and Russia EEZ waters in exchange for Iceland discontinuing fishing the loophole.

The Norwegian Sea Banana Hole is similar to the Barents Sea Loophole. The Banana Hole is located in international waters and is a gap between the EEZs of Norway, Iceland, the Faroe Islands, and Greenland. It is also a gap between Jan Mayen and Svalbard economic zones and is not a protected or managed fishery. The Banana Hole is an area around 96,000 square miles (250,000 sq. km). The countries of Iceland and Denmark along with the Faroe Islands are working on extending their continental shelf outside 200 nautical miles, which would include roughly 23,000 square miles (60,000 sq. km). If these continental shelf claims are validated, the Banana Hole will be reduced to around 73,000 square miles (190,000 sq. km). In the Nansen Basin, outside the 200 nautical miles, EEZ is about 5,400 square miles (14,000 sq. km). It is a gap between Norway and Russia. Both countries have cooperatively mapped the area.

Russian Federation

Russia ratified the UNCLOS in 1997 and had time until 2007 to construct its extended continental shelf claim. In 2007, the Russian Federation submitted their UNCLOS claim in accordance with the UNCLOS (article 76, paragraph 8). In their continental shelf claim, the Russian Federation included the area beyond the 200-nautical-mile zone. One of the arguments for the extended continental shelf was that the Lomonosov and Mendeleev Ridges were an extension of the Eurasian continent, thus, an extension of the Russian territory. The Russian Federation claim extends only to the North Pole. The United Nations has not ruled in favor or opposition to the Russian Federal continental shelf claim proposal. The United Nations requested more research on the matter before determining the claim as valid or invalid. By contrast, Denmark claims that the Lomonosov Ridge is part of Greenland. Canada also claims the Lomonosov Ridge.

In 2007, the Russia Federation used a Finnish-made self-propelled deep submergence vehicle called MIR (meaning "world" or "peace" in Russia). The MIR submersible was part of the Arktika 2007 expedition, which was part of the Russian North Pole expedition and the International Polar Year 2007–2008. It was also part of the Russian Arctic territorial claim. The Arktika 2007 expedition explored the seafloor near the North Pole, collected flora and fauna samples, and deposited a Russian flag encased in a titanium tube. The Arktika mission was led by an international crew, but majority of the crew was Russian and led by Artur Chilingarov. The crew included Anatoly Sagalevich and Yevgeny Chernyaev, Vladimir Gruzdev, and Mike McDowell (Australian) and Fredrik Paulsen (Swedish). The MIR

Anatoly Sagalevitch, the head of the manned submersible laboratory of Russia's P. P. Shirshov Institute of Oceanology, sits at the controls of the submersible Mir I. (Ralph White/AP Photo)

submersible was the first manned mission to the seabed under the Geographic North Pole. The MIR reached a depth of almost 14,000 ft. (4,261 m) while exploring the North Pole seafloor. The Arktika 2007 Expedition, along with the MIR submersible, was attempting to establish whether the Lomonosov Ridge was an extension of Russian continental shelf.

United States

The United States from 1983 to 1990 accepted the UNCLOS as customary law, but refused to ratify the treaty over objections to Part XI. Part XI created International Seabed Authority (ISA), which had the authority over seabed exploration and mining. The ISA authority over seabed mining included the ability to impose fines, decide mining activities, and terminate or suspend contracts due to environmental or marine harm. Those opposed to Part XI viewed it as being against national security interests and is economically disadvantageous to U.S. companies. Since 1994, the United States has supported and resisted ratifying UNCLOS. In 2007, President George W. Bush urged the U.S. Senate to ratify UNCLOS as did the secretary of state, Hillary Clinton, in 2009. In 2012, 34 Republican senators sent a letter to the senator John Kerry (R-Mass) stating they would vote against the ratification of the treaty. The ratification of the treaty was tabled because 67 senators or two-third votes are needed for ratification.

The United States has been active in exploring the Arctic. In 2007, the U.S. Coast Guard Cutter Healy mapped the seafloor off the coast of Alaska and established the size of the continental shelf north of Alaska. The mapping project was overseen by Dr. Larry Mayer (University of New Hampshire), director of the Center for Coastal Ocean Mapping. The United States still has not ratified the UNCLOS.

Andrew J. Hund

See also: Arctic Territorial Claims and Disputes; Beaufort Sea Dispute; Coastal Erosion; United Nations Convention on the Law of the Sea (UNCLOS)

Further Reading

McKitterick, T. "The Validity of Territorial and Other Claims in Polar Regions." *Journal of Comparative Legislation and International Law* 3rd Ser. 21, no. 1 (1939): 89–97.

"The Scramble for the Arctic: The United Nations Convention on the Law of the Seas and Extending Seabed Claims." Paper presented at the annual meeting of the Midwest Political Science Association 67th Annual National Conference, The Palmer House Hilton, Chicago. http://www.jstor.org/discover/10.2307/754556?uid=3739560&uid=2&uid=4&uid=3739256&sid=21103220142241. Accessed January 8, 2014.

Yenikeyeff, S., and T. Krysiek. *The Battle for the Next Energy Frontier: The Russian Polar Expedition and the Future of Arctic Hydrocarbons.* Oxford: Oxford Institute for Energy Studies, 2007.

Cook, James (1728–1779)

James Cook grew up as the son of a farm laborer in Scotland. At age 17, he became a merchant navy apprentice for a Quaker and ship owner who supplied coal with small vessels along the coast of England. During this three-year apprenticeship, Cook acquired the skills for navigation and cartography, which he put to good use in his career as a sailor and chart maker.

In 1755, Cook abandoned his budding career as a merchant marine and joined the Royal Navy. In the service of the navy, he traveled to the Canadian Atlantic coast, where he produced detailed maps of the St. Lawrence River and the coast of Newfoundland and Nova Scotia. The Royal Society was planning an expedition to observe the Venus transit across the sun, which would be visible at the longitude of Tahiti in 1769. Venus transits occur only every 121 years (in pairs with 8-year separation between the two events) and are one of the best methods to determine distances in the solar system. Cook was appointed to command this expedition, which became his first of three voyages around the globe.

In August 1768, Cook traveled southwest from England around the southern tip of South America to the South Pacific. After observing the Venus transit, he proceeded to explore the coasts of New Zealand and the east coast of Australia. He returned to England three years after he had left, sailing through the Indian Ocean and around the Cape of Good Hope in South Africa. Even though the Venus transit observations were somewhat disappointing for the astronomers, the newly charted territories and coastlines made the voyage an overall success.

One of the greatest explorers of the eighteenth century, Captain James Cook made three voyages to the Pacific, conducting detailed surveys of all he saw and adding significantly to European knowledge of the region. (Library of Congress)

A year later, Cook was commissioned for a second voyage to the South Pacific. It was hypothesized that a large continent stretching all the way across the South Pole was to be found south of Australia. The main goal of the second voyage was to search for this *Terra Australis* continent. Cook started the second voyage in the summer of 1772, heading south and then turning east once he rounded the Cape of Good Hope. He went as far south as he dared, encountering icebergs, but never reaching the Antarctic continent. His ship was the first European ship to cross the Antarctic Circle. They reached as far south as 71° latitude when they encountered pack ice and had to turn around. He stopped again in New Zealand and Tahiti to resupply and avoid the southern winter, and completed a circumnavigation in the Southern Ocean.

Cook returned to Cape Town and then proceeded back to England in 1775. After this voyage, the navy retired Cook to land duty, but a year later, he volunteered to commend a search for the Northwest Passage, the northern route around the American continent. In 1776, Cook left for his third voyage. He headed south to round South America and headed into the South Pacific to Tahiti. From there, he sailed north, discovering a group of islands that he named Sandwich Islands in honor of the Lord of the Admiralty, Lord Sandwich, and that we now know as Hawaii. From there, he continued to what is now Oregon and followed the coast to Alaska and into the Bering Strait. He carefully mapped the coast of Alaska looking for passages to the east. On the way north along the west coast of Alaska, Cook got as far as 70° latitude when he encountered a wall of ice that was 10–12 ft. tall and impassable. He returned to Hawaii to try again the next summer. After recovering and refitting on Hawaii, an unfortunate series of events lead to the death of Captain James Cook in February 1779. A cutter, the largest landing craft on Cook's ship had been stolen, and in the process of recovering it, a skirmish broke out, and Cook got killed by a Hawaiian chief.

Although Cook named some of the landmarks and islands he discovered after people he honored, he stuck with transcribed native names whenever he could learn them. Places like Cook Inlet (near Anchorage Alaska) or Cooktown in Queensland were named after him by others. His greatest achievements were the mapping of coastlines of the northeast and northwest coasts of America, Australia, New Zealand, and numerous Islands in the Pacific and South Atlantic. His Quaker upbringing instilled a value of cleanliness and personal hygiene in him that he forced onto the crews on his ships. Together with frequent resupply of fresh fruit and vegetables, he was one of the first long-distance voyagers that did not lose a substantial number of their crew to scurvy. He was honored with a medal for not losing a single man to scurvy on his second voyage. A Scottish surgeon, James Lind, had published his experiments that concluded that scurvy can be avoided by eating citrus fruit in 1753, just before Cook started his voyages. Cook knew about this and included sauerkraut in his crew's diet, hoping that the acidity of the sauerkraut has the same effect as that of citrus fruit. After he demonstrated that one can avoid scurvy with diet and cleanliness, more English captains adopted his methods.

Dirk Lummerzheim

See also: Cook, James, Voyages of; Klënova, Mariya Vasilevna (1898–1976); Kotzebue, Otto von (1787–1846); Peary, Robert Edwin (1856–1920); Rasmussen, Knud (1879–1933); Ross, Sir James Clark (1800–1862)

Further Reading

Edwards, Philip, ed. *The Journals of Captain Cook.* London: Penguin, 1999.

Finnis, Bill. *Captain James Cook: Seaman and Scientist.* London: Chaucer Press, 2003.

Kratoville, Betty Lou. *Captain James Cook.* Novato, CA: High Noon Books, 2001.

Lace, William W. *Great Explorers: Captain James Cook.* New York: Chelsea House, 2009.

Cook, James, Voyages of

Captain James Cook (1728–1779) is a famous navigator and explorer, who crossed the Antarctic Circle three times in his quest for habitable southern continent. His parents James and Grace Pace with their eight children were farm laborers. Cook's romance with seas began as an apprentice to the coal shipper John Walker of Whitby, where he spent several years from 1747 across the North Sea. As an experienced sailor, he joined the Royal Navy in 1755 becoming a master within four years. He was commanding the *Mercury* during the Seven Years' War and sailed to Canada. He surveyed the channel of St. Lawrence River, and his fleet captured Quebec in September 1759. Appointed as Master of HMS *Northumberland*, Cook surveyed Halifax harbor, the coasts of Nova Scotia and Newfoundland, before sailing to homeland from St. John in 1762. In December, he presented before the Lords of the Admiralty his observation during the War in North America. He also got married to Elizabeth Batts on December 21 at St. Mary's Parish Church, Barking, Essex. He took his first command in the HMS *Grenville* in April 1764 for the surveying of Newfoundland, where he came in contact with the future admiral Hugh Palliser, the then governor of Newfoundland. Cook was gaining attention of the Admiralty and Royal Society for his acute observation of the Newfoundland region. He was regularly in touch with Admiralty during repeated visits to Newfoundland reporting about charts, solar eclipse, and different aspects of astronomy. The British government was on the lookout for the mythical Southern Continent beyond South Pacific Ocean. The Southern Ocean had remained uncharted by the navigators entering it from east because of westerly currents. Cook was the person chosen to accomplish the task although Royal Society preferred Alexander Dalrymple as the leader of voyage to the South Seas. The Admiralty had promoted Cook from master to lieutenant.

First Voyage (1768–1771)

Captain Cook along with two notable botanists Joseph Banks and Daniel Solander as well as 94 persons sailed aboard HMS *Endeavour Bark* of 368 tons. Thus began the First Voyage (1768–1771) on May 26, 1768, when Cook took command of the ship at Deptford. The *Endeavour* sailed from Plymouth on August 26 and crossed the Equator on October 25. On April 13, 1769, it anchored at Matavai Bay, Tahiti, by way of Cape Horn. He was charmed by the Polynesian way of life in spite of occasional pilferage of assorted goods from the ship by indigenous people. On June 3 and 18, the transit of Venus and eclipse of Moon was observed respectively. Cook sailed for New Zealand on October 6, 1769, to determine the existence of southern continent. The crew had a fight with the Maoris, the earliest inhabitants. Cook took possession of New Zealand after circumnavigating the island. Convinced that it did not form a part of a larger southern continent, Cook sailed along Australia's eastern coast, which had not been visited by any European voyager. The newly designated New South Wales on August 22 came under British possession. Afterward, the *Endeavour* went through the strait between Australia and New Guinea arriving in Batavia, Java (part of modern Indonesia), on October 11. After repairing the ship, Cook departed on December 26 for Britain arriving on July 13, 1771, at Plymouth. The three-year sojourn of Cook and his teammates had resulted in plethora of charts, journals, drawings, paintings, and scientific specimens. Crew was free from scurvy, and ship was intact. New South Wales had been colonized. It was a remarkable feat for Cook voyaging 5,000 miles (8,000 km) without a chronometer. But the indomitable captain was not satisfied and appealed to the Admiralty for a second voyage.

Second Voyage (1772–1775)

Cook was promoted to a commander in August 11, 1771. After being ordered to find the southern continent, he made preparations for another voyage and devised a plan for approaching the Pacific by voyaging south from Cape Town into high latitudes and afterward moving in an easterly direction. Johann Reinhold and his son Georg Forster, experts on natural history, and astronomers William Wales and William Bayly accompanied him. Cook commanded the HMS *Resolution* with 110 crew, and the companion ship HMS *Adventure* of Tobias Furneaux having 80 crew sailed from Plymouth on July 13, 1772. On September 7, the vessels crossed the Equator and sailed from Cape of Good Hope on November 13. Sailing south toward Antarctica, Cook sighted icebergs frequently. He became the first person to cross the Antarctic Circle on January, 17, 1773. In the thick fog of February month, the *Resolution* lost contact with *Adventure.* After reaching 61° 52′S, Cook sailed toward New Zealand due to adverse weather conditions. On March 25, New Zealand was sighted after leaving the Cape, and the ship anchored at Anchor Point in Anchor Island after two days. Next few weeks were spent for botanical expeditions, meeting family of indigenous people, and setting up of an observatory. On April 30, the *Resolution* was again on the sea. Cook was determined in his quest for great southern continent. The ship anchored on November 3 at Wellington and, on December 20, crossed the Antarctic Circle again. Four days afterward, Cook decided to head for north because of ice packs and intense cold weather. But he sailed for south again much to the dismay of crew thinking mistakenly that they were homebound.

On January 26, 1774, the *Resolution* crossed Antarctic Circle again for the third time, and four days afterward, it was at the farthest south at latitude 71° 10′S and 106° 54′W longitude, approximately 1,250 miles (2,000 km) from South Pole. Ice packs again prevented journeying further south. While on return voyage to New Zealand, Cook sighted the Friendly Islands, Easter Island, Norfolk Island, New Caledonia, and Vanuatu. On April 22, the *Resolution* anchored in Matavai Bay, Tahiti. He found an island enveloped with ice while on return journey to Plymouth. He named it South Georgia and took possession of island for Britain. Turning in northerly direction toward South Africa, Cook continued his voyage toward homeland. In January, he discovered some islands naming them as South Sandwich Islands after exploring. Cook arrived in St. Helena in May, crossed the equator next month, and on July 29, 1775, arrived in Plymouth. He was promoted as a post-captain and became a Fellow of the Royal Society. Cook also was recipient of Copley Gold Medal. The popular myth about *Terra Australia* was put to an end by the second voyage of Cook. Cook made successful use of the marine chronometer for pinpointing longitudinal position and making charts of the southern Pacific Ocean. He had sailed farther into the South Pacific than anyone else and crossed the Antarctic Circle thrice. Circumnavigating the world, it was no small accomplishment for Cook, who had traversed 60,000 miles in a span of three years and eight days.

Third Voyage (1776–1779)

The third voyage of Cook began from Plymouth on July 12, 1776, on the *Resolution* with the motive of finding the Northwest Passage from the Pacific side. Discovery of northerly way to Asia was less dangerous than route around Cape Horn in South America. Cook wanted to enter the Pacific from Indian Ocean. The *Resolution* anchored at Cape Town on October 18. The companion ship *Discovery* reached next month on 10th. Both the ships departed on November 30 sailing southeast. On December 12, Cook sighted a group of islands naming them Prince Edward Islands. Sailing further south, the *Resolution* and *Discovery* entered a bay on Christmas day, where they anchored close to the beach. Exploring the region for four days, Cook came across some islands discovered by the French captain Yves-Joseph de Kerguelen-Trémarec in 1772, and the latter had named it Isles Kerguelen. As there was hardly any vegetation there, Cook designated it as Islands of Desolation. Moving toward west and south for New Zealand, Cook sighted the Rock Point on February 10, 1777. Moving further, the ships sailed for Tongatapu (Amsterdam Island) on June 8. Two days after, they arrived at Nukualofa Harbor, and Cook met the ruler of Tonga. The eclipse of Sun was observed on July 5, and Cook sailed east for Tahiti.

On January 18, 1778, Cook made his last great discovery and became the first European to reach the Hawaiian Islands. On February 2, the group of islands that he sighted was named as Sandwich Islands in honor of fourth Earl of Sandwich, John Montague, who was also the acting First Lord of the Admiralty. The two ships sailed up the Pacific coasts of North America. Cook sailed north in search of the western end of a Northwest Passage from the North Atlantic to the Pacific. The ships sailed through the Bering Strait and crossed the Arctic Circle. In October, the ships entered Unalaska Bay and anchored at Samganunuda on October 3. Cook also met Russian fur traders and received a letter from the governor of Kamchatka and Petropavlovsk handed over by the Russian factor Gerassim Ismailov. Cook gave up the endeavor of finding the Northwest Passage and turned south for the Hawaiian Islands.

On January 17, 1779, the ships anchored at Kealakekua Bay. Cook stayed for some time and left the Hawaii Islands to continue exploration of Northern Pacific but came back again to repair foremast of the *Resolution.* After a scuffle with locals amidst tension over stealing, Cook was killed near the village of Kaawaloa at about 9:00 A.M. on February 14, 1779. A remarkable career came to an end tragically. His remains were buried at sea in Kealakekua Bay after a week. In September, the ships eventually reached Britain.

Captain Cook took utmost care about health of crew with his rigid rules of hygiene and food. The dreaded scurvy was very much contained in his ships. The storage chambers of the vessels were full of antiscorbutics such as citrus fruit, raisins, and sauerkraut. He was also keen on experimenting with indigenous remedies like brewing tea from barks of tree. Through his strength and self-determination, Cook overcame many obstacles facing his ships and crew. One could have a glimpse of his character from the name of ships of his three voyages: *Endeavour*, *Resolution*, *Adventure*, and *Discovery.* However, Cook was very short tempered with indigenous people not complying with his wishes. He did not flinch away from using violence, which brought his nemesis and untimely death.

The theory of existence of a southern continent, which had held the attention of geographers and maritime powers for a long time, was finally put to rest by exploration of Captain Cook. The circumnavigator of the globe had left innumerable drawings, logs, charts, and notes for the posterity. It was very beneficial to later-day mariners. The whole world was aware of an accurate geographical picture of the South Pacific by Cook's endeavor. The numerous islands and lands that he had mapped were cartographer's delight later on. Cook came across again places such as Isles V and Marquesas discovered by his predecessors and positioned them correctly. Exploring New Hebrides and New Caledonia, Cook also surveyed north Pacific region spanning from present British Columbia to the Bering Strait. The voyages of Cook against backdrop of colonial rivalry over territorial aggrandizement and commercial rivalry were very significant. The northwest coast of North America became a playground of Anglo-Spanish rivalry. Spain was perturbed over Russian expansion also in the region of Alaska. The discovery of new islands dotted throughout the globe by Cook was instrumental in the expansion of already secured British Empire. Another impact of Cook's voyages was impetus given to owners of whaling fleets, who were interested in seals and whales mentioned in his logbooks and journals. These fleets constantly moved in the Antarctic waters. The world of science was enriched by the three expeditions of Cook, who had collected specimens in course of his sojourn. Scientifically, his travels had made significant contributions. Apart from contributing considerably to natural history, travels of Cook also added new dimension to astronomy and navigation. His journals were helpful to anthropologists to have an idea about various Pacific cultures. Captain James Cook had mapped, surveyed, and charted thousands of miles of coastal regions as well as crossed the

Antarctic Circle thrice. For all his contribution, the name "James Cook" has become synonymous with exploration.

Patit Paban Mishra

See also: Cook, James (1728–1779); Klënova, Mariya Vasilevna (1898–1976); Kotzebue, Otto von (1787–1846); Peary, Robert Edwin (1856–1920); Rasmussen, Knud (1879–1933); Ross, Sir James Clark (1800–1862)

Further Reading

Lawlor, L. *Magnificent Voyage: An American Adventurer on Captain James Cook's Final Expedition.* New York: Holiday House, 2002.

Meltzer, M. *Captain James Cook: Three Times around the World*. New York: Benchmark Books, 2001.

Thomas, N. *Discoveries: The Extraordinary Voyages of Captain James Cook*. London: Allen Lane, 2003.

Williams, G. *Captain Cook: Explorations and Reassessments.* Woodbridge: Boydell, 2004.

Crabeater Seal

The crabeater seal (*Lobodon carcinophaga*) is one of four phocid pinnipeds that live exclusively in the Southern Hemisphere. Breeding populations are confined to the circumpolar pack ice of Antarctica. The genus name is from the Greek *lobos*, meaning lobe, plus *odons*, tooth, which refers to the conspicuously lobed post-canine teeth, while the species name is from the Greek *karkinos*, crab, plus *phagein*, to eat, a mistaken reference to its diet. Crabeater seals grow to about 8.5 ft. (2.65 m) long and some rare ones topping 9 ft. (2.77 m). These seals typically weigh around 450 pounds (210 kg) with some rare ones weighing more than 900 pounds (410 kg). Females are usually larger than males. Crabeater seals can live up to 40 years, but most live to about 20–25 years of age. Sexual maturity is attained around four to five years of age. Getting an accurate population count of crabeater seals is challenging because of their movements and migration patterns. Continent-wide estimate of crabeater seals is somewhere between 7,000,000 and 15,000,000, the most numerous seal found anywhere.

Crabeater seals have a relatively slim, lithe, and streamlined body, with elongated snout, slightly tip-tilted or piglike due to the dorsally positioned nostrils. The head is small compared with their body. The canines are moderately sized with the post-canines sieve-like with elaborate four to five blunt cusps each, and interlocking when the jaw is closed. The interlocking teeth reflect their ability of filtering crustaceans out of the water column. The short pelage is usually silvery grey to golden or creamy white (faded), sometimes brown with back darker than belly. There are reticulated chocolate brown markings and fleckings on shoulders, sides, and flanks shading into predominantly dark hind and fore flippers and head. They have a high incidence of obvious scarring on their bodies, mostly caused by leopard seal attacks.

The crabeater seal pups are born from October to early November and possibly as late as December. The exact timing varies by geographic region. Mating has never been observed; presumably, it takes place in the water in pack-ice habitats from December to early January. After the pups are born, the mother nurses them for two to three weeks. Like their birth times, the exact timing of pupping season varies and is dependent on the region of the Antarctic. Crabeater seals molt through January and February, sometimes extending into March, and the mean dive depth by crabeater seals ranges from around 130 to 450 ft. (40–140 m) but can dive as deep as 2,300 ft. (713 m). A typical dive of the crabeater seal is less than 5 min in duration. Diving patterns vary seasonally, with a clear preference for diving during darkness and hauling out during daylight during summer and autumn and a reverse pattern in winter. Diurnal or diel patterns in the diving behavior of crabeater seals are perhaps in response to diel vertical migrations of prey. They are believed to feed primarily on Antarctic krill, but also eat fish and cephalopods when krill is not available.

Although little is known of the species' distribution, abundance, life history, and basic natural history, they occur all around the Antarctic continent and are most abundant in pack-ice habitats. Tending to stay over the continental shelf during the breeding season, they become more widespread in the outer pack ice during summer and autumn. Crabeater seals are generally solitary or in small groups with an average about one or two. The seals are also found in larger groups of up to 28 seals, and occasionally they can be seen in large aggregations on fast ice in bays or straits. Crabeater seals often swim directionally in small groups, sometimes up to 500 individuals. The seals move with the pack ice as it expands and contracts seasonally. Crabeater seals have been satellite-tracked over several thousand miles or kilometers, and occasionally haul out at subantarctic islands, but rarely further north along the southern fringes of the continents. They may also wander onto the Antarctic continent, far up glaciers and into dry inland valleys.

Threats

Although they were harvested commercially twice during the previous century, the sealing ventures were economically unsuccessful, and none is planned or likely to be considered. Crabeater seals rely on certain specific ice characteristics to complete its annual cycle. Climate-change-related alterations in habitat and constriction of seasonal pack ice will likely affect them most. The effects of changes in sea ice on crabeater seal foraging seem likely to be detrimental since they forage on species that are linked with the pack-ice ecosystem. Furthermore, population size and distribution may be altered through changes in food web dynamics.

Conservation Status

The crabeater seal is listed as lower risk, least concern on the IUCN Red List and is protected in its range under the Protocol on Environmental Protection to the Antarctic Treaty. It is also protected under the Convention for the Conservation of Antarctic Seals, Annex I, which provides for commercial harvests of limited numbers, as do the Convention on the Conservation of Antarctic Marine Living Resources, Article II.

Marthán Bester

See also: Antarctic Fur Seals; Bearded Seal; Harp Seal; Hooded Seal; Leopard Seal; Polar Bear; Ribbon Seal; Ringed Seal; Ross Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Spotted Seal; Weddell Seal

Further Reading

Bester, M., and G. Hofmeyr. "Seals: Overview." In B. Riffenburgh, ed. *Encyclopedia of the Antarctic.* New York: Taylor and Francis Books, Inc., 2007, pp. 877–81.

Reeves, R., et al. "Leopard Seal." In *National Audubon Society Guide to Marine Mammals of the World.* New York: Alfred A. Knopf, Inc./Chanticleer Press, 2002, pp. 177–79.

Siniff, D., et al. "Projecting the Effects of Environmental Change on Antarctic Seals." *Antarctic Science* 20 (2008): 425–35.

Southwell, C., et al. "A Review of Data on Abundance, Trends in Abundance, Habitat Use and Diet of Ice-Breeding Seals in the Southern Ocean." *CCAMLR Science* 19 (2012): 49–74.

Cryoconite Holes

Cryoconite holes are vertical holes that are found on surfaces of glaciers, ice sheets, sea ice, and lake ice. They are water filled (termed cryoconite water) and contain small, dark, granular spheres in their base (0.1–3 mm in diameter, termed cryoconite). Holes can range in size, from one or two centimeters, to several meters in diameter, and can reach up to half a meter in depth depending on their location. Cryoconite holes were first described by the Swedish explorer Adolf Nordenskjöld during his 1870 Greenland expedition: he named them *cryo-* meaning "ice" and *-conite* meaning "dust." On glaciers, they are mostly observed within the snow-free ablation zones, and their coverage can vary from 0.1 to 10 percent of the ice surface. Cryoconite holes vary from being transient changeable structures, which eventually melt out or become destroyed, to holes that are more permanent and that develop thick ice lids, isolating them from the surrounding environment for up to 10 years. The type of cryoconite hole that develops is dependent on the environmental and physical factors of the surrounding location, including factors such as slope gradient and surface heat balance.

Cryoconite holes form when windblown organic and nonorganic material lands on the surface of the ice. The low albedo of this material (approx. 30% lower than the surrounding ice) causes an increased absorption of solar energy, relative to the surrounding ice, resulting in the melting of the ice below. As the ice melts, a water-filled hole is created into which the dark material sinks. Filamentous bacterial Cyanobacteria entwine both biotic and abiotic material, creating balls of cryoconite. These granules form a protective environment for biotic communities to establish. As these communities develop and increase their organic matter, they become darker in color and further enhance hole melt. A final depth is established when the intensity of solar energy reaching the cryoconite is no longer sufficient to melt the ice below.

Cryoconite holes provide a niche for complex biotic communities to survive within the challenging environment of the cryosphere. The microorganisms present within cryoconite holes are predominantly found within cryoconite (3.49×10^5 cells mg^{-1}). However, bacterial assemblages also exist within cryoconite water ($1–4.50 \times 10^4$ cells ml^{-1}). Biological studies of the bacterial, eukaryotic, archaeal, and viral composition have shown considerable diversity. Predominant members include bacterial Cyanobacteria; alpha-, beta-, and gamma Proteobacteria and Bacteroidetes; and eukaryotic Metazoa, Fungi, Alveolata.

Cryoconite holes within polar regions have been identified as being important hydrological and biological systems, providing refuge from the extreme conditions of the cryosphere. The physical features of cryoconite holes generate a harbor for both cryoconite and cryoconite water to remain on the surfaces of glaciers, reducing the effects of wind, desiccation, freezing, and glacial runoff. The assimilation, storage, and recycling of organic material and nutrients within cryoconite make these systems one of the most concentrated nutrient pools within the glacial ecosystem, creating a nutrient-rich microzone in relation to the otherwise largely nutrient-poor surroundings. Cryoconite holes freeze into the ice during polar winter months, capturing a low-albedo microbial community within the glacial surface, and facilitating ice melt when solar intensities increase again in the summer.

Glacial surface melt, which is enhanced by the low albedo of cryoconite, provides a significant and valued source of water to the glacial ecosystem and to ecosystems beyond. In the event of high melt rates, the contents of cryoconite holes are flushed out and transported via streams, crevasses, or moulins to subglacial, ice marginal, or glacial for field regions. Here, cryoconite provides a diverse seed bank of viable microbes and a source of nutrients, which establish or fuel the development and survival of other ecosystems within the wider glacial environment.

Karen A. Cameron

See also: Blood Falls, Antarctica; Ice Cap; Microbial Survival

Further Reading

Cameron, K., et al. "Structure and Diversity of Bacterial, Eukaryotic and Archaeal Communities in Glacial Cryoconite Holes from the Arctic and the Antarctic." *FEMS Microbial Ecology* 82 (2012): 254–67.

Fountain, A., et al. "Evolution of Cryoconite Holes and Their Contribution to Melt Water Runoff from Glaciers in the McMurdo Dry Valleys, Antarctica." *Journal of Glaciology* 50 (2004): 35–45.

Hodson. A., et al. "Glacial Ecosystems." *Ecological Society of America—Ecological Monographs* 78 (2008): 41–67.

Takeuchi N., et al. "Structure, Formation, and Darkening Process of Albedo-Reducing Material (Cryoconite) on a Himalayan Glacier: A Granular Algal Mat Growing on the Glacier." *Arctic Antarctic and Alpine Research* 33 (2001): 115–22.

Cryoprotectorants

The production of cryoprotectorants in living species is a remarkable genetic adaptation for survival in freezing climates. The word *cryo* is derived from the Greek word κρύο, which means "icy cold." Biological cryoprotectorants are natural, nontoxic, organic (carbon-containing) substances produced by living organisms that protect them from freezing in extremely cold climates. They work by having an antifreeze effect. Cryoprotectorants lower the freezing temperature of cells inside living species, which helps them survive below zero temperatures experienced during winter hibernation season and in Arctic and Antarctic climates.

Arctic and Antarctic living species including insects (Arctic wholly bear moth), fish, and amphibians (e.g., frogs and salamanders) naturally produce a greater number of cryoprotectorant molecules in comparison with non-Arctic and non-Antarctic species. Frogs naturally produce glucose (sugar) molecules, molecular formula: $C_6H_{12}O_6$, for cryoprotection. Arctic salamanders naturally produce glycerol molecules, molecular formula: $C_3H_8O_3$, for cryoprotection.

In cryoprotectorant-producing living species, the fluids outside the cells (extracellular fluids) freeze during hibernation season, but the fluids inside the cells (intracellular fluids) do not freeze. During extremely cold hibernation season, the heartbeat, blood circulation, breathing, and brain activity of the wood frog (*Rana sylvatica*) slows down to almost complete cessation due to the freezing of extracellular fluids of the frog; however, because the frog also produces a large concentration of glucose molecules that are secreted into its bloodstream and then fill its cells, the fluid inside the cells of the frog does not freeze. The glucose molecules added to the wood frog's cells during freezing cold hibernation season act as natural antifreezing agents, thus lowering the temperature of freezing of the cells inside its body protecting it from freezing in extremely cold environments. The more glucose produced in the living species and added to its cells, the colder climate the species may survive. Researchers have found that Alaskan populations of wood frogs produce higher concentrations of glucose molecules and can survive at temperatures as low as 3.2°F (−16°C). In comparison, Ohio populations of wood frogs can survive only at temperatures as low as 24.8°F (−4°C). It appears that depending on the location of the living species and how cold the environment the species must survive, it has a built-in biochemically adaptive cryoprotection survival mechanism.

During hibernation season, living systems may be frozen and thawed several times before returning again to their normal warmer climatic conditions for living. Furthermore, natural biological cryoprotection is a survival mechanism.

The colligative property that makes cryoprotection possible is known as *freezing point depression.* The freezing point of any pure solvent (the majority component in a solution) can be lowered by increasing the number of dissolved solute particles in that solution. In living organisms, the majority component in cells is water,

FREEZING POINT OF A CHEMICAL SUBSTANCE

The freezing point of a chemical substance is the temperature at which it begins to solidify (turn into a solid) at a specified pressure. At sea level and standard pressure conditions, water normally freezes at 32°F (0°C). The process of freezing involves a change in phase from the liquid state to the solid state. When freezing takes place in water, the loss of energy in the form of heat decreases the energy of motion (kinetic energy) of the bent water molecules, and they begin to line up with one another due to attractive forces (intermolecular forces) between adjacent molecules. This ordered arrangement of molecules leads to the formation of a crystalline molecular solid or a crystalline state of the H_2O molecules of water. Substances in the solid state have different chemical properties and behavior than substances in the liquid state. For example, the molecular liquid state of water is fundamental to living systems, because it is in the liquid state where numerous dynamic and interdependent biochemical life-sustaining reactions and processes take place within the cells of living organisms. Cells are the basic building blocks of all living systems, and when they freeze, important biochemical life-sustaining reactions and processes almost stop. It is important that some energy (in the form of heat) is retained in living systems so that intercellular environments can retain a liquid or fluid state and the life-sustaining biochemical reactions and processes may continue at rates for optimal functioning. The liquid or fluid state of matter is fundamental to the healthy biological functioning of living species within their larger interdependent ecological environment.

Karen Knaus

molecular formula: H_2O, and the cytoplasm (intracellular environment of a cell) usually comprises between 60 and 80 percent water. In Arctic wood frogs, glucose (sugar) molecules act as the solute particles that are dissolved in the water-based cell solution. Furthermore, the underlying principle behind the action of biological cryoprotection is the prevention of the freezing of the water-based cells found in living organisms by the addition of glucose as a solute, which acts as an antifreeze again and lowers the freezing temperature of the cell. Water is necessary for all life. Its essential existence in cells and the fact that its freezing temperature can be lowered make it even more significant for species survival in extremely cold climates!

Biological cryoprotectorants are known to be nontoxic chemical substances produced in living species that naturally protect them from freezing climates, but cryoprotectorants have also been created and used for other purposes including the protection of laboratory-grown protein crystals during the collection of scientific crystallographic X-ray diffraction data using high-intensity radiation. As perceptions of extreme weather events and the potential of another ice age looms, there is greater interest in understanding cryoprotectorant-producing living species.

Karen Knaus

See also: Arctic Woolly Bear Caterpillar/Moth; Microbial Survival; Pink Snow

Further Reading

Costanzo, J., C. do Amaral, A. Rosendale, and R. Lee. "Hibernation, Physiology, Freezing Adaptation and Extreme Freeze Tolerance in a Northern Population of the Wood Frog." *Journal of Experimental Biology* 216 (2013): 3461–73.

Shah, B., U. Chinte, S. Tomanicek, L. Hanson, and C. Schall. "Flash Cooling Protein Crystals: Estimate of Cryoprotectant Concentration Using Thermal Properties." *Crystal Growth and Design* 11, no. 5 (2011): 1493–1501.

Stead, N. "Alaskan Wood Frogs Stock Up on Solutes to Survive." *Journal of Experimental Biology* 216 (2013): 1. http://jeb.biologists.org/content/216/18/i.1.short?rss=1.

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Deception Island

Deception Island (62° 58′ 37″S 60° 39′W) is an active volcano in the South Shetland group off the Antarctic Peninsula. Best known for its large caldera that is directly connected to the open sea, it provides one of the best-sheltered harbors in Antarctica. The nearly circular island has a diameter of 12 km, and the flooded caldera extends 5.5 miles by 3.8 miles (9 km by 6 km). The entrance to the caldera is only about 750 ft. (230 m) wide and named Neptune's Bellow. While glaciers permanently cover the majority of the island, there are also ice-free areas and volcanic beaches, most notably at Whaler's Bay close to the entrance into the caldera. Used by sealers and whalers as a sheltered harbor since the early nineteenth century, Deception Island also became the location of various Antarctic research stations and home of the southernmost shore-based whaling station on the globe, operated by the Norwegian Hector Whaling Company between 1912 and 1931.

Deception Island also became the base for the first Antarctic aerial expeditions, with the first motor flight in Antarctica starting from an improvised runway at Whalers Bay piloted by the Australian Hubert Wilkins and the Canadian Carl Ben Eielson. During World War II, the British built up their first secret Antarctic station, Base B, in the abandoned whaling station in the context of Operation Tabarin. Argentinean and Chilean stations followed the British after the end of World War II, and Deception Island became one of the most contested islands in Antarctica prior to the Antarctic Treaty system, in particular due to overlapping territorial claims by the United Kingdom, Argentina, and Chile in the region of the Antarctic Peninsula.

Volcanic eruptions of the twentieth century occurred during the periods between 1906 and 1910 and 1967 and 1970, the latter responsible for the destruction of some of the research stations and partial burial of the remains of the whaling station at Whaler's Bay including the largest cemetery in Antarctica. Today, there is geothermal activity in some parts of the island, and the whole island is classified as a restless caldera with a significant volcanic risk.

The fauna of Deception Island includes nine species of breeding seabirds and the world's largest colony of chinstrap penguins. Flora is different from most other Antarctic islands due to the geothermal and volcanic activities and includes several species found nowhere else in Antarctica.

Deception Island is one of the most visited islands in Antarctica, as nearly all cruises to the Antarctic Peninsula visit the island. Because of the geothermal activities, it has become standard practice for the Antarctic cruise industry to offer their passengers a quick bath at Deception Island directly in the water of the caldera or in water-filled pits dug in the geothermal active beach areas. As one of the most visited islands of Antarctica, a number of issues with tourists have occurred during recent years, despite the existing management scheme for Deception Island as Antarctic Specially Managed Area (ASMA) #140, including, for example, graffiti at the protected remains of the whaling station or Base B. Argentina, Chile, and Spain operate research stations at the island during the Austral summer, mostly focusing on biological and volcanic research.

Ingo Heidbrink

See also: Abandoned Arctic Islands; Bear Island (*Bjørnøya*)

Further Reading

Dibbern, S. *Fur Seals, Whales and Tourists: A Commercial History of Deception Island, Antarctica.* Verona, VA: Mid Valley Press, 2012.

Downie, R., and J. Smellie. *A Management Strategy for Deception Island.* Cambridge: British Antarctic Survey, 2001.

Hall, P. *Deception Island and the Antarctic Peninsula: An Artistic Adventure.* Freshwater: Coach House, 2005.

Dinosaurs of Antarctica

The only macro-organisms to permanently live and breed today on mainland Antarctica are seals and penguins, of which the latter, technically highly specialized marine theropod dinosaurs, outnumber the seal populations several times over. So, in a very bizarre sense, the age of dinosaurs still persists in Antarctica. During the Mesozoic (250–65 mya), the Antarctic continent was joined to Australasia, South America, and Africa as part of the southern supercontinent of Gondwanaland. A very large part of Gondwanaland extended over the Mesozoic South Polar Region, but there is no evidence of a permanent ice cover. Indeed, during the Cretaceous, there is evidence that conditions were almost tropical at times. Dinosaurs had a near-global distribution for most of the Mesozoic and may even have made their first appearance in Gondwanaland around the middle of the Triassic. In Antarctica, Triassic-age dinosaurs have yet to be discovered, but at least two dinosaur groups have been found in very early Jurassic strata, strongly suggesting that dinosaurs were present in Antarctica during the Triassic.

Many dinosaur species have been reported from Late Cretaceous age strata of the high-latitude regions of Gondwanaland, but most of these come from the Australian locality of Dinosaur Cove in Victoria, which lay well within the Antarctic Circle during the Cretaceous. At this time, a much smaller portion of Antarctica lay within the Antarctic Circle, with some parts lying as far north as 55° S.

Because dinosaurs have only relatively recently been discovered in Antarctica, present knowledge of the fauna is scant, although this is also due to the difficulty of working in Antarctica and due to the very limited amount of exposure of rocks of Mesozoic age (most of the Mesozoic strata are concealed by the Antarctic ice sheet).

There were few physical barriers to dinosaur dispersal in Gondwanaland until the Late Cretaceous, and so any differences between high-latitude Antarctic dinosaur assemblages and those of low and midlatitudes probably relate to climatic differences (temperature and humidity) and daylight duration and its effects on vegetation.

The first dinosaur fossils to be found on the continent of Antarctica were noted in 1987 by Gasparini, Leanza, and Garate Zubillaga, who described a partial skeleton of an ankylosaur found in Late Cretaceous strata of James Ross Island. After considerable study, the specimen was finally recognized as a new species in 2006 when it was named *Antarctopelta oliveroi.* Later, remains of other dinosaurs, including a dromaeosaur and ornithopods, were also discovered on James Ross and nearby islands. The first dinosaur to be named from Antarctica, however, came from Early Jurassic strata of the Transantarctic Mountains. First discovered in 1991, this animal, a theropod dinosaur named *Cryolophosaurus ellioti* in 1994, was represented by a partial skull with a distinctive forward-curving crest. A third dinosaur species from Antarctica, *Glacialisaurus hammeri*, was named in 2007 from a series of foot and other leg bones. These partial remains indicated a new type of sauropodomorph, closely related to the South African *Massospondylus.*

Two recent dinosaur discoveries on Antarctica were made in 2010–2011. The first made on James Ross Island is the first sauropod dinosaur from the continent. The remains are really scrappy, just a partial, broken caudal vertebra, but they are sufficiently distinctive to identify them as from a titanosaur, a group with a near-global distribution in the Late Cretaceous. The second is an Early Jurassic sauropodomorph from near the same locality as *Glacialisaurus* in the Transantarctic Mountains. This specimen is much more complete and represents a young individual, perhaps a juvenile of *Glacialisaurus.*

Apart from the three named dinosaur species, there have been several other discoveries of dinosaur fossils in Antarctica that are either too fragmentary to determine their true affinities or still under study. These include remains of a hadrosaur known from isolated teeth found on Vega Island and a hypsilophodontid from James Ross Island. The hypsilophodontid is represented by a partial skeleton including jaws with teeth indicating an animal of between 4 and 5 m in length, making it one of the largest hypsilophodontids if its initial identification proves correct.

Antarctic Mesozoic Birds

A surprising discovery in Antarctica is the occurrence of three modern-type birds from the Late Cretaceous. Three neognath birds have been reported from the Late Cretaceous of Antarctica. The first to be discovered was *Polarornis gregorii*, supposedly a loon (family Gaviidae) from James Ross Island, but there is some doubt about its true affinities as the material is highly fragmentary. A second Antarctic Cretaceous bird, *Vegavis iaai*, was much more complete and is clearly related to modern anseriforms (ducks and geese), while a third bird is represented only by a single, but distinctive limb bone. This specimen was tentatively assigned to the cariamids or phororhacids, a group also known from the Eocene of Antarctica, but it was not named, even though it almost certainly represents a new species. Some scientists speculate that the early evolutionary radiation of modern birds may have taken place in or near Antarctica during the Late Cretaceous.

Stratigraphy

There are four important dinosaur-bearing horizons in Antarctica. The Early Jurassic (Hettangian to Pliensbachian) Hanson Formation of the Transantarctic Mountain yielded *Cryolophosaurus*, *Glacialisaurus*, and some indeterminate theropod bones. This formation is a nonmarine sequence, and so it is not unusual that dinosaur and other terrestrial fauna and flora occur within it. Another dinosaur-bearing horizon is the Late Cretaceous (Santonian to Campanian) Santa Marta Formation, which yielded *Antarctopelta*, while a third dinosaur-bearing unit, the Snow Hill Island Formation (Late Cretaceous, Maastrichtian) has yielded the partial foot of a dromaeosaur.

The Santa Marta and Snow Hill Island formations are a series of marine turbidites up to 1 km thick deposited on a submarine fan in front of a river delta. Dinosaur remains usually occur in nonmarine sediments deposited in lakes and rivers, so the James Ross Island dinosaurs of these two formations must have drifted out to sea, presumably having been washed down rivers during floods. On Vega Island, the Late Cretaceous (Campanian to Maastrichtian) Lopez de Bertodano Formation, also a marine sequence, has yielded isolated teeth of a hadrosaur as well as Antarctica's Cretaceous birds.

Antarctic Dinosaur Assemblages

Because of the great disparity in age between the Early Jurassic Antarctic dinosaurs and those of the Late Cretaceous of James Ross and other islands, the Antarctic dinosaur assemblage cannot be considered as a whole. The Early Jurassic assemblage of the Transantarctic Mountains comprising the theropod *Cryolophosaurus* and the sauropodomorph *Glacialisaurus* is difficult to interpret as there are only two identifiable taxa. *Cryolophosaurus* was initially thought to be a tetanuran, perhaps close to *Sinraptor* from China, but later considered closer to *Dilophosaurus*,

Table 1 Dinosaur discoveries in Antarctica.

Date of Discovery	Dinosaur Name or Type	Place	Age
1986	*Antarctopelta oliveroi*	James Ross Island	Late Cretaceous
1989	Unnamed hypsilophodontid	Vega Island	Late Cretaceous
1996	Unnamed theropod	James Ross Island	Late Cretaceous
1998	Unnamed hadrosaur tooth	Vega Island	Late Cretaceous
2007	*Glacialisaurus hammeri*	Transantarctic Mts	Early Jurassic
2007	Unnamed dromaeosaur	James Ross Island	Late Cretaceous
2012	Unnamed titanosauroid sauropod	James Ross Island	Late Cretaceous
2012	Unnamed sauropodomorph	Transantarctic Mts	Early Jurassic

a theropod also of ambiguous affinity, from Arizona. *Glacialisaurus* appears to be closely related to *Massospondylus* from South Africa and *Lufengosaurus* from China. As both *Cryolophosaurus* and *Glacialisaurus* appear to have close affinities with dinosaurs from Laurasia, it is strongly suggestive of a globally distributed dinosaur assemblage with endemism only at the generic level. The same can be said of the Late Cretaceous dinosaur assemblage from the Santa Marta and Snow Hill Island Formations. The presence of hadrosaurid and hypsilophodontid ornithopods, an ankylosaur, a titanosauroid sauropod, and a dromaeosaurid theropod shows affinities with dinosaur faunas from elsewhere in Gondwanaland and Laurasia. The taxonomic spread of the assemblage shows that most major dinosaur groups, except ceratopsians, were present in Antarctica by the end of the Cretaceous. It is to be hoped that future discoveries will help to reveal more about how large dinosaurs, especially the herbivores, were able to survive in the environments of Gondwanaland at high latitudes where nearly 24 hours of darkness prevailed for the winter months.

David M. Martill

See also: Mesozoic Marine Reptiles of Antarctica; Paleoecology of Antarctica; Pliocene Arctic Fossils

Further Reading

Gasparini, Z., H. Leanza, and I Garate Zubillaga. "*Un pterosaurio de las calizas litogra´ficas tithonianas del a´rea de Los Catutos, Neuque´n, Argentina*." *Ameghiniana* 24 (1987), 141–43.

Stilwell, J., and J. Long. *Frozen in Time: Prehistoric Life in Antarctica.* Collingwood, Victoria, Australia: CSIRO Publishing, 2012.

Vickers-Rich, P., and T. Rich. *Wildlife of Gondwana: Dinosaurs and Other Vertebrates from the Ancient Supercontinent.* Life of the Past. Bloomington: Indiana University Press, 1999.

Dirck Gerritsz Laboratory, the Netherlands

The Netherlands Polar Programme (NPP) is a research program that funds Dutch polar research. The NPP has set up the Dirck Gerritsz Laboratory at the British Antarctic Survey's Rothera Research Station in Antarctica. The operator for the NPP is the Earth and Life sciences division of the Netherlands Organisation for Scientific Research (NWO). The Dirck Gerritsz Laboratory is a collaboration in infrastructure in Antarctica between NWO and the British Antarctic Survey (BAS). It was officially opened on February 25, 2013, by the Netherlands Ministry of Education, Culture and Science.

What the Labs Look Like

The Dirck Gerritsz Laboratory is made up of four independent laboratory units each of which is housed in a sea container. The laboratories are located in a docking station, which provides electricity, an Internet connection, water, and storage space. The docking station also protects the laboratories from the weather conditions. With funding from NWO, BAS designed and constructed the docking station, and the Royal Netherlands Institute for Sea Research (NIOZ) constructed the four mobile laboratories. The laboratories have a basic design of two workbenches, a fume cupboard, a sink, and storage cupboards. The docking station was built at Rotherain in the Antarctic summer period 2011–2012. Foundations were laid in the summer period 2010–2011. Each lab is fitted with additional equipment in accordance with the specific requirements of the individual research projects. Apart from the Dutch scientific goals, the Dirck Gerritsz Laboratory also extends the research capabilities of the British Rothera Research Station, nicely complementing the facilities of the Bonner Laboratory.

Naming

There are four mobile laboratories with the names "Annunciation," "Love," "Faith," and "Hope." The names are taken from ships that set sail from Rotterdam in 1598 in search of a trade route via South America to Asia.

The ship Annunciation commanded by Dirck Gerritszoon Pomp was blown southward when sailing close to the southern tip of South America. Gerritsz then saw the snowcapped mountainous landscape, which looked like the country of Norway. Most likely, he saw the South Shetland Islands, and so was the first to set eyes on Antarctica. The entire research facility therefore bears the name "Dirck Gerritsz Laboratory."

Development of the Labs

Although it is not a new concept for scientific research, a lot of work had to be done before a standard sea container could be converted into a laboratory. Adapting the containers to the conditions in Antarctica proved particularly challenging for the technicians at NIOZ. They worked together with a specialized refrigeration company that built an experimental hall set at −13°F (−25°C) to test the performance of each lab.

Besides aspects such as good insulation, ventilation (Antarctica is very dry), and the placing of an extra window, the designers paid particular attention to reliability and robustness; repairing a lab in Antarctica would be very expensive of course. Once the project proposals for the labs had been approved in May 2011, the researchers submitted details of the other adaptations needed for their specific project proposal.

Four Laboratories

The laboratories have been designed in standard sea containers that are 19 ft. (6.06 m) long, 8 ft. (2.44 m) wide, and 9.5 ft. (2.89 m) high. Optimum use is made of the space inside the laboratories to maximize the room available for the researchers and their research. The laboratories give the researchers the opportunity and space to use their own research equipment, including an Internet connection. Annunciation and Hope have been equipped as dry labs, each with their own specific requirements, Love has been equipped as a clean lab, and Faith as a wet lab/culturing lab. The researchers can use several labs for their research if needed.

Annunciation. The temperature in this container is kept between 59°F and 68°F (15°C and 20°C). It is a dry lab and therefore suitable for the use of a wide range of analytical instruments. Besides the standard equipment, the lab also contains a laminar flow cabinet.

Hope. This lab has a mass spectrometer that quantifies climate gases in the atmosphere. There is also a culturing cabinet with plasma lamps that provide the daylight spectrum.

Love. This lab is for carrying out analytical work of trace metals in seawater that demands a high degree of accuracy. It has therefore been equipped with special filters in the air-processing system to ensure that the air entering the container is dust free. The lab is intended for work under ultraclean conditions, free of contamination from metals, so that analyses on uncontaminated samples can be carried out later. In addition to the standard fittings, this lab has two laminar flow cabinets.

Faith. This wet lab has an incubation unit to study effects on the composition of Antarctic algal species. This unit allows the researchers to vary, for example, the pCO_2 (partial pressure of carbon dioxide), pH (degree of acidity), temperature, salt level, and turbidity. Water samples will also be processed in the lab. It is maintained at a constant 35.6°F (2°C) temperature.

Environment and Sustainability

The basic assumption of the Antarctic Treaty is that the member states will cause as little damage as possible to the Antarctic environment. The Netherlands has first of all applied this concept by not setting up its own base but instead making use of the existing infrastructure of BAS. Furthermore, various features in the design of the Dirck Gerritsz Laboratory ensure that it consumes as little energy as possible. Sustainability also plays an important role in the energy supply of the Dirck Gerritsz Laboratory. Solar panels have been placed on the docking station's roof, and the laboratories have a heat pump: this extracts heat from the air outside and blows colder air back outside again, a sort of reverse fridge. As the mobile laboratories can be transported, then should the need arise, they can be placed elsewhere in a few years' time instead of new laboratories having to be constructed.

D. (Dick) A. van der Kroef

See also: Antarctic Programs and Research Stations/Bases; Gerritsz, Dirck (a.k.a. Dirck Gerritszoon Pompor (1544–1608); Vostok Station

Further Reading

Dutch research Laboratory in Antarctica, Dirck Gerritsz Laboratory (NPP). http://www.nwo.nl/en/research-and-results/cases/dutch-research-laboratory-in-antarctica.html. Accessed January 9, 2014.

Netherlands Polar Programme Website. http://www.nwo.nl/en/research-and-results/programmes/Netherlands+Polar+Programme. Accessed January 9, 2014.

Discovery Expedition (1901–1904)

The British National Antarctic Expedition, now known as the Discovery Expedition, took place between 1901 and 1904. During this time, other expeditions from Germany, Sweden, France, and Scotland also traveled to Antarctica. The Discovery Expedition was carried out under the auspices of the Royal Society and the Royal Geographical Society, and was intended to renew Great Britain's involvement in the exploration of Antarctica.

The Discovery Expedition had both exploratory and scientific objectives. Specifically, they were to forge as far south as possible and to conduct oceanographic, meteorological, magnetic, biological, and geological observations en route.

The projected cost of the expedition was £90,000, half of which was sourced from the British Government, while the balance was raised by the two royal societies. The expedition vessel, the *Discovery,* was a three-masted wooden sailing ship, specifically designed for research in Antarctic conditions. She was constructed in Dundee at a cost of around £51,000.

The ship's crew was recruited from the Royal Navy, the Merchant Marine, and the civilian population. Robert Falcon Scott (1868–1912) was appointed as commander of the *Discovery* and leader of the expedition. Other noteworthy members of the crew were Ernest Shackleton (1874–1922), Tom Crean (1877–1938), and John Robert Francis "Frank" Wild (1873–1939). The scientific team consisted of Louis Bernacchi (meteorologist and magnetic observer), Hartley Ferrar (geologist), Thomas Hodgson (marine biologist), Edward Wilson (junior doctor and zoologist), and Reginald Koettlitz (senior doctor). Of these, only Bernacchi had previous Antarctic experience.

British naval officer Robert Falcon Scott helped define the heroic era of Antarctic exploration. (National Oceanic and Atmospheric Administration)

Discovery departed from Cardiff on August 6, 1901, traveling via Cape Town to Lyttelton, New Zealand. There, she prepared for the journey into the Southern Ocean, taking on supplies that included 45 live sheep donated by local farmers. After three weeks in port, she departed, sailing south. She stopped at Cape Adare and then Cape Crozier, which was to serve as a point where messages detailing the location of the expedition could be relayed to relief ships. *Discovery* then proceeded eastward along the Victoria Barrier (now known as the Ross Ice Shelf), before entering McMurdo Sound on February 8, 1902. Here she dropped anchor and soon became frozen into the sea ice, where she would be trapped for two years. Huts were erected on a nearby rocky peninsula. The larger hut was intended to act as accommodation. However, it was not conducive to habitation, and the expedition personnel continued to live on the ship. Two smaller huts housed scientific instruments including magnetometers and a seismograph.

The scientists, who had made measurements on the journey south, continued to take meteorological and magnetic observations during the winter. Preparations were also made for work to be undertaken during the next summer.

The men, who had little or no experience of skiing or dog sledging, began to practice these skills. They underestimated the dangerous conditions, and on a training journey, one of the parties fell to his death during a blizzard. Two overland journeys took place during the winter. A team led by Royds traveled to Cape Crozier to leave a message for a relief ship. When they arrived, they discovered a colony of emperor penguins. Scott, Wilson, and Shackleton also set off across the ice shelf with the goal of getting as far south as possible. Due to their inexperience with polar travel, progress was slow. The conditions of men and dogs deteriorated rapidly. The weaker dogs were killed and fed to the other dogs. They reached 82° 17′S before turning back. This was the closest that anybody had got to the South Pole. After the last of the dogs died, the men were forced to haul the sleds themselves. Shackleton was unable to assist since he was overcome with scurvy. The team returned to the *Discovery* on February 3, 1903.

While Scott's party was away, a relief ship arrived with supplies and a letter addressed to him authorizing the expedition to stay for a second year. A number of the men, including the ailing Shackleton, returned home with the relief ship. The *Discovery* spent a second winter in the ice.

In the spring of 1903, a group led by Scott once again set out, heading westward toward the South Magnetic Pole. Since there were no dogs left, it was a man-hauling journey. Their progress, however, was appreciably better than on the previous journey. After ascending a large glacier, they reached the Polar Plateau at a height of around 6,500 ft. (2,000 m). On the return journey, they discovered a valley completely free of snow. The existence of such dry valleys was not previously known.

Upon Scott's return, the *Discovery* was still stuck in the ice despite extensive efforts to free her. Two relief vessels soon arrived bearing instructions to Scott to abandon the *Discovery* if he was not able to free her quickly. Explosives and ice saws were employed to break up the ice around the ship. When she still would not budge, the men started to transfer important items to the relief ships. However, suddenly on Valentine's Day, 1904, the ice around the *Discovery* broke up, and she was free. On February 17, 1904, she began her journey home. Returning via Lyttelton, the *Discovery* arrived in Portsmouth on September 10, 1904, and soon sailed for London, where she docked with little fanfare.

After his return, Scott was promoted to captain and received an array of awards. A number of the officers and crew also received the Polar Medal. Among the various outcomes of the expedition, the highlights were the discovery of the Polar Plateau, a dry valley, and an emperor penguin colony; evidence suggesting that the ice barrier was not seated on land but floating on the sea; and magnetic measurements that allowed a better estimate of the location of the South Magnetic Pole. Numerous new geological and biological specimens were also found.

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See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

Further Reading

Crane, D. *Scott of the Antarctic: A Life of Courage, and Tragedy in the Extreme South.* London: HarperCollins, 2005.

Preston, D. *A First Rate Tragedy: Captain Scott's Antarctic Expeditions.* London: Constable, 1999.

Savours, A. *The Voyages of the Discovery: Illustrated History.* London: Chatham Publishing, 2001.

Distant Early Warning (DEW) Line

The Distant Early Warning (DEW) line was built in the mid-1950s as a radar detection system for soviet military activity in the Arctic airspace on the coast of the Arctic Ocean. The system was operated until 1993 and then replaced by the North Warning System (NWS). Recent environmental assessments revealed comparable environmental effects along the DEW line sites, such as scattered debris, eroding and leaching landfills, and historic disposal practices that contaminated soils with chemical substance concentrations so as to harm living organisms. Environmental investigations determined that the sites are chronic sources of contaminants that are potentially harmful to the ecosystem and traditional Inuit food sources but not an acute risk to human or environmental health. The Canadian sites have been remediated to reduce excess contaminants from entering the food chain. As of 2012, the majority of the DEW line sites have been cleaned up.

The DEW line was designed and built by Western Electric under contract to the U.S. Air Force (USAF) between 1955 and 1957, to detect soviet military activity in the Arctic airspace. An Aleutian extension was completed in 1959, whereas the Greenland extension became operational in 1961. Eventually, a total of 63 radar sites formed the line, spanning 3,100 miles (5,000 km) of Arctic coastline along the 69th parallel. The DEW line comprises 6 main stations, 26 auxiliary stations, and 31 intermediate stations (I-sites). Forty-two of these installations, including twenty I-sites, were located in Canada. The sites not only housed radar surveillance equipment but also included other infrastructure, such as airstrips, hangars, garages, fuel and water tanks, warehouses or storage buildings, module trains with living quarters and utilities, and a sewage lagoon. The type and amount of site infrastructure was dependent on the station type. Main stations served as central points of operation, administration, maintenance, and communications for their section of the line and were manned by approximately 60 staff. The main and auxiliary sites were dominated by a white plastic-covered dome that housed the radar (radome) and large billboard-sized antennae, while the I-sites used a different type of equipment and functioned as gap-fillers. Most of the sites on Canadian territory are located in aboriginal land claims areas. While the construction of the sites disrupted traditional land use patterns, they also provided an opportunity for year-round work and initiated the formation of some Arctic hamlets in proximity to the stations.

Due to technological advances, all I-sites were rendered obsolete and decommissioned in 1963 followed by the Aleutian sites in 1969. The 21 abandoned Canadian sites became the responsibility of the Aboriginal Affairs and Northern Development Canada (AANDC), the federal department responsible for Crown lands located north of 60° N. The remaining sites continued to operate until they were gradually replaced from 1989 to 1993 by the modernized NWS. The DEW line officially ceased operation in 1993. The 21 decommissioned Canadian auxiliary and main sites became the responsibility of the Canadian Department of National Defence (DND). The stations in Greenland and Iceland were transferred to the USAF in 1980, while the remaining American sites have been updated and continue to be operated by the U.S. military.

All DEW line sites were designed to be fully self-sufficient with built-in redundancy to ensure continuous operation. Waste disposal practices were consistent with the environmental knowledge at the time, but were also driven somewhat by convenience given the challenging climate, remote location, and geographical environment. Depending on the future use of the site, decommissioning involved the demolition of buildings and disposal of remaining fuel and other chemicals in dumps on-site. However, at the time of closure of the DEW line in 1993, scattered debris, abandoned buildings, eroding landfills, and contaminated soils remained at all sites.

Environmental investigations of the sites were initiated separately by the Canadian DND in 1989 and by the USAF in 1990. The Canadian DEW line cleanup strategy was developed through a series of environmental investigations by the Environmental Sciences Group (Royal Military College, Kingston) conducted between 1989 and 1994. The main contaminants found were hydrocarbons from fuel, polychlorinated biphenyls originating from equipment such as transformers and capacitors, and inorganic elements. The most prevalent inorganic elements were copper from plumbing and human waste, lead from fuel and discarded batteries, and zinc from metal debris and paints. When these initial environmental investigations were conducted, no environmental standards existed specific to the Arctic ecosystem. Existing environmental guidelines were modified to account for the unique northern environment. These adjustments were made based on plant, water, and soil sample data from the environmental investigations. The revised cleanup guidelines also acknowledged the close dependence of the Inuit on a subsistence way of life. As of 2013, these DEW line cleanup (DLCU) criteria are used as the standard for the remediation of all Canadian former DEW line sites.

The signing of a memorandum of understanding between DND and AANDC in 1989, in which both departments agreed to physically restore the closed DEW line sites. This was the beginning of a large-scale environmental remediation program, the DLCU project conducted by DND. The DLCU protocol sets out methodologies and activities to be completed during the cleanup of a site, including the demolition and disposal of infrastructure, the removal and disposal of hazardous materials, and the excavation and treatment or disposal of contaminated soils, and outlines activities and methods associated with long-term monitoring of any landfill facilities remaining on-site. It was agreed upon by DND, AANDC, Environment Canada, Fisheries and Oceans Canada, the Government of the Northwest Territories, and the Government of the Yukon Territory and aims to restore the 21 former auxiliary and main DEW line sites to an environmentally safe condition. This protocol served as the basis for the agreements formed by DND with the Inuvialuit Regional Corporation (1996) and the Nunavut Tunngavik Incorporated (1998, 2001, 2005), the organizations representing aboriginal groups, on environmental provisions for the cleanup and restoration of the DND DEW line sites and for economic benefits of Inuit in the implementation of this work. The challenges of the remote Arctic environment and political context in the Arctic were key influences on the project evolution and management: early and ongoing consultation with affected parties ensured compliance with the intent of the land claim agreements; collaboration with science experts and regulatory agencies addressed the need to develop project-specific criteria and protocols; and unique engineering landfill designs were developed and implemented to account for the challenging Arctic environment. A similar protocol was adopted in 2008 by AANDC for the cleanup of the 20 Canadian I-sites. As of 2012, the cleanup of 20 Canadian sites under DND's responsibility and of 9 sites under AANDC's responsibility is complete.

Daniela Loock

See also: Arctic Observatories; Rocket Ranges in the Arctic

Further Reading

Lackenbauer, W., et al. "The Distant Early Warning (DEW) Line: A Bibliography and Documentary Resource List." Prepared for the Arctic Institute of North America, 2005.

Metcalf, T. "Annotated Bibliography: Distant Early Warning System, Alaska." Prepared for the United States Air Force, 611th Air Support Group, Elmendorf Air Force Base, Alaska, 2008.

Reimer, K., et al. "The Environmental Impact of the DEW Line on the Canadian Arctic." Victoria, BC, Canada: Environmental Sciences Group, Royal Roads Military College, 1993.

Dogs in the Arctic

The dog (*Canis familiaris*) was the first domesticated animal in human care and the only one which had spread over all continents already in prehistoric times. The domestication of the gray wolf (*Canis lupus*) took place between 14,000 and 30,000 years ago. This process gave rise to an extensive phenotypic variation among dog breeds during ancient times.

A crew member of Roald Amundsen's expedition to Antarctica drives a dogsled. In October 1911, Amundsen set out for the South Pole with four companions and four dogsleds, each pulled by 13 dogs. (National Oceanic and Atmospheric Administration)

The native dogs of the circumpolar area are all spitz-type dogs. Recent research indicates that the dogs of northeastern Eurasia and North America (including Greenland/Kalaallit Nunaat) have a common origin. Dogs entered North America through the Bering Strait more than 9,000 years ago. There are recent and historical accounts of wolves being bred into dog lines, and early genetic data indicate to the closeness of this relationship, too. However, this occurred much more seldom than some sources report.

Dogs lived in close symbiosis with circumpolar peoples and have been crucial for their survival since time immemorial. They were fully integrated members of Arctic and subarctic human societies. These dogs are well adapted to a life in harsh Northern climates, with thick, insulating fur, small ears to reduce the risk of frostbite, and thick fur that grows on the paws to protect the dogs from sharp ice.

Dogs in Arctic Mythology

Various native peoples in Eurasia and North America see dogs as the first ancestor of human beings. The Inuit myths about the goddess Sedna is one example. Sedna married a dog and thereafter gave birth to many dog children. In Koryak mythology, dogs interact with the mythological heroes and are used by them for traveling as well. Dogs were also sacrificed to the Supreme Being and related entities or to evil spirits. When, for instance, a Nanai hunter dreamed of the barking of a black dog, this was warning him of the presence of malicious spirits. An etiological myth among the Sámi tells how a hungry dog, then a wild species, approached human settlement and sought the service of a herder to still its hunger. In exchange for food, the dog agreed to serve as a herding dog. This was the beginning of association of the dog with man.

Use of Dogs

Dogs in the circumpolar areas have been developed to fit several purposes for human societies such as guarding, herding, hunting, carrying loads, and pulling sleds. Before the advent of snow-machines in the 1970s, traveling on dog sleds was the means of transportation genuine to the Arctic and subarctic regions. In many cases, the European or non-Native American explorers, colonizers, settlers, traders, clergymen, and others adopted sled dog husbandry from the local natives. A good example is the Danish explorer Knud Rasmussen (leader of the Fifth Thule Expedition, 1921–1924), who traveled almost 20,000 miles (32,000 km) by dog sled from Greenland to the Pacific Sea.

Herding dogs that understood highly elaborated commands are traditionally known from the Sámi in Scandinavia, and the Nenets and Komi in northwestern Russia. Many Sámi preferred bobtailed herding dogs and were docking them. Nowadays, dog are very seldom used for herding in Sámi.

Dogs have also provided other economic services in the Arctic and subarctic regions, such as fur skin, medicine, and even as a source of protein and fat (i.e., food). They have also naturally served in traditional societies as companions and pets. Childless couples among Utkuhikhalik Inuit in Canada could bring up a puppy almost like an infant, giving it the same caring love as a human child would have received.

Sled-Dog Keeping

The availability of a dog feed source is the main reason for sled dog husbandry in the Arctic. Dogs are part of a highly adapted economic system that provides humans and dogs with food. Traditionally, a Greenlandic hunter travels on a dog sled out on the ice to hunt. With the help of his dogs, he searches for breathing holes of sea mammals. This sustainable way of harvesting provides both hunting partners, humans and dogs, with food and does not require imported energy like fuel. Usually, dogs were fed much the same as humans eat or could eat.

Even though some groups use their dogs as pack animals, such as for hauling boats during summer, most sled dogs are not used during the summer months. This also means that they are hardly fed or even let loose. Only in early winter, when their working power is needed again, are they tied up and properly fed again.

Historical sources show a trend toward having more dogs per household and larger dog teams with the advent of colonial taxation, market economy, and general globalization. Before the Copper Inuit/Kitlinermiut in Canada began to engage in trapping, they had small dog teams of three to four animals. This was enough to pull their necessary belongings. During hard way passages, people would rather help their dogs pull the sled than get another sled dog that needed to be fed. Trapping made bigger sleds necessary as a means to transport the gear, feed, and pelts. After 50 years, the Inuit families described earlier were reported to have 15–20 dogs to cater all their new transportation needs.

The equipment for traditional as well as modern mushing is not very sophisticated: sled, harness, and lines that tie the dogs to the sled. Additionally, dogs may wear little sock-like shoes that protect their paws from sharp crusted snow (booties); most dogs wear collars. Mushers working with old sled dog breeds that may show high potential of aggression toward their peers, like malamutes, might take a whip on their travels to be able to separate fighting dogs. Modern short-haired sled dogs sometimes need to wear coats and sleeves. The equipment used depends also on the regional or cultural style of dog sledging or hitch.

There are several types of harnesses that are put on the dogs to pull the sleds. In earlier times, the harnesses, like the lines, were made out of sea mammal or bear skin. The disadvantage is that hungry or bored dogs like to chew on leather and can therefore easily destroy the equipment. The rear part of the harness has a toggle that is hitched into a loop or iron ring of the main line. If accessible, the toggles are substituted by metal snaps. Today, harnesses are fabricated out of nylon band.

The Inuit use mostly the fan-hitch where every dog's harness is tied directly to the sled. No necklines are used, and the dogs can decide themselves whether they prefer to run in the middle of the team or toward the sides of the fan. The fan-hitch is used on ice and wide open space, which allowed the animals to avoid sudden holes in the ice. It is, however, not suitable for forested areas because the dogs risk to get entangled between the trees. Here, the gangline hitch is common: the dogs are usually attached in pairs to a main line. Sometimes, the dogs' collars are attached to the gangline through a neckline. Dogs can also be hitched in a line one behind the other.

The first dog or the first pair of dogs is called lead dog(s). These are usually more experienced and intelligent animals, not necessarily the strongest. They know and obey to the commands, keep the middle line straight, know the trails, and can find home even during snow storms. Good lead dogs are highly valued, and a few of them attained even a hero status, like Balto of the serum run in Alaska (today's Iditarod). Usually, there is a strong bond between the owner of the team and the lead dog. Oftentimes, the sled drivers have to fully trust the reactions of their lead dogs as the dogs see things before they come to the musher's sight. The Ainu are even said to cancel entire journeys if the lead dog refuses to go.

Sled dogs and especially lead dogs are supposed to listen at least to the basic commands for left, right, slow, and stop. Dogs that are not tired do not need a command to run. However, sometimes they need to be cheered up and motivated when the runs become long and monotonous. Native mushers from Kamchatka report that they sometimes sing for their dogs or imitate animals to motivate their team. The command "stop" has often to be accompanied by the use of the break. This can be iron foot break that is pushed into the snow. Mushers that drive seated use a steering and braking pole with an iron tip (*ostol*) that is pushed into the snow and pulled back like a lever between the support poles of the sled. This pole is called *ostol* in Eastern Siberia.

There is a variety of different local types of dog sleds. Sleds vary according to their use: sleds for transporting heavy and big loads are accordingly broad and rugged; sleds for taking out children may be covered. Race sleds have to be sturdy, easily maneuverable, and lightweight. All sleds are flexible and easy to repair. Modern race sleds are high-tech constructions made for speedy runs on well-prepared trails. Traditional sleds are made of birch-wood, which is hard and elastic at the same time. Where available, the runners of sleds in Northern areas were made out of rib bones of whales. To enhance the sliding, people would cover the runners with thin layers of ice.

It can become life threatening to lose one's dog team in a remote place. To prevent dog teams from taking off on their own, mushers carry at least one snow-hook that holds the team back like an anchor. The braking pole *ostol* can be used for the same goal.

Native mushers in Eurasia and Inuit mushers usually drive seated on their sleds. Modern sportive and other North American mushers stand on the rear part of the runners behind the luggage section of the sled. In deep snow or steep trails, some mushers jump off to help their dogs by pushing the sled.

Dogs as Biological Resources

Generally, dogs were not eaten. However, during extreme famines, dogs served as an emergency food. In 1942, Frank Connell found trichina in 72 percent of 83 Alaskan and Canadian dogs investigated. He concludes that the economic importance of the sled dogs protects people, except in case of emergency, *from infection by its most dangerous source.* In rare cases, dog fat and meat has also been used for medicine. Among the Sámi, a broth boiled on dog meat was used against rheumatism.

Dog skins and wool have been used for clothes or parts of costumes among many circumpolar groups. In the late nineteenth century, during the time of the Klondike gold rush, dog skin coats were in demand in North America. A large amount of dog skins came not only from Manchuria but also from Korea and Kamchatka to cover the growing demand before World War I. Dogs began to be reared on a commercial scale for their fur.

Breeds and Breeding of Sled Dogs

In early times, people in Northern regions would not distinguish between sled dogs and other dogs, because all dogs in their area were used as draft animals. This changed drastically when European breeds were introduced into these areas. The resulting interbreeding dogs, together with the diseases brought by the new dogs, lead to the decay of the native sled dogs. Genetic analyses have shown that even in remote areas, most dog lines had been replaced by dogs of European ancestry today.

There are several breeds recognized by the American Kennel Club, Canadian Kennel Club, and Fédération Cynologique Internationale as sled dog breeds or breeds used as show dogs and pets that stem directly from working sled dogs: Alaskan Malamute, American Eskimo Dog, Alaskan Husky, Siberian Husky, Canadian Inuit Dog, Greenland Dog, Samoyed, West Siberian Laika, Chukotka Laika, and others.

Old breeds are typically referred to as native dog breeds or village dogs. Usually, they show a high variety of traits. The Greenland equator is the line beyond which no nonlocal sleds dogs are allowed to be kept to preserve the breed of the Greenland sled dogs.

People who work with sled dogs select for criteria that are relevant for the working quality of the dogs. This contrasts to the standards of many breeder associations that require selecting for physiological features and not for qualification as good sled dogs. Sled dog keepers would typically select and breed for criteria like health, size and weight, vulnerability of the paws, endurance, character, no aggression toward people and other dogs, speed, and thickness of fur. To comply with the needs for the modern competitive sprint races, dog breeders have mixed fast dogs like German hunting dogs into their lines. Modern long-distance mushers, like the participants of the Iditarod or Yukon Quest races, prefer smaller and faster dogs that can run 1,000 miles (1,600 km) in fewer than 10 days. These dogs do not comply with any dog breeder association's catalog; nevertheless, they win the races.

Explorers' Use of Dogs in the Polar Regions

Arctic sled dogs were of great importance in early exploration of Arctic areas. Some expeditions brought dogs back to their countries: the Samoyed Spitz in Great Britain and Scandinavia is regarded as a descendant of dogs brought by expeditions from Siberia.

Due to the success of using sled dogs in the Arctic, they were employed in the Antarctic exploration as well. Roald Amundsen used Greenland dogs to reach the South Pole during his Antarctic expedition in 1911. During Amundsen's expedition, sled dogs not only were used to haul sleds but also served as food for other dogs and humans along the way. Sled dogs were used by various expeditions in Antarctica until 1992, when they were banned by the Protocol on Environmental Protection to the Antarctic Treaty.

Recent Changes

To forcedly make native people sedentary and to modernize them, dog mass-killings took place in Canada as well as in other circumpolar regions in the second half of the twentieth century. Only in 2011, the Canadian Inuit received an official apology and reparation payments for this highly traumatic event from the Canadian government.

Major social, economic, and cultural changes for hunters and herders of the twentieth century came along with the introduction of snow-machines to all Arctic and subarctic regions in the 1970s. When the Copper Inuit in Canada bought their first snow-machines in the early 1970s, they suddenly found themselves with a lot of spare time because they did not have to hunt and care for their dogs anymore. On the other side, they then needed to procure money to be able to buy the snow-machines and fuel, and repair parts.

Arctic Dogs in the Twenty-First Century

The importance of dogs in the Arctic is symbolically indicated by the fact that the Nunavut adopted the Inuit sled dog or Qimmiq as the official animal emblem for this newly established Canadian territory in May 2000. Since the days of Jack London's *The Call of the Wild* (1903) and the real-life husky dog hero Balto in Nome, Alaska, popular culture has made them famous worldwide.

Although dogs have to a large extent lost their traditional use in many areas of the North, there are still working dogs among Arctic hunters in Greenland, Canada, and Siberia. In very few areas, sled dogs are kept for subsistence practices like trapping and for transportation even today. In Greenland, dogs are also employed by the Danish navy elite unit known as *Siriuspatruljen* (Sirius Patrol), which conducts reconnaissance, patrolling, and enforces Danish sovereignty in northern and eastern Greenland. *Sportive* mushing and sled dog racing have become an increasingly popular sport in the circumpolar North and beyond. Besides a large number of local and interregional sprint races, there are several famous long-distance races: Iditarod (Alaska, USA), Yukon Quest (Canada—Alaska, USA), Finnmark (Northern Norway), Beringia (Kamchatka, Russia), and Hope/Nadezhda (Chukotka, Russia).

Lisa Strecker and Ingvar Svanberg

See also: Arctic Fox; Arctic Ground Squirrel; Arctic Hare; Arctic Seabirds; Arctic Wolf; Caribou; Lemmings; Musk Oxen; Polar Bear; Wolverine

Further Reading

Anderson, M. "From Predator to Pet: Social Relationships of the Saami Reindeer-Herding Dog." *Central Issues in Anthropology* 6, no. 2 (1986): 3–11.

Bonam, M. *Northern Breeds.* Hauppage, NY: Barron's, 2001.

Coppinger, L. *The World of Sledgedogs: From Siberia to Dog Race.* New York: Howell Books, 1977.

Cummins, B. *First Nations, First Dogs: Canadian Aboriginal Ethnocynology.* Calgary, AB: Detselig Enterprises, 2002.

Florio, M. *Run until Dead: A Brief History of the Polar Expedition Dog.* Mercersburg, PA: Polar Press, 2010.

Gerth, N., P. Newman, J. Speakman, S. Jackson, and J. Starck. "Energy Metabolism of Inuit Sled Dogs." *Journal of Comparative Physiology B* 180 (2010): 577–89.

Jensen, B. "Folkways of Greenland Dog-Keeping." *Folk* 3 (1961): 43–66.

Laugrand, F., and J. Oosten. "The Position of the Dog in the Inuit Cultures of the Canadian Arctic." *Anthropos* 97 (2002): 89–105.

Dolgans

The Dolgans are a small Turkic-speaking ethnic minority who live in the Taimyr Peninsula in the northern Russian Federation. Most reside within the Taimyr Dolgan-Nenets District (5,500 or 14% of the population in the district) of the Krasnoyarsk Krai and in the Sakha Republic (1,900 or 0.2% in the republic). According to the 1926 Soviet census, there were 656 Dolgans. In the latest Russian census 2010, the Dolgans total 7,900 persons. Some Evenki are said to have assimilated among the Dolgans during the past century. Culturally and linguistically, the Dolgans can be divided into three subgroups: western Dolgans in the Yenisei area, the central Dolgans in Ust Avam, and eastern Dolgans who are living close to Sakha and are to some extent assimilated among them, especially due to the high rate of mixed marriages.

History

The Dolgans moved to the present area in the eighteenth century. They are predominately taiga or boreal forest hunters. Researchers consider the Dolgans to be descendants of Evenki who became linguistically assimilated by the Sakha people in the region. Tsarist administration forced them to pay the *yasak* or tribute in furs. They later developed reindeer nomadism, but hunting and fishing continued to be important for their survival until recently. Dolgans in the Noril'sk Lake region and in the Popigai depression spent the winters in the forest-covered river valleys, and the summer on the bare steppes. Others, living along the forest–tundra belt from Lake Piasino to the lower reaches of River Popigai, spent their summer pasturing with their herds in the tundra and the winter in the forests.

The households were dispersed over vast areas. They used herding dogs for tending the reindeers. Hunting of fur animals (especially polar fox) continued to be important. Not only molting red-breasted geese (*Branta ruficollis*) were captured with nets in large number, but ducks were also important game birds. Seabirds could be stored frozen in the permafrost. Fish like whitefish (*Coregonus* sp.), pike (*Esox lucius*), and burbot (*Lota lota*) were captured with nets and were kept in pits where it was fermented. Cloudberries, bilberries, and other fruits have been gathered for food and are still used by the Dolgans. Traditional applied art among the Dolgans included mammoth bone carving and embroidery with colored beads.

In the late nineteenth century, they became nominally Christianized by Russian Orthodox missionaries working in the area, but many Dolgans have retained old practices, and their native religion has to some extent survived until today. Collectivization of their herds and properties began in the late 1920s, and the hunters and nomads were forced to settle. During the Soviet rule, the Dolgans lived in collectivized farms, but the collectivized hunting and reindeer herding economy was never especially efficient, due to high transportation and production costs, and was therefore very much relying on state subsidies. After the breakup of the Soviet Union, many Dolgans had to return to a primary sector of economy with hunting and fishing. However, domestic reindeers continue to be important for their economy. The extensive nickel mining in the Noril'sk area has created major environmental problems with deterioration of public health, which has affected the people on the taiga.

The first scientific data on any value of the Dolgans were given by the Finnish philologist Matthias Alexander Castrén (1813–1853) in a travelogue, published in St. Petersburg in 1856. The Swedish journalist Jonas Stadling traveled in the 1890s among the Dolgans and provided some insights into their lives in his published travel report. The Soviet ethnographer Andrei A. Popov has made important recordings of their folklore and traditional culture. More recently, foreign anthropologists like Aimar Ventsel and John Peter Ziker have conducted research among them.

Language

The Dolgan language belongs to the Northern branch of the Turkic languages. It is very closely related to Sakha and sometimes regarded as a dialect of it with a lot of Tungusic (Evenki, Even) borrowings. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) lists the Dolgan language as definitely endangered with 4,865 fluent speakers. Very few linguistic studies exist, although the Polish scholar Marek Stachowski has made some important contributions. Most Dolgans speak Russian, some also Evenki or Nganasan. They have a rich oral literature, and especially animal tales were popular. There is little written literature in Dolgan language. The first book was a collection of poems published in 1973. A textbook for school use was published in 1980.

Ingvar Svanberg

See also: Chukchi; Enets; Eskimos; Evenks; Evens; Inuit; Ket; Khanty; Koryak; Kosterkin, Tubyaku (1921–1989); Malitsa; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

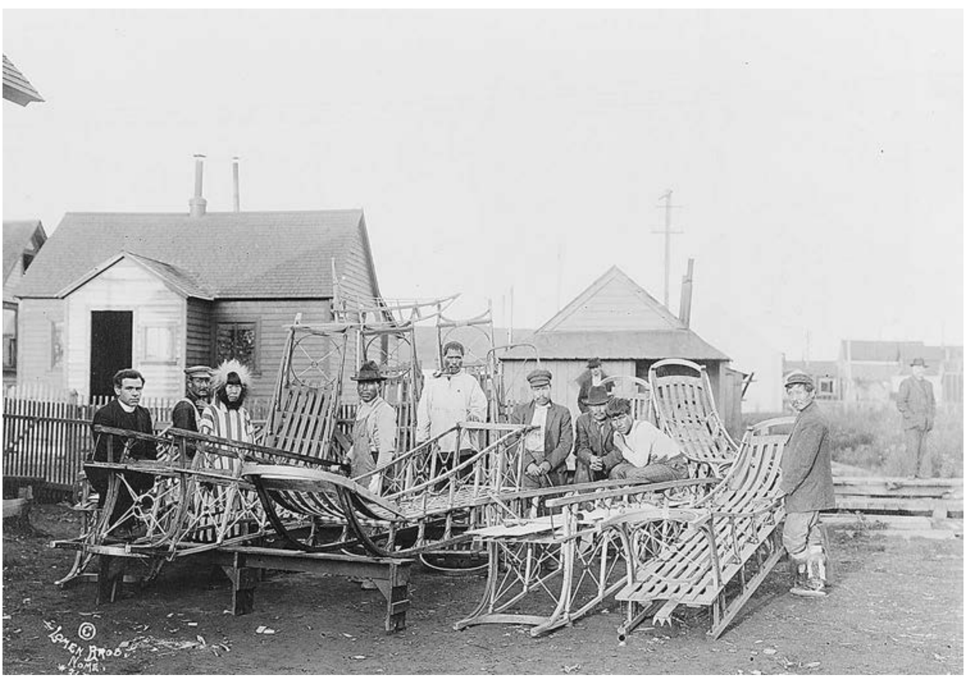
Ventsel, A. *Reindeer, Rodina and Reciprocity: Kinship and Property Relations in a Siberian Village.* Halle, Germany: Lit Verlag, 2005.

Ziker, J. *Peoples of the Tundra: Northern Siberians in the Post-Communist Transition.* Prospect Heights, IL: Waveland Press, 2002.

Drifting Research Stations in the Arctic Ocean

Sea ice was an insurmountable obstacle for navigators in the sixteenth to nineteenth centuries in their attempts to make a through voyage from the Atlantic to the Pacific Ocean around the shores of Siberia or North America. Thick pack ice, ice ridges, strong ice pressures, and adverse wind had made it impossible to find the Northeast and the Northwest Passages for several hundreds of years. Finding a passage to the North Pole by ships to perform scientific explorations in the central Arctic Ocean was equally elusive for explorers.

The idea to use the sea-ice drift for spatial–temporal meteorological, glaciological, oceanographic, hydrographic, and geomagnetic observations belonged to the Norwegian polar explorer Fritjof Nansen (1861–1930) in the end of the nineteenth century. An analysis of American shipwreck remains found near the coast of Greenland suggested to Nansen a hypothesis about a strong transarctic ice drift from the shores of East Siberia and Chukotka toward the strait between Spitsbergen and Greenland. He designed a ship of unusual structure with an egg-shaped lower part of the hull, which allowed the ship to be squeezed onto the ice surface at ice pressures. The sailing motorboat *Fram* was built for Nansen's expedition,



Dogsleds of the Stefansson-Anderson Canadian-Arctic Expedition. Built in Nome, Alaska, 1913. (Library of Congress) and in 1893–1896, she made a unique drift along the route planned in advance. The ship had fuel and food supplies for many years and was equipped with necessary scientific instruments. This unique scientific experiment on the artificial platform frozen into the ice massif became a prototype of the future method of exploring the Arctic Basin.

On March 15, 1918, a group of explorers headed by the Canadian Vilhjalmur Stefansson (1879–1962) started on dog sledges for the north from the Alaskan coast with the intention of spending a year on drifting ice to investigate the ability of European people to survive under the extreme conditions of the high-latitudinal Arctic. Choosing a reliable ice floe, five courageous investigators had drifted westward over approximately 450 miles (740 km) and returned to the continent. The total time of the stay on drifting ice was 238 days. This group did not make any hydrometeorological and geophysical observations of the environmental state.

On May 21, 1937, the Soviet research drifting station later called the "North Pole-1" (NP-1) was deployed in the area of the North Geographical Pole by means of four multiengine heavy airplanes. A temporary camp was arranged directly on the drifting ice floe for performing a program of scientific studies by four specialists. Ivan Papanin (1894–1986) was the head of the station, mechanic, and cook; Yevgeny Fedorov was meteorologist, astronomer, and geophysicist; Petr Shirshov was oceanographer and hydrobiologist; and Ernest Krenkel was radioman. The organization of NP-1 station was connected with the need for meteorological support of transarctic flights of Soviet airplanes under the command of Valery Chkalov, Mikhail Gromov, and Sigismund Levanevsky from Moscow to the United States across the North Pole made in 1937. The station objectives also included scientific investigation of the practically unexplored region of the Arctic Ocean and the above surface atmosphere. The NP-1 drift continued for 254 days and ended on February 19, 1938, in the Greenland Sea. The station personnel were evacuated back home by means of the Soviet icebreakers. This expedition served as a basis for deploying scientific stations directly on drifting ice of the Arctic Ocean.

The given method of studies was continued to 1950 when the USSR organized the next drifting scientific North Pole-2 station (NP-2). This time it was established in the eastern Arctic Ocean. Its drift revealed one more unique peculiarity of the general ice drift direction in this ocean, when in the eastern ocean area, it has a character of the anticyclonic gyre (clockwise). The station personnel numbered 18.

In 1946, a new stage in the life of the world international community called the Cold War began. The leaders of two rival political systems, the Soviet Union and the United States, began to consider the Arctic Ocean as the most prospective theater of war actions. Operations of fighter aviation, nuclear submarines, and strategic ballistic missiles using the Arctic vector—the closest distance between the opposing countries—became quite important. From 1953 to 1991, the USSR regularly organized 1–2 drifting North Pole stations in the Arctic Ocean. The United States began to use such methods of studies in 1952, when a group of specialists headed by USAF Major John Fletcher landed on the ice island named "T-3." Besides the program of ice airfield construction, they carried out meteorological geomagnetic, glaciological, and oceanographic studies. In the next years, the United States organized several drifting stations that had letter indexes or abbreviations of the names of full-scale experiments made at them. The personnel of drifting stations were accommodated in prefabricated panel houses with heating stoves. The station camp had a diesel electrical power station, a radio station, a medical unit, a galley and a mess-room, a garage for tractors, scientific laboratories, and outdoor and indoor warehouses. As a rule, the stations had ice airfields. Their arrangement and evacuation were provided by aviation or icebreakers.

Military or civil aircraft and sometimes nuclear submarines visited the Soviet and U.S. drifting stations. At the same time, unique scientific materials on the Arctic Ocean seabed relief, structure and genesis of water masses, peculiarities of the water circulation regime and currents, dynamics and physics of sea-ice structure, meteorological regime of the atmosphere, peculiarities of geophysical processes of polar latitudes, and biological diversity of organisms inhabiting water and ice of this ocean were collected with their help.

In 1997–1998, the United States organized in the northern Beaufort Sea a full-scale experiment in the ice cover "Surface Heat Budget of the Arctic Ocean" (SHEBA) by means of the Canadian icebreaker *Des Grosseliers,* which was moved to a position in the ice massif and allowed to be frozen.

The USSR finished the program of its drifting stations when the North Pole-31 station was closed in 1991. In 2003, this program was resumed when the North Pole-32 station already under the Russian flag was opened. In 2012–2013, the Russian North Pole-40 station operated in the Arctic Ocean. The military aspect of activity of drifting stations ended in 1991 with the termination of the Cold War. Currently, this type of activity has an exclusively scientific character aiming in general at studying the influence of climate variability on ice and waters of the Arctic Ocean. In total, the history of Soviet drifting North Pole stations had 2,851 people who worked on them with the general operation period of the stations of 31,963 days. The total drift of the ice floes of the stations is 117,525 miles (189,139 km).

Valery Lukin

See also: Antarctic Programs and Research Stations/Bases

Further Reading

Armstrong, T. *The Russians in the Arctic.* London: Methuen and Co., 1958.

Papanin, I. *Life on an Ice Floe.* New York: Julian Messner Co., 1939.

Romanov, I., Y. Konstantinov, and N. Kornilov. *"North Pole" Drifting Stations (1937–1991).* Saint Petersburg, Russia: Gidrometeoizdat, 1997.

Treshnikov, A. "Results of the Oceanological Investigations by the "North Pole" Drifting Stations." *Polar Geography* 1 (1977): 22–40.

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East Antarctica

East Antarctica encompasses the highest ice domes, from which ice flows eventually to the surrounding oceans. The eastern lines of longitude were the original extent of East Antarctica; however, the Transantarctic Mountain range is more commonly used as the boundary in modern times. Much of East Antarctica consists of a high plateau of ice, with mountains showing above the ice (nunatuks) only at its edges. The highest point is an ice dome, called Dome Argus (80° 22′S, 77° 22′E), reaching an elevation of 13,421 ft. (4,091 m) and is located about 745 miles (1,200 km) inland. It lies approximately midway between the head of Lambert Glacier and the South Pole, near the center of East Antarctica. The lowest officially recorded temperature ever was −128.6°F (−89.2°C) at the Russian Vostok Station on July 21, 1983. In 2010, remote temperatures collected from high ridge in the East Antarctic Plateau were −136°F (−93°C). Beneath the ice of the plateau, the rock topography lies at a low average elevation (including areas below sea level) and consists of ridges, valleys, mountain ranges, and even lakes. If the ice were to disappear, the rock would rise considerably by isostatic rebound, just as postglacial North America did.

At the fringes of the plateau, outlet glaciers flow either through the Transantarctic Mountains or through other outlets down to the surrounding ocean. The center of the plateau receives little snow, the air being too cold to carry much moisture. Near the edges of the plateau, more snow falls, and downslope katabatic winds can form drifts. These katabatic winds mold the surface, especially in the low snow inland areas, yielding hard sculptured ridges, called sastrugi, which can reach as high as 1 m (3 ft.). In some regions, especially near the coast, the katabatic winds cause almost constant blizzard conditions during much of the year.

History

The Transantarctic Mountains were first seen by Captain James Ross in 1841, from the Ross Sea. Other shipborne expeditions sighted and mapped the coast over the next 70 years. But land beyond the mountains remained terra incognita for some time. The East Antarctic Plateau was first sighted in 1903 through the western mountains route during the Discovery Expedition to the Antarctic, led by Robert Falcon Scott (1868–1912). That expedition did not make a serious attempt on the

South Pole, but did reach a new farthest south of 82° 17′S. In late 1908 into early 1909, Australian Edgeworth David led the first expedition (which included Douglas Mawson and Alistair Mackay) to cross the Transantarctic Mountains, west of Ross Island. They went on to reach the South Magnetic (Dip) Pole, which was then located on a lower portion of the plateau, west of the Ross Sea. The trio covered a distance of more than 1,200 miles (2,000 km), a record for the longest unsupported sled journey until the mid-1980s. David described the journey in "Narrative of the Magnetic Pole Journey," which appeared in the second volume of Ernest Shackleton's "Heart of the Antarctic."

A number of countries made sovereign claims over portions of East Antarctica during the early exploration, many of which overlapped. These have all been set in abeyance by the Antarctic treaty, signed in 1959 and enacted on June 23, 1961. The treaty (among other things) prohibits military activities and allows any signatory to monitor the activities on the continent of other signatories. Most would consider this treaty a model for international cooperation. In East Antarctica, there are more than two dozen countries such as Russia, France, and Japan that have established permanent and seasonal research stations and bases.

Although the sea coasts of East Antarctica harbor the usual Antarctic fauna, essentially nothing lives inland. The occasional skua gull has been spotted on the plateau. One skua gull followed the QMLT 2 party, in the middle of the plateau, for about a week before disappearing. Also, instances of the wayward seal or even penguin have been found heading inland from the coast; they clearly would not live long. Lichens and some primitive mosses have been found on ice-free mountain areas up to a couple of hundred miles from the coast, but the ice plateau appears devoid of higher life forms.

East Antarctica consists primarily of a large Precambrian shield, the stable portion of a continent composed of old rocks that have changed very little over a long time. Rocks over 3 billion years old have been found in this area. These rocks consist of metamorphic rocks overlain by younger, flat-lying ocean-deposited sediments. Many of these rocks recrystallized during an orogeny, a mountain-building episode caused by plate collisions, in the Early Paleozoic (about 500 mya). Typical rock types include gneiss, schist, granite, shale, sandstone, and limestone.

East Antarctica formed part of Gondwana, the large, single landmass made up of the present-day South America, Africa, Arabia, Madagascar, India, Australia, and Antarctica. Gondwana existed as far back as 1 billion years ago and moved and rotated in the Southern Hemisphere as a unit until about 200 mya, when it began to break up and finally broke apart from the other continental landmasses about 40 mya. Gondwanaland was part of Pangaea, the supercontinent made up of all the major continents in the Paleozoic.

The Transantarctic Mountains (more than 4,500 m [nearly 15,000 ft.] at their highest) formed in the Early Paleozoic (about 500 mya) during the Ross Orogeny.

They consist primarily of flat-lying sedimentary rocks, typically sandstones, shales, and limestone.

William (Bill) F. Isherwood

See also: Antarctic Ice Sheet; Antarctic Peninsula; Transantarctic Mountains; West Antarctica

Further Reading

Chen, J., C. Wilson, D. Blankenship, and B. Tapley. "Accelerated Antarctic Ice Loss from Satellite Gravity Measurements." *Nature Geoscience* 2, no. 12 (2009): 859.

Steig, E., D. Schneider, S. Rutherford, M. Mann, J. Comiso, and D. Shindell. "Warming of the Antarctic Ice-Sheet Surface since the 1957 International Geophysical Year." *Nature* 457, no. 7228 (2009): 459–62.

East Siberian Sea

The East Siberian Sea is a marginal sea of the Arctic Ocean and is located off the Siberian coastline between the Laptev (west) and Chukchi (east) Seas. The New Siberian Islands and Wrangel Island are located in the East Siberian Sea. The northern border of the East Siberian Sea is from the northernmost point of Wrangel Island (179° 30′W) to the De Long Islands (76° 39′N, 153° 39′E) and to Bennett Island (76° 44′N 149° 30′E). The southern border is the 1,800-mile (3,000-km) Russian coastline. The East Siberian Sea is frozen for most of the year and is navigable only in August and September when it is ice free. East Siberian Sea got its name in 1935 under the Soviet Union. Prior to that, the sea did not have a formal name but was called "Indigirskoe," "Sibirskoe," or "Ledovitoe." The city and the port of Pevek (69° 42′N 170° 17′E) is the most populated place in the East Siberian Sea area.

Several rivers empty into the East Siberian Sea, such as the Alazeya, Chaun, Chukochya, Indigirka, Kolyma, Pegtymel, Rauchua, and Ujandina Rivers. The total area of the East Siberian Sea is about 360,000 square miles (936,000 sq. km). The average depth is about 150 ft. (45 m). The maximum depth is just more than 500 ft. (155 m). The shallow East Siberian Sea has a highly productive seafloor that enables bottom-dwelling prey, such as fish (Arctic char, polar and saffron cod, grayling, whitefish, smelt, etc.), crustacean, and mollusks to thrive. The abundance of prey attracts many predators, such as seabirds, whales (beluga, bowhead, gray, and narwhals) walrus, and seals (ringed and bearded). Common birds are murres, cormorants, and various gulls. The sea ice of the East Siberian Sea also provides dens area for polar bears. During the ice-free season, there is a significant plankton (mostly copepods) bloom estimated at 5 million metric tons.

Originally, the Yukaghirs and the Chukchi people used the coast and coastal waters of the East Siberian Sea for subsistence activities, such as the hunting of fur-bearing animals, marine mammals (whales, walrus, etc.), and reindeer herding. Later, the coast and coastal waters of the East Siberian Sea were also used by the Even, Evenks, and Yakuts, who migrated to the region to avoid the Mongols. The Russians journeyed into the region in the seventeenth century. Semyon Ivanovich Dezhnyov (1605–1673) and Fedot Alekseyevich Popov were credited as having been the first nonindigenous people to navigate the East Siberian Sea coastline, in 1648. Several scientific explorations were conducted in 1735–1743 (Great Northern Expedition), 1820–1824 (Ferdinand Wrangel), and 1911–1914.

The coast of the East Siberian Sea was home to several *Glavnoe Upravlenie Ispravitelno-trudovykh Lagerej* (Gulag) or in English "the Chief Directorate of Corrective Labor Camps." A Gulag was a system of forced labor camps of the Soviet Union. In 1930, a Gulag was set up at Ambarchik (69° 37′N 162° 18′E) in Ambarchik Bay of the Kolyma River Delta. The prisoners of the Ambarchik Gulag built the port and unloaded the incoming ships. In 1949, another Gulag was established at Chaunchukotlag and operated until 1957. A third Gulag was established in 1951 at Chaunlag and operated until 1953. The prisoners were used in mines and construction projects. In modern times, the Ambarchik is a meteorological station.

Andrew J. Hund

See also: Arctic Ocean; Barents Sea; Beaufort Sea; Chukchi Sea; Greenland Sea; Kara Sea; Laptev Sea

Further Reading

"East Siberian Sea." In *The Columbia Encyclopedia*. 6th ed. *Encyclopedia.com*. 2013.

Robinson, A., and K. Brink. *The Global Coastal Ocean: Regional Studies and Syntheses.* Cambridge, MA: Harvard University Press, 2005.

Economic Growth in the Changing Arctic

Extraction of Arctic natural resources has played a major role in the economic growth of Arctic countries, as well as for the international economy and development policy. Natural resource extraction has given some initial economic and welfare benefits, especially to high-income economies often located outside of the Arctic. Native people and many species depend on Arctic cold and natural conditions. Nonetheless, they tend not to receive the benefits of economic growth, but most of the long-term negative effects, such as contamination and global warming impacts.

Arctic Economies

Apart from some international ocean sectors, the Arctic territories mostly belong to eight nations: Canada, Denmark (Greenland), Finland, Iceland, Norway, Sweden, the United States, and the Russian Federation. Arctic nations are usually rather high-income countries. The gross domestic product (GDP) per capita in the Arctic high-income countries has increased dramatically since the 1970s. In the 1960s, these countries had a GDP per capita of approximately US$2,500; already by the 2000s, the average of Arctic high-income countries increased to US$41,500. However, as common for high-economic growth economies, a strong separation developed in regard to the actual distribution of wealth and related metrics (education levels, social standing, welfare, life expectancy, domestic violence, infant mortality, etc.). Consequently, many crucial issues like poverty and education remain not resolved, and poor people in the Arctic tend to be in a rather abysmal state.

Economic activities in Arctic countries are diverse, but in many countries, the extractive resource industry is the most important. For instance, oil and gas extraction, and transportation are the main industries in Alaska (ca. 30% of the Alaskan Gross State Product) and for Arctic Russia.

Major extractive activities are, for instance, fisheries and the processing of fish (Greenland, Iceland, and Norway), mining (Arctic Finland, Sweden, Greenland, and Canada), and energy resources (Arctic Norway). Tourism plays a big role in parts of Alaska, Canada, Iceland, and Scandinavia; it is growing in Russia, too. The Arctic is also a source of wealth for non-Arctic countries that benefit from Arctic

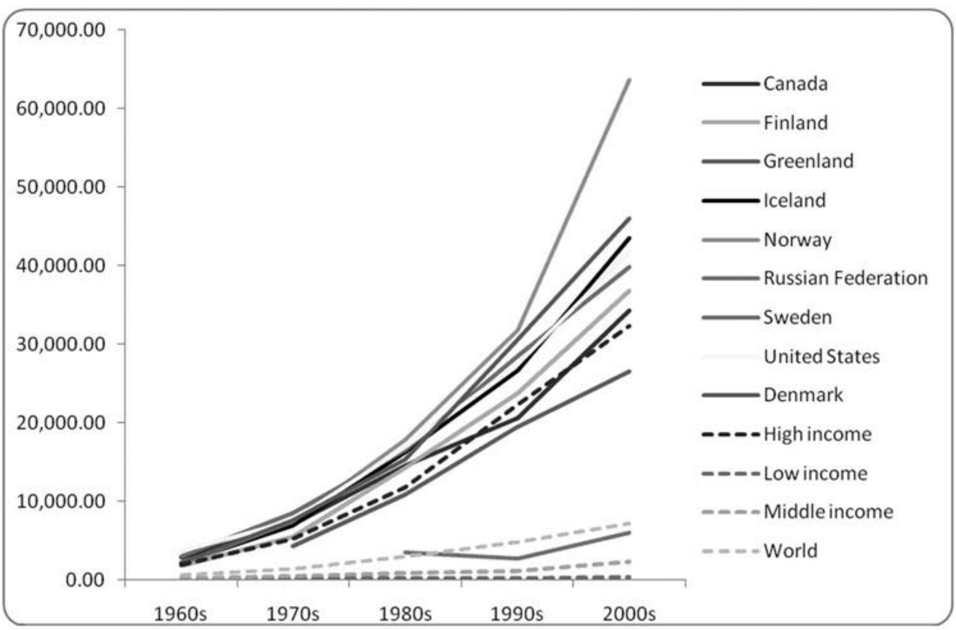

Figure 1 Average GDP per capita and per decade in primary Arctic countries *vs.* income categories (US$) (The World Bank 2012 in Resendiz 2012).

resources, and their legacies, such as Svalbard raw materials, including oil and gas, are sold to high-income countries and emerging economies to produce commodities and to maintain certain welfare (e.g., Russia selling oil to Germany, Japan, and China). Like with tourism, many of such activities already had a negative impact on the ecosystem economy, and ecological services as well.

Arctic Environmental Issues as a Result of Economic Growth Promotion

Human activities in situ and elsewhere, intensification, and commercial exploitation of living and nonliving resources are known to have a negative impact on the Arctic land and seascape. This is because virtually all products and goods are based on natural resources eventually, and their consumption is essentially taken directly from sensitive ecosystem. In the case of the Arctic, the industrial impacts onto the fragile ecosystem tend to be long-lasting. While Arctic resources are exported worldwide (anywhere), negative effects also come in from everywhere (e.g., the Asian Brown Cloud ABC, contamination, and man-made climate change).

Many Arctic species depend directly on ice and snow habitats, and thus are competing with humans for space and resources on a finite globe. Direct and indirect effects represent a serious threat to species, the trophic food web and ecosystem resilience, and therefore to the whole earth system as well as to humankind.

So far, the known outcome of economic growth in Arctic ecosystems has been habitat destruction, death of individuals and cultures, fragmentation of animal migration routes, erosion and pollution, among others. Nations like Canada and the United States are now engaged in fracking, as well as oil sands, to meet energy needs. Northern Alberta and British Columbia are among the most advanced provinces in those businesses, and the impacts of these activities are devastating on many accounts, also reaching Arctic watersheds. Mining presents another Arctic business scheme: it is already among the largest industries in the Canadian Arctic (e.g., Yukon), and especially the diamond industry is still growing. It just started there in the 1990s, and today Canada is the third largest producer of diamonds in the world. Currently, three of four diamond mines in Canada are located in the Arctic region. Waste and the human footprint from mining activities are increasing, and include heavy metals (e.g., Pb and Zn), trace elements, and other contaminants, often extending their impacts now under the earth too. Considering ongoing stresses, other disturbances will also have cumulative impacts and result into overstepping relevant tipping points. Sport hunting, for instance, may become a threat for some species such as musk oxen (*Ovibos moschatus*) and caribou (*Rangifer tarandus*) (both have already shown extinct subpopulations in the past). It is noteworthy that polar bear (*Ursus maritimus*) hunting by nonlocal people has already increased in the past 30 years.

Climate Change and the Future of Economic Activities

Climate change is accelerated in the Arctic, for example, due to thawing permafrost, methane seepage, and solar reenforcements. The shrinking sea-ice cover will further enhance the accessibility of the Arctic Ocean for shipping and exploration of natural resources (e.g., fisheries, oil and gas) as well as for tourism. Non-Arctic countries already started showing interest in the region (e.g., countries from East Asia). China, for example, may create a new marine route for the transportation industry. This will further increase the anthropogenic pressure on the Arctic ecosystems and confront risks over rights of way. An increase in accessible maritime routes and the risk of invasive species and diseases will keep adding more stress to the Arctic.

Even a quick assessment allows one to conclude that economic growth in the Arctic has already had a significant and negative impact on the ecosystem. Future development will most likely add to these problems, and therefore, better ways for living in, and with, the Arctic need to be found to achieve a sustainable economy in equilibrium with the Arctic ecosystem.

Falk Huettmann and Cynthia Resendiz

See also: Climate Change and Invasive Species in the Arctic; Climate Change and Permafrost; Climate Change in the Arctic; Environmental Concerns, Arctic Mining Operations

Further Reading

Howard, R. *The Arctic Gold Rush: The New Race for Tomorrow's Natural Resources.* New York: Continuum International Publishing Group, 2009.

Sale, R. *The Scramble for the Arctic: Ownership, Exploitation and Conflict in the Far North.* London: Frances Lincoln, 2009.

Ellesmere Island Ice Shelves

Originally, the Ellesmere Ice Shelf (82–83° N 64–90° W) was located from Point Moss to Nansen Sound on the northern coast of Ellesmere Island in Nunavut, Canada. It was called the Ellesmere Ice Shelf because, when discovered, it was a single continuous ice mass. The ice dates from 3,000 to 4,500 years old. In the early 1900s, the Ellesmere Ice Shelf was estimated to cover an area of 3,400 square miles (8,900 sq. km) and be more than 300 miles (500 km) in length. The Ellesmere ice shelf no longer exists as a single continuous ice mass. Over the past hundred years, more than 90 percent of the Ellesmere ice shelf has collapsed and continues to fragment with each passing year.

The first Europeans to explore the Ellesmere ice shelf were those with the British Arctic Expedition (1875–1876) led by Sir George Strong Nares (1831–1915). The focus of the British Arctic Expedition was to explore the Arctic waters, the

Greenland coast, and reach the North Pole. Lieutenant Pelham Aldrich (1844–1930) of the British Arctic Expedition led a team to explore the Ellesmere Island coast. Aldrich's team traversed the northern portion of the Ellesmere ice shelf from Cape Sheridan (82° 28′N 61° 30′W) westward to Cape Alert (82° 16′N 85° 33′W). They explored part of what is now called the Ward Hunt ice shelf. In the summer of 1906, as part of the Robert Edwin Peary Sr. (1856–1920) privately funded expedition, Ross G. Marvin led a team along the entire Ellesmere ice shelf. In the early 1950s, Hattersley-Smith and others investigated and explored the Ellesmere ice shelf.

From 1906 to 1982, the Ellesmere ice shelf shrank by more than 90 percent to just more than 400 square miles (1,043 sq. km). The Ellesmere ice shelf fragmented into the Ayles, Milne, Markham, McClintock, Petersen, Serson (formerly called Alfred Ernest), and Ward Hunt ice shelves. Several of these collapsed during this century. From 1963 to 1968, the McClintock ice shelf completely collapsed. The Ward Hunt ice shelf from 1961 to 1962 lost roughly half of its size (230 square miles [600 sq. km]). This ice shelf lost more than a quarter more of its ice mass from 1967 to 1999.

By the twenty-first century, the remaining Ellesmere ice shelves had shrunk to just under 350 square miles (900 km). The remaining ice shelves were the Ayles, Milne, Markham, Serson, Petersen, and Ward Hunt. In 2005, the Ayles ice shelf calved, drifted to sea, and formed a giant ice island called Ayles Ice Island. The Ayles Ice Island was almost 9 miles (14 km) long and 3 miles (5 km) wide. In 2008, the Markham ice shelf broke from the coast and drifted out to sea. Also in 2008, the Serson ice shelf calved two large sections that broke off and drifted into the Arctic Ocean reducing the ice shelf by 60 percent. Between 2005 and 2008, the Petersen ice shelf had fractured and calved large segments into the Arctic Ocean. In 2002, the Ward ice shelf split into two parts and fractured into multiple parts in 2008. The Ward Hunt ice shelf calved two sections: one being almost 8 square miles (21 sq. km), in 2008, and another measuring 19 square miles (50 sq. km), in 2010. The Ward Hunt ice shelf is still the largest ice shelf of the Ellesmere ice shelves at 130 square miles (340 sq. km). The four remaining ice shelves are the Milne, Serson, Petersen, and Ward Hunt, which account for around 216 square miles (560 sq. km) or about 6.5 percent of its estimated size in 1906.

Andrew J. Hund

See also: Ice Shelf; Ice Worms

Further Reading

Copland, L., D. Mueller, and L. Weir. "Rapid Loss of the Ayles Ice Shelf, Ellesmere Island, Canada." *Geophysical Research Letters* 34, L21501 (2007): Let. 34.

Jeffries, M. "Ellesmere Island Ice Shelves and Ice Islands." *Satellite Image Atlas of Glaciers of the World: Glaciers of North America—Glaciers of Canada*. US Geological Survey Professional Paper 1386-J-1 (2002): J147–J164.

Jeffries, M. "Ice Island Calvings and Ice Shelf Changes, Milne Ice Shelf and Ayles Ice Shelf, Ellesmere Island, N.W.T." *Arctic* 39, no. 1 (1986): 15–19.

Emperor Penguin

The emperor penguin (*Aptenodytes forsteri*) is the largest of all penguins. It is flightless but a proficient swimmer with flippers designed for agility underwater. Emperor penguins can dive to depths up to 1,700 ft. (518 m). They can stay under water for up to 18 minutes. Features that allow this species to survive at such depths include hemoglobin that facilitates activity despite low blood oxygen levels and solid bones necessary for surviving such high water pressure.

As with most penguins, the emperor's plumage is black above and white below. It has a black head and a bicolored bill, the upper mandible being black and the lower largely orange. As with the king penguin, the other member of the *Aptenodytes* genus, the most unique feature is the coloration in the auricular region behind the ear. The emperor has a yellowish tinge that approaches burned orange along the border with the black head; the yellow extends onto the bird's frontal bib. There is no sexual dimorphism in the plumage, although weight varies widely due to the sex of a bird. Adults range from around 3.5 to 4.25 ft. (1–1.30 m) and weigh between 50 and 100 pounds (23–45 kg), making this species the fifth heaviest bird in

Emperor penguin with colony of chicks in the Antarctic. (Shutterstock.com) the world just behind the Ostrich and its cousins. The juvenile plumage is one of few such penguin plumages commonly portrayed in popular culture; it consists of a gray down body, white head, prominent black eye, and black cowl.

Contrary to popular belief, the emperor penguin was not named after Napoleon Bonaparte. It was first described in 1844 by British naturalist George Robert Gray (1808–1872), director of ornithology at the British Museum for more than 40 years. The type specimen was collected as part of James Ross's four-year expedition to chart the entire coastline of the continent. There was some initial confusion over the separation of the emperor from the king penguin, but Gray compared the two and noted the differences. The scientific species name *forsteri* was chosen in honor of Johann Reinhold Forster, who had participated in Captain James Cook's second voyage and had painted the print from which Gray determined the specimen to be a new species. As mitochondrial DNA sequencing revealed much later, both members of the *Aptenodytes* genus are basal species, meaning their evolutionary line branched directly from the main penguin genetic tree, splitting off some 40 mya.

With the exception of a small colony on Dion Island, all of the emperor breeding sites are found on the Antarctic mainland, with most of the colonies found along the Antarctic Peninsula, the western edge of the Ross Sea, and the African quadrant of the East Antarctica coast. Along with the Adélie, the emperor is the only penguin to breed in Antarctica away from the Antarctic Peninsula. Beach-wrecked birds, which are oiled or starving, have been found as far away as South Georgia, New Zealand, and Argentina.

The emperor is the only penguin to breed during the Austral winter, enduring the coldest temperatures of any breeding bird species on earth. To combat the cold, birds have on average one inch of blubber, the densest feather configuration of any species, and an unusually large range of body thermoregulation, whereby the birds are able to keep their metabolism constant despite wide variances in temperature. Unlike other penguin species, emperors nest on the snow and undergo lengthy treks (up to 50 miles [80 km]) to reach breeding areas, attracted to nest sites by vocalizations from their mate. Unlike most other penguins, emperors lay only one egg per breeding season. In *The Worst Journey in the World*, Apsley Cherry-Garrard (1886–1959) of the ill-fated Terra Nova Expedition describes the journey he took with Dr. Edward Wilson to secure an emperor penguin egg during the height of the winter season, as at that point the species was considered a possible evolutionary bridge between birds and reptiles. Describing the harsh conditions, Cherry-Garrard concludes: "I do not believe anybody on Earth has a worse time than an Emperor Penguin."

Due to the effects of climate change, commercial overfishing, and ecotourism, emperor penguin numbers have declined over the past several decades, with a current global population of about 400,000 birds. Noting these factors and declining numbers in most of the 40 or so colonies, the species now carries a status of near threatened. The emperor penguin is one of the more commonly portrayed penguins in popular culture, although many such depictions conflate the emperor with the similar-looking king penguin.

Andrew J. Howe

See also: Adélie Penguin; Chinstrap Penguin; Gentoo Penguin; King Penguin; Macaroni Penguin; Rockhopper Penguin

Further Reading

Burger, J., and M. Gochfeld. "Responses of Emperor Penguins (*Aptenodytes forsteri*) to Encounters with Ecotourists While Commuting to and from Their Breeding Colony." *Polar Biology* 30, no. 10 (2007): 1303–13.

Kooyman G., P. Ponganis, M. Castellini, E. Ponganis, K. Ponganis, P. Thorson, S. Eckert, and Y. LeMaho. "Heart Rates and Swim Speeds of Emperor Penguins Diving under Sea Ice." *Journal of Experimental Biology* 165, no. 1 (1992): 1161–80.

Stonehouse, B. "The Emperor Penguin *Aptenodytes forsteri* Gray I. Breeding Behavior and Development." *Falkland Islands Dependencies Survey Scientific Report* 6 (1953): 1–33.

Enets

The Enets (plural unchanged, sometimes Entsy) are today one of the smallest north Siberian indigenous groups. They live on the Lower Yenisei in the Krasnoyarsk Territory (*krai*). At present, there are two Enets communities left. Forest Enets dwell in the village of Potapovo, which is situated on the eastern bank of the Yenisei River. Tundra Enets live 350 km further north in Vorontsovo near the Yenisei Bay. Some of the Tundra Enets live also west to the Yenisei in the Tukhard tundra.

The name "Enets" was derived from an Enets word *enchi* (man) and was made into an official ethnic label in the 1930s. It was only gradually adopted by the Enets in the 1960s. Earlier in the literature, they were referred to as the Yenisei, Khantai, or Karasin Samoyeds. Until recently, the Enets did not consider themselves as a clear-cut nationality, and they lacked a unifying ethnic name for themselves. Instead, clan names like Madu (Tundra Enets), Bai (Forest Enets), or others were used.

The Enets language is related to two languages, Forest Enets and Tundra Enets. Both belong to the Samoyed branch of the Uralic family, being close to Tundra Nenets and Nganasan. Today, as Enets is not used for everyday communication anymore, nearly all the Enets are more proficient in some other languages than in Enets. According to the latest 2010 census, there are 227 Enets in Russia among whom 43 (19%) have declared to be able to speak Enets. They are all more than 50 years old. The United Nations Educational, Scientific, and Cultural Organization lists the Forest and Tundra Enets language as critically endangered with 20 fluent speaking Forest Enets and 10 Tundra Enets.

In the early seventeenth century, Russian colonizers reached the areas where nomadic Enets lived. They built a town called Mangazeya on the Taz River in 1601. Until 1677, Mangazeya (the name originates from an Enets clan name) served as the most important center for fur tax collection in the region. At this time, the Enets numbered about 3,000, being one of the biggest indigenous peoples in the area. They occupied a large area from the Taz River system to the right bank of the Yenisei. The Russians brought epidemics that decimated the indigenous population, and they forced the Enets' neighbors, such as the Selkup, Evenks, and Nenets, to relocate with some to avoid paying taxes and others to look for better hunting areas and free reindeer pastures. Enets had fierce conflicts with their neighbors but quickly lost ground to them. The Enets either moved further to the east bank of the Yenisei or became assimilated, especially with the eastern Tundra Nenets. The last battle between the Enets and Nenets took place in the mid-nineteenth century on the ice of the Turuchedo Lake near Potapovo. This event stopped the Nenets' eastward advance and is recorded in the Enets oral history.

In the twentieth century, the Enets shared the fate of neighboring indigenous groups by going through Soviet collectivization, which considerably altered property and working regimes as well as social relations in the community. During the Soviet period, the authorities discouraged traditional family-based nomadism. Many Enets families were forced to settle down in villages and a few years later to move from small villages to bigger multiethnic settlements. Today, the Enets live in the villages where other ethnic groups dominate (Russians in Potapovo and Nenets in Vorontsovo). As a result, they take partners from other ethnic groups, and the younger generation has gradually shifted to Russian, and also to Nenets in the north. At present, virtually all Enets children have parents from different ethnic groups, resulting in the Enets having Siberians' highest percentage of mixed marriages.

Before the Soviet period, the main livelihood for the Enets came from fishing and hunting caribou. For hunting, similar to their eastern neighbors the Nganasans, the Enets used domesticated caribou (called reindeer in North America) as decoys to attract the caribou, and also huge nets, bows, and arrows. From the nineteenth century, during hunting parties, they used firearms as well. For trading and paying taxes, the Enets trapped Arctic fox and other fur animals. Trapping remained essential throughout the Soviet period but lost its importance in the 1990s. In the early colonial period, Enets used small domestic reindeer herds mainly for transport but also for getting hides that were irreplaceable for clothing and tent covers in the harsh climate. Influenced by the Nenets, northern Enets started to be engaged in large-scale reindeer herding in the nineteenth century. East to the Yenisei, on the Taimyr Peninsula, reindeer herding disappeared during the late Soviet period due to losing domestic reindeer to the herds of wild reindeer. Reindeer breeding is still the major occupation in the mixed Nenets–Enets groups west to the Yenisei estuary in the Tukhard region. Nowadays, the village Enets live not only from fishing and hunting but also from social allowances.

Despite baptismal campaigns of the Russian Orthodox Church in the tsarist period as well as later antireligious policies in the Soviet period, the Enets' worldview has remained largely animistic, sharing many features with the Nenets' and Nganasans' cosmologies. The cosmos with its various layers are populated by numerous spirits and deities. A variety of taboos, probably the most persistent part in otherwise drastically altered local religion, are still followed by Enets. For the past 80 years, there have not been shamans around, as the last Enets shaman Olkho Bolin died in a prison camp in the 1930s.

Laur Vallikivi

See also: Chukchi; Dolgans; Evenks; Evens; Ket; Khanty; Koryak; Malitsa; Mansi; Nenets; Nganasan; Yukaghir

Further Reading

The Red Book of the Peoples of the Russian Empire. 2001. http://www.eki.ee/books/redbook/index1.shtml. Accessed January 9, 2014.

Thubron, Colin. *In Siberia.* New York: HarperCollins, 1999.

Environmental Concerns, Arctic Mining Operations

For over a decade, a distribution war over the access to and extraction of oil, gas, and mineral resources in the Arctic has been taking place. Presently, the Arctic has a number of projects that claim, explore, and extract these resources (see Table E.1 for a list of selected projects). These Arctic resources are usually found in extreme locations and are considered stranded, which requires them to be connected with markets in populated regions (e.g., located in the EU, Southeast Asia, and coastal North America). The development of these resources for global markets is expensive with a considerable ecological footprint and has an adverse effect on biodiversity in the Arctic. These resource extraction activities are heavily subsidized by governments and usually kept alive for political reasons, for short-term economic gains that tend to benefit just a small group of people. Many of these commodity prizes cannot be relied on for stability. The world has seen many such development exercises though, which failed to deliver and do not serve global well-being.

The environmental concerns and implications of resource extraction projects in the extreme Arctic locations need to be considered, such as, how are they used, by whom, at what cost, who pays for the cleanup, under what economic paradigm and governance, and how much progress is provided for global sustainability overall. So far, none of these questions are really clear, resolved, or agreed on. The historical and current global arrangements are not based on future generations' benefit or welfare. That is because when all knowledge is taken together, any resource extraction in the polar regions still is very risky, is costly, and usually presents us with a sustainability sink. Mining and gas and oil are usually not a sustainable resource but just a one-off.

The polar regions are fragile and are not really intended for intensive use. Arctic indigenous populations lived thousands of years in harmony and virtually never destroyed the ecosystem or caused a global (atmospheric) footprint. This destructive legacy has been primarily brought about by the new Western society, which has lost most taboos (the new free markets allow for virtually all and everything, even when it is very destructive to the earth and atmosphere).

Right from its inception, industrialization had ongoing riots, environmental destruction, and human suffering. Examples include the first automated looms in Poland ("weavers" described by H. Heine, 1846, as a nationally acclaimed piece of literature), large-scale industrialization process in the United Kingdom (see classic descriptions by C. Dickens, 1999), rubber extraction from Amazonia (see Revkin, 1994), and various mining activities (see Henton and Flower, 2007, and Resendiz, 2012). Director James Cameron's 2009 film *Avatar* is a suitable visual representation for these activities in extreme Arctic locations.

With the fall of communism, there was the big hope that the neoclassic economy, U.S. style capitalism, would trump all and provide sustainability and well-being for everybody, even in the Arctic and in all of the polar regions. But after 30 years, we must admit that we are far from such goals. Some scholars note that it is better to leave fossil fuel in the ground.

With industrialization and resource extraction either already ongoing or planned, the state of the Arctic regions shows us that their economies are far from being stable or sustainable (see various economic crashes in Iceland, Alaska, United States, United Kingdom, and Russia). The human aspect of resource extraction creates additional problems, such as human rights violations, accusations of genocide, and elevated suicide rates and drug addiction rates among the population in some Arctic villages. The legacy of globalization in the Arctic and the free market economy creates many social problems that are not stabilizing any time soon. Presently, the current industrial society, lifestyle, and consumption must be seen as the major culprit for social and economic decay, as well as for the wholesale environmental destruction of the fragile Arctic locations, its atmosphere, and society. It represents a fundamental policy failure and a lack of respect toward mankind. This is well described and can be seen worldwide now. Consequently, a change of this framework and its actors is required if we care about the polar regions or, for that matter, the world.

Falk Huettmann

See also: Economic Growth in the Changing Arctic

Table 1 Selected mega projects for resource extraction in (sub) Arctic regions; for instance, many of these projects are fueled by an outside demand from China and India.

Project Name	Location	Resource
Red Dog Mine	Alaska	Zinc–lead
Isua project	Greenland	Uranium and iron
Snovhit [Snow White] offshore	Norway	Natural gas
Obed Mountain Mine	Canada	Coal
Baffin Island Iron Mine	Canada	Iron
Labrador Iron Mines	Canada	Iron ore
Avalon Rare Metal's Nechalacho Mine	Canada	Rare earths
Alcoa smelter	Iceland	Bauxite (smelter)
Northern Dreki area offshore	Jan Mayen	Hydrocarbon
Mirny Mine	Russia	Diamonds
Talvivaara Mine	Finland	Nickel and zinc

Further Reading

Butt, N., H. Beyer, J. Bennett, D. Biggs, R. Maggini, M. Mills, A. Renwick, L. Seabrook, and H. Possingham. "Biodiversity Risks from Fossil Fuel Extraction." *Science* 342, no. 6157 (October 25, 2013): 425–26.

Dickens, Charles. *Oliver Twist.* Oxford: Oxford University Press, 1999.

Glornsrod, S., and I. Aslakseneds. *The Economy of the North.* Oslo: Statistics Norway, 2006.

Heine, H. *Die schlesischen Weber*. 1st ed. Borna, Germany: Reiche publisher, 1846.

Henton, D., and A. Flower. "Mount Kare Gold Rush: Papua New Guinea 1988–1994, as Told by Andi Flower." *Mt Kare Gold Rush*. Self-Published, Queensland, Australia, 2007.

Huettmann, F. "From Europe to North America into the World and Atmosphere: A Short Review of Global Footprints and Their Impacts and Predictions." *Environmentalist* 32(3) (2011): 289–295.

Humphries, G., and F. Huettmann (with a contribution from E. Woehler). "Global Issues for, and Profiles of, Arctic Seabird Protection: Effects of Big Oil, New Shipping Lanes, Shifting Baselines, and Climate Change." In F. Huettmann, ed. *Protection of the Three Poles.* Tokyo: Springer, 2012, pp. 217–45.

Kongsvinger Resendiz. Meta-Analysis on the Effects of Global Economic Growth on Birds in the Nations of the Three Poles. Master Thesis MINC program. Georg-August University, Germany, 2012.

Revkin, A. *The Burning Season*. New York: Plume Publisher, 1994.

Eskimo Coast Disaster of 1885

The North is not usually associated with hurricanes, but, as the following telegram from a fish firm's Labrador-based agent demonstrates, a particularly cruel hurricane event devastated the Eskimo Coast of Labrador in 1885. The telegram stated as follows:

> SOME TWENTY-NINE VESSELS LOST FROM CAPE CHARLES TO INDIAN TICKLE. *EXCEL* LOST AT BLACK ISLAND, WHERE TWENTY-ONE OF HER CREW PERISHED. *IAMAWAY* A TOTAL WRECK. *AUGUSTA OF BRIXHAM* WITH 3700 QUINTALS FISH A TOTAL LOSS. *BRUNDETT* ASHORE, STERN OUT AND RUDDER BROKEN . . . *PRINCE* RODE OUT THE GALE IN GRADY . . . *FLORA* AND *LEOPARD* TOTAL LOSS. *GENERAL GORDON* AT SOUTHEAST COAST DISMASTED . . . ANOTHER THERE DISMASTED, LEAVING 180 SOULS ON DUMPLING ISLAND WITH SCARCELY ANYTHING TO EAT AND ALL TRYING TO GET TO GRADY . . .

The eventual losses were much worse than the merchant's agent R. D. McRae had indicated to his employers in this telegram. No fewer than 66 ships were wrecked, and more than 70 people died, many of them women and children. Most of the dead had been on the *Release*, the *Excel*, or the *Hope*, all of which were moored off White Bear Island near Groswater Bay. Nine people on the *Village Belle* were lost at Domino, while two from the *Gleaner* died at Mark's Harbor.

The victims from the *Village Belle* were British as the seasonal Labrador fishery attracted vessels from Britain, the United States, and Canada as well as Newfoundland, from where the bulk of the fishermen came. The stationing Newfoundland fishermen brought their families each year, engaging their wives and children in curing fish, preparing meals, and growing root crops. Men, women, and children traveled in ships' holds with their pots, pans, goats, and hut windows pressing in on them. In such conditions, "decency is impossible and vice is flagrant," wrote one observer. The *St. John's Mercury* chimed in, labeling the system "a blot on Christianity" while Montreal's *True Witness* went further, referring to the women and children as "the white slaves of Labrador." The contemporary moral bent of the commentary aside, *True Witness* rightfully condemned the dangerous habit of cluttering up the hatch with puncheons, casks, and punts.

Thus, so many women and children were trapped when the October 19 gale whipped the ships around; regardless, their chances of surviving the Labrador Sea were slim. Captain William Bartlett of Brigus, Newfoundland, father of the celebrated Captain Robert Abram Bartlett, emerged as a hero of the tragedy. In the *Panther*, he picked up victims all along the coast, cramming over 400 onboard and bringing them safely home.

The loss of so many ships and the summer catch, totaling at least $250,000 in 1885 dollars, pushed some of the fish firms into precariousness. The Tessiers of St. John's lost eight ships, leading the firm's English owner to remark, accurately, "I won't live another year." In some measure, the Eskimo Coast disaster contributed to Newfoundland's 1894 bank crash and the collapse of some of the major fish firms.

In 1892, legislation mandated separate shipboard accommodation for men and women, but the new law was not enforced until a decade later. The Labrador fishery continued in almost steady decline until Canada's 1992 groundfish moratoria.

Maura Hanrahan

See also: Eskimo Coast Disaster of 1885; Lost Patrol; Thule Air Base, Greenland, B52G Stratofortress Crash of 1968; Whaling Fleet Disaster of 1871

Further Reading

Hanrahan, Maura. *Domino: The Eskimo Coast Disaster.* St. John's, Canada: Flanker Press, 2006.

Eskimo/Inuit Communal Houses

Northern indigenous cultures made use of semi-subterranean communal houses. The name of the communal house changed between cultures. For example, the Yup'ik called the communal house a "qasgiq," the Inupiat called it a "qargi," and the Russians called them "kashim." In the Eskimo/Inuit cultures, the qasgiq/qargi was predominately a men's gathering place and a community house used mostly during the winter. During the summer months, the Eskimo/Inuit people would gather food for the winter and did not have time to participate in leisure activities. Each man had a position or spot in the qasgiq/qargi, which was a reflection of a man's position within the communal social structure. The social structure mirrored that of the natural world with those being higher on the social ladder receiving the better position in the qasgiq/qargi. The men of the village would gather in the qasgiq/qargi to build boats, repair equipment, socialize, sleep, eat, and bath. The qasgiq/qargi was a main hub for male social and cultural activities of a Inupiat or Yup'ik village. The qasgiq was commonly constructed out of wood or bowhead whale bones for the structure and sod for the roof. Normally, the qasgiq/qargi was not decorated.

During the winter, community ceremonies, festivals, and meetings were held at the qasgiq/qargi. The shaman would also participate in the ceremonies. The Inupiat or Yup'ik would wear their traditional garments called a "kuspuk," which is a light fabric parka-type outfit that is worn in causal and formal gatherings. The qasgiq/qargi would be elaborately decorated during these activities, which included craved masks, ceiling hoops, and drums with painted imagery that told various traditional stories. The decorations embodied the Inupiat or Yup'ik spiritual and cultural way of life, which embraced unity with nature.

At the village gatherings and celebrations, entertainment would include singing, dancing, and storytelling. The dancing and storytelling are still practiced today throughout the state of Alaska and beyond. The qasgiq/qargi was also a school for young boys (after age five) where they could learn the art and craft of Inupiat or Yup'ik mask making, tool making, and kayak construction. It was also a place for learning hunting and fishing skills.

In the Yup'ik culture, women also had a community house of their own, which was adjacent to the men's qasgiq. The women's communal house was called the "ena." Depending on the village, qasgiq and ena communal houses were connected by a tunnel. In other villages, they were not connected. Boys were allowed to move into the qasgiq around the age of 10 years. The ena was also a school for young girls where they could learn the art and craft of sewing and weaving, food preparation, and so on. As part of the schooling, it was customary for the boys and girls to switch communal houses for a couple of weeks to learn the opposite gender's arts, crafts, and skills.

Andrew J. Hund

See also: Eskimos; Siberian Yup'ik

Further Reading

Burch, E. *The Eskimos.* Norman: University of Oklahoma Press, 1988.

Kawagley, A. *A Yupiaq World View.* Prospect Heights, IL: Waveland Press Inc., 1995.

Steckley, J. *White Lies about the Inuit.* Toronto: University of Toronto Press, 2007.

Eskimos

The term "Eskimo" has different meanings depending on one's perspective. In Greenland, Nunavut, Northwest Territories, Yukon, and northwest Siberia, the groups use Inuit to describe their groups and to use the term "Eskimo" can be considered offensive. The term "Eskimo" is still used in Alaska, without it being viewed as a pejorative. The word "Eskimo" is thought to originate with the Cree Natives. The Cree were traditionally rivals with the Arctic or Northern Native tribes. The Cree Native word "Eskimo" means eaters of raw meat and was originally meant to be a derogatory name. Others claim the name "Eskimo" is honorary because the eating of raw meat provided the Natives with high doses of vitamin C, which prevented adverse health conditions, such as scurvy.

Alaska Subgroups (Inupiat and Yup'ik)

In North America, there are two main groups of Eskimos (Yup'ik and Inupiat [Inupaiq]), with many subgroups. The Yup'ik group is further divided into three groups, which are the Central Yup'ik, the Alutiiq (frequently referred to as the

Rear Admiral Harley Nygren with a group of Eskimos at Brownlow Point during a 1949 expedition. (National Oceanic and Atmospheric Administration)

Chugach or Sugpiaq), and the Siberian Yup'ik (mostly found in Russia, but a small group lives on St. Lawrence Island, Alaska). The Inupiaq live above the Arctic Circle, while the Yup'ik live on the Yukon-Kuskoquim delta on the southwestern side of the state of Alaska. The Inupiat group of Alaska can be divided into four communities, which are the Bering Strait, Kotzebue Sound, North Alaska Coast (called the "Tareumiut," which means "people of the sea"), and Interior North Inupiat. These Eskimo groups are mostly found on the coastal areas and are predominately an ocean-based culture. There are inland groups of Eskimos on the Yukon-Kuskoquim delta and in the northwest region of Alaska.

Population

Alaska Native population based on self-identification with one group is at approximately 99,000 as of 2010 census. The total Alaska Native population is estimated at approximately 140,000, including bi- or multirace/ethnicity groupings. Just under half of Alaskan Natives in the state of Alaska live in rural or remote areas. The two Eskimo groups account for 48 percent of the Alaska Native population in Alaska. The Yup'ik population is about 34,000, and the Inupiat are about 33,000.

The Yup'ik

The name "Yup'ik" is broken down into two parts to derive its meaning. In the Yup'ik language, *yuk* means a "person" and *pik* means "real." Thus, to the translations of Yup'ik to English would be roughly the equivalent of "real people." Until the middle of the twentieth century, the Yup'ik were a nomadic group that followed the food sources with the change of seasons. For example, in the spring, summer, and early fall, the Yup'ik would travel to fish camps and harvest salmon. The salmon would be smoked and dried to preservation for food throughout the winter. During other times of the year, seals, moose, bears, and caribou would be harvested for food. Many of these traditional food-gathering activities persist today.

Yup'ik Subgroups

The three main Yup'ik groups have occupied specific areas in Alaska. The Alutiig group (commonly called the Sugpiaq) lives in the Alaska Peninsula (called the Kenai Peninsula in Alaska) near the Prince William Sound to the beginning of the Aleutian Islands. The neighboring groups to the East are the Eyak, to the West are the Central Yup'ik, and to the South are the Unangax (Aleuts). The Alutiig live in the coastal areas and a few of the islands in this region. Over the years, the Alutiig have territory disputes with the Eyak and Unangax as well as the early Russian explorers and fur traders.

The Central Yup'ik group is located on the Yukon-Kuskoquim delta and along the Kuskoquim River basin that runs along the Bristol Bay coast. To the east, the Central Yup'ik territory stretches as far east as Nushagak Bay and the Naukan River near the traditional lands of the Alutiig. To the west, the traditional lands of the Central Yup'ik extend to the Bering Sea and to north to the traditional lands of the Inupiat. The Siberian Yup'ik within Alaska territory are found on St. Lawrence Island.

Yup'ik Languages

The Yup'ik language is one branch of the Eskimo-Aleut family. It is estimated that there are about 13,000 people who speak the Yup'ik languages. Most of the Yup'ik languages are consider endangered and/or near extinct, with the Central Alaskan Yup'ik being the least threatened. The Yup'ik language is divided into five main dialects: Alutiiq, Central Alaskan Yup'ik, Central Siberian Yup'ik, Naukan Yup'ik, and Sirenik. There are fewer than a 1,000 speakers of the Alutiig or Sugpiaq language and two dialects of the Konaig and Chugach. Speakers of the Central Alaskan Yup'ik language are estimated at more than 10,000 speakers with several dialects of the Yugtun (most common), Hooper Bay/Chevak, Norton Sound, and Cup'ik (spoken mostly on Nunivak Island). The Central Siberian Yup'ik is spoken mostly in the Russian Far East, but the Yup'ik on St. Lawrence Island speak a St. Lawrence dialect. There are approximately 200 St. Lawrence dialect speakers. The Naukan or Naukanski speakers are estimated at fewer than 100 speakers, and many of these speakers live in the Russian Far East. The Sirenik dialect became extinct in 1997.

Inupiat

The Inupiat of the Northwest Arctic region live above the Yukon-Kuskoquim delta to across the North Slope region in and above the Brooks-British range. The Athabaskan groups border the south. To the west, the Inupiat are bordered by the Bering Strait all the way down to the Seward Peninsula. The Inupiat subgroups are based on the region they have been traditionally located. These groups are the Bering Strait Inupiat, the Kotzebue Sound Inupiat, the Interior North Inupiat, and the Tareumuit or more commonly called the North Alaska Coast Inupiat.

The Inupiaq, like the Yup'ik, have traditionally relied on subsistence hunting and fishing. The Inupiat are expert marine mammal hunters, including such mammals as whales, walrus, seals, and various fish species (i.e., burbot, halibut, salmon, etc.). The harvesting of a whale was led by a whale crew that used a skin boat. The whale was harvested and used by the whole community. The distribution of the whale was based on traditional method of sharing. The whale was allocated to members based on a formula that ensured everyone received an adequate portion. The oil from the whale was used for eating, heating, and cooking. A common food of the bowhead whale is Maktak, which is a small strip of whale skin and blubber that is nutritious and high in vitamins A and C.

Inupiaq Language

The traditional language of the Inupiat is called "Inupiaq." The Inupiaq language is one branch of the Eskimo-Aleut family. It is estimated that there are about 2,000 people who speak the Inupiaq languages. The Inupiaq language is considered endangered and/or near extinct. Speakers of the Inupiaq are referred to as the Inupiat. The Inupiaq language is divided into two main dialects: Seward Peninsula Inupiat and the Northern Alaskan Inupiat. Each of these dialects has two subdialects. The Seward Peninsula Inupiat language subdialects are the Bering Strait and Qawiaraq. The subdialects are found in specific geographic locations. The Bering Strait subdialect is spoken in villages that are north of Nome, Alaska, such as Diomede, King Island, and Wales. The Qawiaraq subdialect is spoken in the villages south of Nome, Alaska, such as Fish River, Teller, and Unalakleet. The Northern Alaskan Inupiaq language subdialects are the Malimiutun and North Slope. Like the Seward Peninsula Inupiaq language, the Northern Alaskan Inupiaq language and subdialects are spoken in specific geographic locations.

The Malimiutun is spoken in the villages in and near Kobuk and Kotzebue, while the North Slope subdialect is spoken in or near the villages of Anaktuvuk Pass, Kivalina, and Uummarmiutun.

Alaska Native Claims Settlement Act

As part of an ongoing land dispute and the discovery of oil in Prudhoe Bay off the Arctic coast of Alaska, the U.S. Congress created the Alaska Native Claims Settlement Act (ANCSA). The act was a settlement that abolished Alaskan Native claims to their traditional lands in exchange for $963 million and 44 million acres (17.8 million hectares). ANSCA compensated Alaskan Natives for the collaborative use of their lands and resulted in the creation of 13 regional and at least 220 federally recognized Alaska Native Villages, 5 unrecognized Tlingit tribes, and multiple tribes that lack federal recognition. The two Eskimo groups of Alaska were distributed into all the Native corporations, but a significant number of Inupiat shareholders are enrolled in the Arctic Slope Regional Corporation, the Bering Straits Native Corporation, and the NANA Regional Corporation, Inc. The Yup'ik shareholders are enrolled in the Bristol Bay Native Corporation, the Calista Corporation, the Chugach Alaska Corporation, the Doyon Ltd., and the Koniag, Inc. Also, under ANCSA, the Eskimo group members were also enrolled in one of approximately 220 village corporations.

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See also: Chukchi; Dolgans; Enets; Evenks; Evens; Eyak; Inuit; Inuit and Yup'ik Concepts of "Ihuma" and "Qanruyutet"; Inuit Concepts of "Naklik" and "Ilira"; Inuit Contribution to Polar Exploration; Inuit Lawsuits over Climate Change; Inuit Worldviews and Religious Beliefs; Ket; Khanty; Koryak; Mansi; Migration Waves of the Eskimo-Aleut; Nenets; Nganasan; Selkup; Siberian Yup'ik; Thule Culture; Yukaghir

Further Reading

Dahl, J. *Saqqaq: An Inuit Hunting Community in the Modern World*. Toronto: University of Toronto Press, 2000.

Steckley, J. *White Lies about the Inuit*. Toronto: University of Toronto Press, 2007.

Stern, P., and L. Stevenson. *Critical Inuit Studies: An Anthology of Contemporary Arctic Ethnography*. Lincoln: University of Nebraska Press, 2006.

Evenks

The Evenks are also called the Evenki or Ewenki. They were formerly known as the "Tungus" in pre-Soviet times. Historically, the Evenks have migrated and inhabited an area of around 970,000 square miles (2,500,000 sq. km) from the Ob River (west), to the Sea of Okhotsk (east), to the marginal seas of the Arctic Ocean (Kara, Laptev, and East Siberian Seas) (north), to the Baikal region near the modern-day Mongolian border (south). The Evenks have inhabited this area since Neolithic times. Presently, there is more than 65,000 Evenks spread across Russia (35,000), China (30,000), and Ukraine (fewer than 100). There are fewer than 1,000 Evenki in Mongolia, which the Mongols call "Khamnigan." More than half of the Russian Evenks live in the Sakha (Yakutia) Republic of the Russian Federation. They are also found in Amur Oblast, Evenkia, Irkutsk Oblast, Khabarovsk Krai, Krasnoyarsk Krai, Republic of Buryatia, Sakhalin Oblast, Tomsk Oblast, Tyumen Oblast, and Zabaykalsky Krai. In these administrative districts, the Evenki are a minority.

A young Evenk sits in a tent, July 17, 2010, in Ulan-Ude, Buryatia, Russia, at the Fourth General Session of the World Mongolians Convention. (Shutterstock.com)

Language

The Evenks language is classified as Northern Tungusic and includes the Even, Negidals, and Udege. The language group is historically linked to the Turkic and Mongolic languages of the Altaic family that originates out of the Altai Mountain region. Some have suggested that the Tungusic languages may be connected to Korean, Japanese, and/or Ainu languages. The Evenki language is currently taught in schools with local Evenki populations. The United Nations Educational, Scientific, and Cultural Organization lists the Evenks language as severely endangered with fewer than 7,500 fluent speakers.

History

Based on archeological evidence, the Evenks originate from the ancient Paleo-Siberian people of the Transbaikal area east of Baikal Lake. The Evenks of the Baikal Lake region are believed to have migrated up the Lena River and Yenisey River basins over the past couple of hundred years. The Evenki also migrated along the Amur River to the Sea of Okhotsk. The migration resulted in the Evenki mixing with northern groups as well as at times taking over their territories. The Evenki are considered culturally similar to the Evens and Yukaghirs. The northern Evenki group had established reindeer herding by 1600, while the southern Evenki group raised horses.

Evenks' contact with the Russians started in the seventeenth century. After contact, the Evenks were exploited by the Cossacks who forced a fur tax on the Evenki and other Siberian indigenous groups. A common practice of the Cossacks was to capture the clan leader and hold them for ransom in the form of a tax payment for their return. The treatment by the Russians resulted in the Evenki migrating as far east as Sakhalin Island (51° N 143° E) and south into Northeast China and Mongolia.

Subsistence

Subsistence activities differ between the northern and southern groups. The northern groups are mostly seasonal fishing and hunter/gathers. Commonly hunted animals included moose, bear, fox, caribou, and roe deer. This group also raised and domesticated reindeer and used them for transportation, decoys for caribou hunts, and milk. The Evenks did not eat their domesticated reindeer. The southern groups raise horses and cattle. The coastal Evenki are primarily fishermen and hunted marine mammals, such as seals. Western food, such as flour, sugar, and so on, was introduced to the Evenks by the Russians in the late 1500s.

Traditionally, the Evenks were nomadic and lived in the boreal forest. The migration patterns coincided with the caribou, fish spawning, and weather conditions. Their preferred structure was a tepee supported by birch poles and covered by reindeer skins and birch bark. During the winter, Evenki participated in group hunting parties. These hunting tents were configured in a circle. When breaking up camp, the Evenki left the birch poles and carried only the coverings.

Traditional hunting gear included bow and arrows, crossbows, traps, knife called a "pike," and a spear. With the introduction of firearms, the use of traditional hunting gear was reduced. Hunting strategies included pursuit of game on skis, using dogs to chase; herding caribou into deadfall pits, fenced area, netting them, and/or finding river crossing bottlenecks; using reindeer as decoys, and hunting from a hideout.

The Evenks used their reindeer for transportation, hauling, and pulling sledges. When riding the reindeer, the Evenki fitted them with a distinctive saddle that set on their shoulders. The saddle did not have stirrups, and to maintain their balance, the Evenki used a stick. Other forms of transportation were by foot, snowshoes, or skis.

The Evenks clothing was adapted to life in the Arctic climate. Winter clothing was made from reindeer and moose skins, while summer clothing was made from cloth. Undergarments were loincloths made of subadult reindeer skin. Outfits included leggings and various length boots. Both genders wore open caftan that had two pleats in the back for riding reindeer. The caftan was closed in the front by an apron with strings in the back. The outfit included a belt, sheath and knife, and taut cap made from the skin of the reindeer's head. Clothing was decorated with various natural materials. Tattooing on the Evenks faces was common.

Social Organization

The social organization of the Evenki was largely male dominated (patriarchal), especially in the family unit. However, elder women participated as part of the clan member's decision-making process. A clan could be up to 100 people and were typically named after a common ancestor. The main leader of the clan could be an esteemed elder, hunter, warrior, or shaman. The Evenki-practiced marriage was within the group (endogamy), and out-group marriage was considered taboo.

Belief System

The Evenks belief system was that all natural things (animate and inanimate) have a spirit (i.e., an animistic worldview) and must be respected as a living being. Under this worldview, it is taboo to disrespect nature. The arrival of the Russia Orthodox church had limited influence on the Evenks' worldview. They incorporated some Christian views but largely maintained their traditional beliefs, totemistic concepts,

EVENKS' TWO BROTHERS' CREATION STORY OF THE WORLD

The creation of the world as told by the Evenks has been passed down through generations. Oral history maintains that prior to the earth being in its present form, there were two brothers. The oldest brother was considered to be evil, while the younger brother was considered to be good and virtuous. The older brother lived in the top of the world, while the younger brother lived in the bottom of the world. The two brothers were separated by water. The younger brother became a master of spirits and had two spirit helpers that lived in the water. These spirit animals were depicted as the loon and the golden-eye duck in most accounts. These helpers swam in the waters between the two worlds of the brothers. Both of the younger brother's helpers were diving birds. One day, the golden-eye duck dove down and brought back the earth in its beak. The earth was then placed on the surface of the water. With the new world, the two brothers started to create. The younger brother created people out of clay. He also created animals that were good and allowed people to take them as food. The older brother created animals that were useless, harmful, or dangerous to humans. Other accounts of the creation story depict the younger brother's helper spirits as either a dog or a raven. Both of these helpers bring the earth to the water's surface.

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rituals, and beliefs of different worlds, shamans, and shamanism. The different worlds were the spirit, present, and upper worlds. Under Christianity, the upper world became the domain of St. Nicholas. The power of the shamans as being intermediaries or mediums between the present and spirit worlds was maintained under Christianity.

Shamans

Shamans were the protectors of the Evenks from the harmful elements. The shamans were able to fly in, around, and between worlds in the form of animals and ancestral spirits. Evenks shamans had the ability to cure people of illness (by removing the evil spirit), facilitate childbirth, ensure successful hunts, locate hidden or lost items, and see into the future. They also guided the dead on their journey beyond. Shamans had assistants that lived in a river. Evenks shamans grew their hair long and left it unkempt. Evenki shamans' outfits were more elaborately decorated than Evenks' outfits and typically incorporated symbols of flight. For rituals into the spirit world, the Evenki shaman sat on white fur blanket, covered their face with a painted mask, used a rattle, and drummed a charm-covered reindeer-skin tambourine. The ritual and travels to the spirit world could last for several days. In Siberia, the Tungus shamans were considered powerful resulting in nearby indigenous peoples seeking their assistance.

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See also: Chukchi; Dolgans; Enets; Eskimos; Evens; Eyak; Inuit; Ket; Khanty; Koryak; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Anderson, D. "Is Siberian Reindeer Herding in Crisis? Living with Reindeer Fifteen Years after the End of State Socialism." *Nomadic Peoples* NS 10, no. 2 (2006): 87–103.

Fondahl, G. *Gaining Ground? Evenkis, Land and Reform in Southeastern Siberia.* Boston: Allyn and Bacon, 1998.

Vitebsky, Piers. *Reindeer People: Living with Animals and Spirits in Siberia.* Boston: Houghton Mifflin, 2005.

Evens

The Evens, formerly known as "Lamuts" (meaning "seaside inhabitants") in the ethnographic literature, are a small Tungusic people who live in the Kamchatka Peninsula, in the Magadan Oblast, in Chukotka, and in the Sacha Republic of the Russian Federation. Small groups of Evens are scattered over a vast territory, which stretches from the Lena River (west) to the Sea of Okhotsk and Central Kamchatka (east). In 1926, their population was around 2,100 persons, but some scholars maintain that many Evens were grouped among the Evenks to whom they are closely related and that the actual figure at that time should have been closer to 7,000. According to the latest Russian census (2010), the Evens total around 22,000 persons.

Tsarist Russian contact with the Evens began in the sixteenth century. On the Kamchatka Peninsula, the Evens did not appear earlier than the beginning of the nineteenth century. Ethnographic data have been gathered by, among others, Dutch geographer Nicolaas Witzen (1641–1717) in the 1660s, Russian explorer Stepan Petrovich Krasheninnikov (1711–1755) in the 1730s, Swedish Russian interpreter Jakob Lindenau in the 1740s, German explorer Peter Simon Pallas in the 1760s, Russian ethnographer Vladimir G. Bogoras in 1895, Norwegian oceanographer Harald Sverdrup in 1919–1920, Swedish zoologist Sten Bergman in the early 1920s, Soviet ethnographer M. G. Levin in the 1930s onward, British anthropologist Piers Vitebsky in the 1980s, Japanese anthropologist Hiroki Takakura in the 1990s, and most recently German ethnographer Katharina Gernet. After the breakup of the Soviet Union, there has been an increased research interest among foreign and Russian scholars.

Traditionally, the Evens have supported themselves as taiga hunters and fishermen. In addition to fur-bearing animals (ermine, foxes, sable, squirrel, wolverine), moose, wild reindeer, mountain sheep, and bear are hunted. Fishing and sealing are important sources of livelihood for the Evens living on the Okhotsk coast. Especially in Kamchatka, some have been reindeer herders supplemented with hunting and fishing. There is still at least one Even reindeer herd around the rural setting Esso. Berries (cloudberry, cowberry, and bilberry) have been important as food. Also the starchy bulbs of *Fritillaria camschatcensis* have been and are still gathered by the Evens in Kamchatka.

In the late nineteenth century, they were nominally Christianized by Russian Orthodox missionaries, but native religion has survived until today. Collectivization began in the late 1920s, and the hunters and nomads were forced to settle. However, some Evens avoided the process for years by distancing themselves from administrative centers. After the Soviet breakup, some Evens have organized to protect their traditional reindeer and hunting activities. Cultural revivalism and ethnic unification have been complicated by the fact that contacts with the highly dispersed Evens are still very limited due to the lack of infrastructure. On the Kamchatka Peninsula, there is a small adventure tourism industry, which nowadays affects the Evens.

Language

The Even language belongs to the Northern Tungusic branch of the Altaic languages. Linguistically, the Evens are divided into the eastern dialect, which is spoken on Kamchatka, while the western is used by the Evens in the Sacha Republic. A dialect spoken in Magadan forms the basis for the written language created in 1932. Very few books exist in the Even language, and Russian and Sacha are used as the language of instruction. The United Nations Educational, Scientific, and Cultural Organization lists the Even language as severely endangered with 7,168 fluent speakers. It has some official recognition in the Sacha republic, but still very little is done to protect the language for the future. Scholarly dictionaries, grammars, and folklore texts have been published by Vera I. Cincius (1947, 1958), Johannes Benzing (1955), Gerhard Doerfer (1980, 2011), and Klavdiya A. Novikova (1960, 1968, 1991), but the language remains very little studied.

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See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Eyak; Inuit; Ket; Khanty; Koryak; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Bogoras, W. *Tales of Yukaghir, Lamut, and Russionized Natives of Eastern Siberia*. New York: The Trustees, 1918.

Lindin, L., and I. Svanberg. "Traditional Reindeer Husbandry among the Evens of Kamchatka in the Beginning of the 1920's." In H. Beach, ed. *Contributions to Circumpolar Studies*. Uppsala: University of Uppsala, 1986.

Sverdrup, H. *Among the Tundra People.* La Jolla, CA: Scripps Institution of Oceanography, 1978.

Vitebsky, P. *Reindeer People: Living with Animals and Spirits in Siberia*. London: HarperCollins, 2005.

Eyak

The Eyak are considered an endangered people. There are about 100 Eyak, presently. The Eyak, however, have historically been a small group, due to intermittent raids by the Tlingit, Alutiiq, and Russians and periodic infectious disease outbreaks in the past. The last full-blooded Eyak who fluently spoke the Eyak language was Chief Marie Smith-Jones (1918–2008), who passed away on January 21, 2008.

The Eyak were part of the second migration wave that crossed the Bering Land Bridge from Siberia around 10,500–9000 BP. This group was the Na-Dene people or Athabaskans. The Eyak are direct descendants of the Na-Dene as are the other culturally distinct Athabaskans. Oral history of Anne Nelson Harry notes that the Eyak "came from far upriver, in boats made of something like cottonwood" (Krause 1982: 152).

The Eyak have historically inhabited the area in between three converging tribes: the Alutiiq (west), the Ahtna (north), and the Tlingit (east). Various rivers, glaciers, mountains, and the Pacific Ocean have separated the Eyak from their neighbors. The borders with the Alutiiq had been as far westward as Simpson Bay in the Prince William Sound, and seasonally the Eyak would travel to Alutiiq territories, such as Egg Island, Hawkins Island, and Strawberry Point and Nuchek on Hinchinbrook Island. The long-standing boundary with the Ahtna was the Childs and Miles Glaciers. The boundaries between the Eyak and the Tlingit have changed throughout time.

The primary settlements of the Eyak were the villages of Alaganik and Eyak. Alaganik is located near Mile 21 of the Copper River Highway, while Eyak village is located 8 miles west of the mouth of the Copper River. There were also several other Eyak settlements: Glacatl, Bering, Yakutat, Icy Bay, Cape Yakataga, Cape Suckling, and Katalla. Glacatl has commonly been mistaken as Eyak village in population and research studies. This site later became a Russian post and was located on the western side of Eyak River approximately 1.5 mile below the Eyak village, which is on the eastern side. Bering Village was located east of Cape Martin and inland from Kanak Island. This group was referred to as the Tlingitized-Eyak.

During the 1700–1800s, the Eyak were progressively migrating westward toward the Copper River Delta. The exact reason for this migration is not known, but some researchers have speculated that the Tlingit conquered the Eyak and others have reasoned that the Eyak were absorbed into the Tlingit moiety system. The Eyak and Tlingitized-Eyak fought with the Russian explorers. For example, the Eyak attacked Baranov's crew in the Prince William Sound in 1792, overwhelmed the Russians and their Native Alaskan slaves at Cape Suckling, in 1799, and directed an assault on a Yakutat colony. These attacks resulted in the Russians retaliating by raiding their villages where many Eyak and Tlingit were captured, tortured, and killed.

Through the 1800s–1900s, the Eyak land area was diminishing as was the population. Much of the early population loss was due to famine, epidemics, and war, all of which are related to Russian activities. Famine was the result of the overharvesting of edible food and sometimes the result of the enslavement of the Eyak (i.e., the Russian will take certain individuals prisoners and force the community to buying them back with food or pelts—hold them for ransom). In 1803, the Tlingit and suspected Tlingitized-Eyak burned down the Sitka fort named New Archangel. The Russians retaliated through a series of raids. The 1837–1838 smallpox epidemic took half of the Eyak population. In 1892, Alaganik was abandoned due to a severe measles outbreak. By 1900, Alaganik, Eyak, and Glacatl villages were abandoned because of epidemics, and the surviving Eyak moved to Old Town, near the fishing cannery Odiak and modern-day Cordova.

The 1900s to present saw a further waning of the Eyak population and culture. The abandoned Alaganik was destroyed when train tracks were placed on top of the village to link the Kennecott copper mine to Cordova around 1908. By 1933, there were 38 known Eyak. Much of what is known about the Eyak is from the 1938 work of Frederica De Laguna and Kaj Birket-Smith, who wrote the only comprehensive work on the Eyak titled "The Eyak Indians of the Copper River Delta, Alaska." By 1952, there were only seven native speakers when the first linguist reached the Eyak.

In 1971, the Native Village of Eyak Traditional Council and the Eyak people were federally recognized, within the City of Cordova. With the acceptance of the Alaska Native Claims Settlement Act (ANCSA), the remaining Eyak people became shareholders of the Eyak Corporation and Chugach Alaska Corporation (CAC). These ANCSA corporations accepted the U.S. legal system over a tribal government (reservation) system and forfeited rights to their ancestral lands. Under ANCSA, the federal government allowed any Alaskan Native inhabitant in a region who could prove residential status in 1971 to become ANCSA shareholder of the local village corporation. As a result, 300 Alaska Natives (Alutiiq, Athabaskan, Tlingit, Unangan, and Yup'ik) residing in the Cordova and Copper River Delta region were enrolled as traditional Eyak village members. The Eyak, as a result, became a minority in their own village corporation. The Eyak make up only 37 of the 326 original members of the Eyak Corporation and number fewer than 50 descendants of the 2,000 CAC regional shareholders.

In 1992, the Eyak Traditional Elders Council (ETEC—formed in 1991 by the Eyak) unsuccessfully challenged the Eyak Corporation, Sherstone Inc., and Sound Development Inc. to prevent logging on the eastern side of the Eyak River, near two smaller Eyak settlements. The Superior Court dismissed the case because the Eyak Corporation and others had failed to find any significant evidence of artifacts or gravesites in the proposed logging area. Yet, in the same vicinity, the Eyak people provide evidence of inhabitance, including burial sites and charcoaled drawings on rocks along the beaches. Similar sites, such as pictographs, have been noted by Old Man Dude, a powerful Eyak shaman, in De Laguna and Birket-Smith's book. These pictographs are figures of men painted in red on the cliffs of the north shore in Cordova Bay. Nonetheless, the court rejected the Eyak people's existence and right as a public interest litigant. ETEC appealed to the Alaska Supreme Court in 1995 and won public interest litigant status. This verdict gave the Eyak the right to have their case heard before the courts, without posting a bond or paying attorney fees, because it was in the public interest. Also, in 1995, the Eyak filed an ANCSA shareholder action to halt logging of their ancestral land; again they were denied by the courts. The Eyak Corporation decided to let the shareholders vote on their ANCSA lands, and 80 percent of the shareholders voted in favor of protecting more than 75,000 acres of land that was scheduled to be clear-cut.

The Eyak Preservation Council (EPC) was formed right after the 1989 Exxon Valdez oil spill and is presently advocating on behalf of the Eyak people to preserve and restore the diminutive Eyak tribe as an independent and distinct Alaskan tribal Nation. EPC works on projects that protect the culture, heritage, language, and ancestral lands of the Eyak. Through their efforts, of the Eyak people, EPC, ETEC, and the tribe held their first potlatch in more than 80 years and are presently working with the Unangan people to preserve both of their dying Alaskan languages and culture.

The loss of the Eyak language has been featured in numerous articles around the world. The Eyak language is considered a divergent branch of the Athabaskan language and from a common ancestor called "proto-Athabaskan." The Eyak language is linguistically similar to the Athabaskan language as well as the Navajos and Apaches of Arizona and New Mexico. Roughly, one-third of the Eyak language resembles the Athabaskan and another one-third resembles the Navajos and Apaches. Prior to Chief Marie Smith-Jones's passing, she and linguist Dr. Krause of the University of Fairbanks were being filmed discussing the Eyak language. Dr. Krause is continuing his work on an Eyak dictionary. Presently, a French student Guillaume Leduey, who had been learning the Eyak language since 2001 (at the age of 12), is now considered a fluent speaker, translator, and teacher of the Eyak language.

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See also: Alaska Native Claims Settlement Act (ANCSA) 1971; Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Gwich'in; Inuit; Ket; Khanty; Koryak; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Birket-Smith, K., and F. De Laguna. *The Eyak Indians of the Copper River Delta, Alaska.* København, Denmark: Levin and Munksgaard, E. Munksgaard, 1938.

Harry, A., and M. Krauss. *In Honor of Eyak: The Art of Anna Nelson Harry.* Fairbanks: Alaska Native Language Center, University of Alaska, 1982.

Hund, A. "Eyak." In *Encyclopedia of the Arctic.* London: Taylor and Francis Publications, 2004.

Krauss, M. *In Honor of Eyak: The Art of Anna Nelson Harry*. Compiled and edited with introduction and commentary by M. E. Krauss. Alaska Native Language Center, University of Alaska, 1982.

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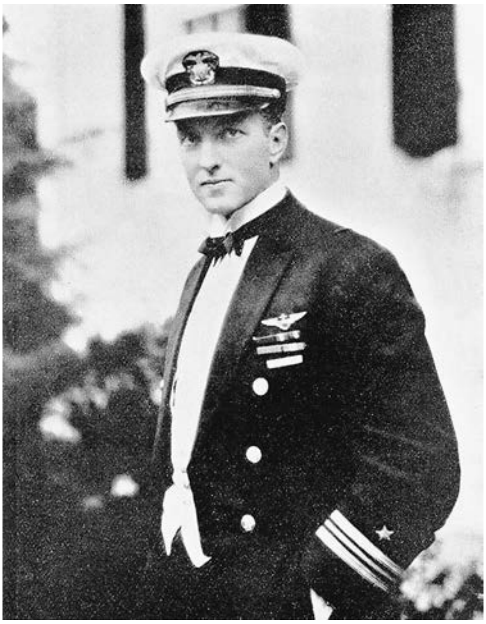
Farthest North

On June 19, 1596, more than 300 years before anyone accomplished a similar feat in the Southern Hemisphere, Willem Barents traveled the farthest north at 79° 49′N off Spitsbergen. Barents had no intention of reaching the North Pole, whereas Henry Hudson was seeking to sail as far north as possible. Hudson and a series of explorers in the 1600 and 1700s made farthest north claims, but these remained unconfirmed. Since the mid-seventeenth century, there had been reports of whalers reaching very high latitudes in these much-fished waters, and although some undoubtedly are apocryphal, it is possible that in exceptional years, whalers may have sailed farther north than any of the documented voyages.

As the impossibility of sailing to the pole became increasingly apparent, attempts were made to travel north over the ice, initially in the expectation that once across a relatively narrow belt of pack ice, open water would be discovered. This hope inspired Edward Parry (1790–1855) to reach 82° 45′N on July 23, 1827, before turning back, when it became obvious that the ice was drifting south faster than he could travel north. Charles Francis Hall (1821–1871) and George Nares (1831–1915) used the steamer *Polaris* to navigate through Nares Strait to reach 82° 11′N on August 30, 1871. The strong southerly drift off Spitsbergen discouraged further attempts in this region, and when the record was next broken, it was north of Ellesmere Island, where Albert Markham (1841–1918) reached 83° 20′N in 1876 during the expedition led by Nares, and then along the coast of northwestern Greenland, where James Lockwood achieved 83° 24′N on May 15, 1882, during Adolphus Greely's expedition.

Fridtjof Nansen (1861–1930) relied on an entirely different method when *Fram* became frozen in the ice north near the New Siberian Islands and allowed to drift across the Arctic Ocean to achieve its highest latitude of 86° 13′N in 1895. Subsequent expeditions were large-scale affairs, powered by dogs and assisted by several supporting parties. Much of what Robert Peary liked to refer to as the "Peary system" had in fact been earlier put into practice by the Duke of Abruzzi's expedition, during which Umberto Cagni reached 86° 34′N in 1900 after setting out from Franz Josef Land. This latitude was probably exceeded by Peary in 1906, when he claimed to have achieved 87° 06′N. He certainly got beyond it on his last expedition, though doubts remain as to whether he actually reached the pole (90° N), in 1909.



Richard E. Byrd, a U.S. naval officer, pioneered modern polar exploration by becoming the first man to fly over the North and South poles. (Library of Congress)

The first record farthest north by air was established by the balloonist Salomon Andrée, who reached 82° 56′N before being forced down on the ice in 1897. Following the failure of Walter Wellman's airship expeditions, the next attempt to reach the pole was made in 1925 by Roald Amundsen and Lincoln Ellsworth in two Dornier-Wal seaplanes. They too were forced down on the ice but not before achieving 87° 44′N. In the following year, Amundsen and Ellsworth returned to Spitsbergen, accompanied by Umberto Nobile as pilot of the airship *Norge.* Shortly before they were able to take off, they were anticipated by Richard Byrd in a Fokker trimotor. Recent evidence suggests that Byrd did not in fact reach the pole on May 9, 1926, as claimed, making Amundsen, Ellsworth, and Nobile the first to see it three days later during their flight across the Arctic Ocean to Alaska.

William James Mills

See also: Arctic Circle; Bartlett, Robert "Bob" Abram (1875–1946); Bering, Vitus Jonassen (1681–1741); Bransfield, Edward (1785–1852); British Arctic Expedition (1875–1876); Canadian Arctic Expedition (1913–1918); Cook, James (1728–1779); Cook, James, Voyages of; First German North Polar Expedition (1868)

Further Reading

Nansen, F. *Farthest North: The Epic Adventure of a Visionary Explorer, by Fridtjof Nansen.* Abridged ed. New York: Modern Library, 1999.

Nansen, F., and Lieut. Johansen. *Farthest North: Being the Record of a Voyage of Exploration of the Ship Fram 1893–96, and of a Fifteen months' Sleigh Journey by Dr. Nansen and Lieut. Johansen with an Appendix by Otto Sverdrup, Captain of the Fram. 2 Volumes.* London: Newnes, 1898.

Farthest South

Before the South Pole could itself be reached, it was gradually approached as vessels and expeditions achieved progressively higher latitudes in their attempt to reach as far south as possible. Francis Drake had no intention of achieving his record farthest south in October 1578, when he was blown by a storm probably to 57° S. Reports that he and the Dutch navigator Dirck Gerritsz reached latitudes close to the Antarctic Circle are not to be believed. In contrast to Drake, James Cook certainly was seeking a high southern latitude on January 30, 1774, when he achieved 71° 10′S in the Bellingshausen Sea. Cook's record was not surpassed until February 20, 1823, when the British sealer James Weddell reached 74° 15′S in the Weddell Sea, during a year when this sea was exceptionally ice free. Weddell's record was in turn bettered by James Clark Ross in the Ross Sea, first in February 1841 and then again on February 23, 1842, when he set the new record at 78° 9′S. On February 16, 1899, Carsten Borchgrevink discovered an embayment in the Ross Ice Shelf in which he managed to reach 78° 34′S.

The first meaningful land record was set by Borchgrevink in February 1899, when he sledged south from the Bay of Whales across the Ross Ice Shelf to reach 78° 50′S. Albert Armitage bettered this by 13 miles when he reached 79° 03′S in the same area in February 1902. This record was short lived, being improved on by his expedition leader, Robert Falcon Scott, on 30 December in the same year. Scott's record of 82° 17′S was surpassed by Ernest Shackleton, who reached 88° 23′S in 1909, only 97 nautical miles (100 miles; 160 km) from the pole itself, which

The Norwegian flag, planted by Roald Amundsen and the *Fram* expedition members, flies over the South Pole in December 1911. (National Oceanic and Atmospheric Administration) was finally reached by Roald Amundsen on December 14, 1911, and by Scott on January 17, 1912.

Aviation "record souths" have less meaning than their northern counterparts, basically because Richard Byrd's flight over the South Pole on November 29, 1929, was achieved so early in the history of Antarctic aviation as itself to be also the first attempt to fly as far south as possible. The earlier flights of Sir George Hubert Wilkins in 1928 had different objectives, with Wilkins pointedly leaving priority at the pole to Byrd.

William James Mills

See also: Amundsen, Roald Engebrecht Gravning (1872–1928); Heroic Age of Antarctic Exploration (ca. 1890s–1920s); Shackleton, Ernest (1874–1922); Shackleton–Rowett Expedition (1921–1922)

Further Reading

Amundsen, R. *The South Pole: An Account of the Norwegian Antarctic Expedition in the "Fram," 1910–12.* Edinburgh: Birlinn Ltd, 2003.

MacPhee, R. *Race to the End: Amundsen, Scott, and the Attainment of the South Pole*. New York: Sterling Innovation, 2010.

Preston, D. *First Rate Tragedy: Robert Falcon Scott and the Race to the South Pole.* New York: Mariner Books, 1999.

First German North Polar Expedition (1868)

During German unification in the second half of the nineteenth century, the country engaged a number of German scientists in polar research. One of the main driving forces was the geographer August Petermann (1822–1878), who was also one of the last proponents of the open polar sea theory. Based on the assumption of an open polar sea, Petermann postulated a number of weak areas in the ice barrier surrounding the open polar sea, with the weakest spots of the ice barrier probably at the east coast of Greenland and north of Spitsbergen. Petermann thought that a small vessel would be best suited for breaking the ice barrier due to its higher maneuverability in ice-covered waters. Despite having some backing for his plans by the respective scientific community, funding for the expedition could not be secured, in particular as the plans for a joint German Austrian expedition came to a complete stop after the outbreak of the Austro-Prussian War in 1866. Finally, mostly private funding was secured in Bremen with the support of the director of the navigation school Arthur Breusing. Breusing also proposed his student Carl Koldewey (1837–1908) become the leader of the expedition and master of the vessel.

With limited funds available, the plans for the expedition had to be scaled down and the construction of a purposefully built expedition vessel had to be scrapped. Instead, Koldewey traveled to Bergen (Norway) and bought a newly built single-masted coaster designed for Arctic operations. After refitting the vessel for polar operations and naming the vessel *Grönland*, the expedition set sail from Bergen in the spring of 1868. The crew consisted of Koldewey, his first mate Richard Hildebrandt, and seven German and three Norwegian sailors. The first leg of the expedition led the ship to the East Greenland coast, and after the ship could not get further north, the second attempt to break the ice barrier was made north of Spitsbergen. The ship was not able to break through the ice barrier due to the solid polar pack ice. On September 13, 1868, the ship reached at 81° 4′ 30″N, which was the northernmost position ever recorded for a sailing vessels without an auxiliary engine.

On September 30, 1868, the *Grönland* reached Bremerhaven without one casualty or major injury during the expedition. Although none of the objectives of the expedition could be reached, valuable insights and experiences on operating ships in the High Arctic were gathered, most notably that any future expedition needed at least auxiliary engine power. Despite the absence of any scientifically trained crew members, important oceanographic and meteorological data were obtained, and large territories of the Arctic were charted, some of them still carrying the names given during the First German North Polar Expedition. After the expedition, a strong controversy developed between Petermann and Koldewey, the first accusing the second of not pushing hard enough to achieve the goals of the expedition. In the aftermath, the expedition was nearly forgotten due to the dramatic events during the Second German North Polar Expedition again under the leadership of Koldewey.

Ingo Heidbrink

See also: British Antarctic Expedition (1910–1913); British Arctic Expedition (1875–1976); Canadian Arctic Expedition (1913–1918); Second German Antarctic Expedition (1911–1912)

Further Reading

Heidbrink, I. *81 45′ Nord unter Segeln: die nordische Jagt Grönland; vomersten deutschen Polar for schungs schiffzumaktiven Museumsschiff.* Bremerhaven, Germany: Dt. Schiffahrtsmuseum, 2005.

Koldewey, K., and A. Petermann. *Die erste Deutsche Nordpolar-Expedition im Jahre 1868.* Gotha, Germany: J. Perthes, 1993.

Petermann, A., and William Leonard Gage. *Erforschung der Arktischen Central-Region durcheine Deutsche Nordfahrt.* Gotha, Germany: [Justus Perthes?], 1865.

Foxe Basin

Foxe Basin (67° N 78° W) is a shallow inland sea located to the north of Hudson Bay in eastern Canada. The basin straddles the Arctic Circle and is bounded in the north and east by Baffin Island and in the west by Southampton Island (64° 30′N 84° 30′W) and Melville Peninsula (64° N 84° W). In the south, it is connected to

Hudson Bay by Foxe Channel, and in the northwest, it is connected to the Arctic Ocean by Fury and Hecla Strait. Politically, Foxe Basin lies within Nunavut, a territory created in 1999 following the signing of a land claims agreement between the Government of Canada and the Inuit of Nunavut. Despite its relatively southern location, Foxe Basin was the last part of Canada to be explored and mapped.

For most of the year, Foxe Basin is covered by ice. The ice adjacent to the coast and islands within the basin is landfast, whereas pack ice prevails away from the coast. Strong currents and high winds keep the pack ice in motion producing a rough surface, while grounding of the ice on the shallow seafloor causes bottom sediment to be incorporated in the ice giving it a brown color. The knolls or hummocky surface and dark color distinguish Foxe Basin ice from all other ice in the Canadian Arctic. Several areas of open water (polynyas) remain unfrozen for much or all of the year in Foxe Basin, and these Arctic oases attract marine mammals and birds.

The floor of Foxe Basin is rising steadily by as much as 30 inches (75 cm) per century in response to postglacial isostatic uplift. The uplift is causing the basin to become shallower with time, resulting in the development of numerous shoals, reefs, and small islands, particularly in the east adjacent to Baffin Island where the water is shallowest.

European mariners entered Hudson Strait early in the seventeenth century in their search for a Northwest Passage from the Atlantic to the Orient around the northern coast of North America. Although the strait at first appeared to offer promise, on his fateful voyage in 1610, Henry Hudson showed that it opened into Hudson Bay. He was unable to continue his search for a westward-leading exit from the bay when his crew mutinied, and Hudson, his young son, and several crew members were set adrift never to be seen again.

Later explorers searched the west coast of Hudson Bay in an attempt to find an exit to the west, but their lack of success led Luke Foxe (1586–1635) to look for a more northerly outlet. In 1631, Foxe sailed for a short distance into the channel, which now bears his name and made observations that indicated that a large body of water (Foxe Basin) existed to the north of Hudson Bay. However, no attempt was made to enter Foxe Basin until the summer of 1822 when Commander William Parry (1893–1972) of the Royal Navy with the two ships *Fury* and *Hecla* sailed north along the coast of Melville Peninsula and discovered the narrow westward-leading strait, which he named after his ships.

Tidal observations revealed to Parry that Fury and Hecla Strait was connected to open sea to the west. Unfortunately, ice conditions were so bad that he was unable to navigate the channel in the summer of either 1822 or 1823, a circumstance that led him to express the opinion that the strait could never be used by ships. This conclusion had the effect of diverting the search for a Northwest Passage from Foxe Basin to the passages leading off Lancaster Sound to the north.

Whaling vessels likely began visiting Foxe Channel from the middle of the nineteenth century although there are no records of any having reached the northern shores of Foxe Basin. However, in 1897, it was learned that an American whaling captain by the name of John Spicer had entered Foxe Basin in 1879 and had discovered the group of small islands in the center of the basin now named in his honor.

The northern part of Foxe Basin remained unexplored until the twentieth century when the German zoologist Bernard Hantzsch attempted to address the problem. In 1910, he crossed Baffin Island from Cumberland Sound with Inuit guides and in 1911 continued north along the west coast of Baffin Island aiming to reach Fury and Hecla Strait. But he became ill and died before achieving his objective. During Knud Rasmussen's Fifth Thule Expedition of 1921–1924, expedition members attempted to reach the area that remained to be explored, but were forced to abandon their efforts after two attempts.

The northeastern coast of Foxe Basin was eventually explored by members of a British Canadian Arctic Expedition led by Thomas Manning when they circumnavigated the basin between 1936 and 1940 using a combination of boat and dog sledge. Manning's expedition not only completed the map of the Foxe Basin coastline but also discovered a number of islands close to Baffin Island. These exploits were considered to constitute the final chapter in the pioneer exploration history of Foxe Basin until 1948. In July of that year, a routine flight of a Royal Canadian Air Force Lancaster airplane from Melville Peninsula to Frobisher Bay (now Iqaluit) on Baffin Island accidentally discovered three large islands in eastern Foxe Basin, which had previously eluded earlier explorers. The islands, subsequently named Prince Charles Island, Air Force Island, and Foley Island, together occupy an area of almost 12,000 sq. km, more than twice as large as the Canadian Province of Prince Edward Island.

It was later shown that Prince Charles Island had in fact been observed and reported to the authorities in 1932 by Captain W. A. Poole in the tug *Ocean Eagle* but surprisingly had never been recorded on any published maps. Prince Charles Island, Air Force Island, and Foley Island were the last major pieces of territory to be added to the map of Canada.

Kenneth Jones

See also: Canadian Arctic Archipelago; Inuit; Northwest Passage; Rasmussen, Knud (1879–1933)

Further Reading

Anders, G. *Northern Foxe Basin: An Area Economic Survey.* Ottawa: Industrial Division, Northern Administration Branch, Department of Northern Affairs and National Resources, 1965.

Crowe, K. *A Cultural Geography of Northern Foxe Basin, N.W.T.* Ottawa: Northern Science Research Group, Department of Indian Affairs and Northern Development, 1969.

Gaston, A., A. Stephen, R. Smith, G. Ilya Storm, and J. Whitney. "Birds and Marine Mammals in Southwestern Foxe Basin, Nunavut, Canada." *Polar Record* 43, no. 1 (2007): 33–47.

Rowley, G. *Cold Comfort: My Love Affair with the Arctic.* Montreal and Kingston, ON: McGill-Queens University Press, 2007.

Franklin Search Expeditions

In polar history, the only analog for the Franklin search is the so-called Heroic Era of Antarctic exploration. During both episodes, intense exploratory activity was focused on regions previously largely ignored, with every venture attracting the enthralled attention of the general public. The great difference between the two is that whereas the goals of the Heroic Era were to reach the South Pole and explore a continent, those of the Franklin search were to find a missing expedition. Both led to great advances in geographical knowledge.

During his lifetime, Sir John Franklin was Great Britain's most popular Arctic explorer, having become generally known as "the man who ate his boots" following his grim first expedition. At the age of 58, he volunteered to take command of a voyage to discover the Northwest Passage. Sailing from London in May 1845, he was last seen in northern Baffin Bay in late July. No plans had been laid for a relief expedition, but when concern began to mount two years later, the Admiralty was eventually pressed into action. Since it was not known exactly where Sir John might be in the maze of islands north of continental America, three expeditions were organized: one to follow his course through Lancaster Sound, one to wait for him at Bering Strait, and one to travel overland to the Arctic coastline, where a narrow belt of open water was known to be present in most years and through which Sir John was expected to sail. These expeditions were led by Sir James Clark Ross, Thomas Moore, and Sir John Richardson, respectively. This threefold strategy remained central to Admiralty planning throughout the Franklin search, based on the advice of a group of distinguished naval explorers known as the Arctic Council. Despite Stephen Pearce's well-known painting showing this council in session, it is thought that its members never met as a body but were rather consulted as individuals. The 10 members were the Arctic explorers Sir George Back, Captain Frederick Beechey, Captain Edward Bird, Sir Edward Parry, Sir John Richardson, Sir James Clark Ross, and Lieutenant-Colonel Edward Sabine, together with three representatives of the Admiralty: John Barrow Jr., Sir Francis Beaufort, and Captain W. A. Baillie Hamilton.

Sir John's instructions are quoted in the entry under his name, but, in brief, he was to seek the passage southwest of the prominent headland Cape Walker, which marked the last known land before Banks Island. Should doing so prove impossible, he was to explore north through Wellington Channel. When the Admiralty's three initial expeditions failed to discover any sign of Sir John, public concern for the missing explorers made it mandatory that further expeditions be organized. They followed the same plan: Horatio Austin (1850–1851) and William Penny (1850–1851) explored from the west, John Rae continued the overland explorations begun with Richardson (1847–1849), and Richard Collinson (1850–1855) and Robert McClure (1850) were sent to explore east from Bering Strait. Three private expeditions accompanied Austin and Penny: Charles Forsyth (1850), sent by Lady Franklin; Sir John Ross (1848–1849), partly sponsored by the Hudson's Bay Company; and Edwin De Haven (1850–1851), sponsored by the American philanthropist Henry Grinnell. Much to the disappointment of Lady Franklin and her many sympathizers, when Austin and Penny returned the following year, they had discovered no more than where Sir John had spent his first winter, but nothing concerning where he had gone afterward. Furthermore, Austin insisted that there was nothing more to be learned: for all practical purposes, Sir John had vanished. Others—notably Penny—disagreed, but not until another year passed was the Admiralty persuaded to make another attempt to find him. Sir Edward Belcher was sent with five vessels, the largest of all the Franklin search expeditions.

Unknown to the searchers, Sir John had encountered exceptional conditions in 1846, allowing him to sail south through Peel Sound, a channel that, when subsequently inspected by Sir James Clark Ross and members of Austin's expedition, appeared completely unnavigable. Thus, by 1852, only Lady Franklin believed that there was any need to look for Sir John south of Parry Channel. In 1851, she had sent William Kennedy to Prince Regent Inlet for this purpose, but unfortunately, he did not explore sufficiently far south to find Sir John, whose ships had become beset west of King William Island. Indeed, when Kennedy returned, it was to report mistakenly that Peel Sound was closed by land. Belcher's orders were therefore to concentrate his search farther north, the presumption being that Sir John had got into difficulties attempting to obey the second part of his instructions, to explore north through Wellington Channel. Not surprisingly, Belcher found nothing, though sledging parties from his vessels and those of his subordinate Henry Kellett greatly extended the coastal survey work conducted previously by Austin and Penny in particular. A second disaster was narrowly averted when Kellett relieved McClure on Banks Island, the latter completing the first crossing of the Northwest Passage on foot. Belcher's ignominious return in 1854 without four of his ships concluded the Admiralty's search effort. Shortly afterward, Rae reached London with conclusive proof that Sir John's expedition had met a tragic fate west of the Boothia Peninsula, near the mouth of the Back River. At the request of the British government, the Hudson's Bay Company sent two of its employees—James Anderson and James Stewart—down this river, but they were able to discover little more.

Table 1 Franklin Search Expeditions, 1847–1859.

Date	Explorer	Route	Chief Sponsor
1847	Penny	Lancaster Sound	Private
1847–1849	Richardson and Rae	Arctic coast from Mackenzie to Coppermine Rivers	British Admiralty
1848–1849	J. C. Ross	Lancaster Sound	British Admiralty
1848–1850	Kellett	Bering Strait	British Admiralty
1848–1852	Moore	Bering Strait	British Admiralty
1849	Penny	Lancaster Sound	Private
1849	Shedden	Bering Strait	Private
1849–1851	Pullen	Bering Strait	British Admiralty
1850	Forsyth	Prince Regent Inlet	Lady Franklin
1850–1851	Austin	Lancaster Sound	British Admiralty
1850–1851	Penny	Lancaster Sound	British Admiralty
1850–1851	John Ross	Lancaster Sound	Hudson's Bay Company
1850–1851	De Haven	Lancaster Sound	Henry Grinnell
1850–1851	Rae	Victoria Island	Hudson's Bay Company
1850–1854	McClure	Bering Strait	British Admiralty
1850–1855	Collinson	Bering Strait	British Admiralty
1851–1852	Kennedy	Lancaster Sound	Lady Franklin
1852	Inglefield	Smith and Jones Sounds	Lady Franklin
1852–1854	Belcher	Lancaster Sound	British Admiralty
1852–1854	Kellett	Melville Sound	British Admiralty
1852–1854	Pullen	Lancaster Sound	British Admiralty
1853–1854	Rae	Boothia Peninsula	Hudson's Bay Company
1853–1855	Kane	Smith Sound	Henry Grinnell
1855	Anderson and Stewart	Back River	Hudson's Bay Company
1857–1859	McClintock	King William Island	Lady Franklin

Table 2 Later expeditions seeking to establish the cause of the fatalities.

Date	Explorer	Route	Chief Sponsor
1860–1862	Hall	Baffin Island	Henry Grinnell
1864–1869	Hall	King William Island and Melville Peninsula	Private
1875	Young	Beechey Island and Peel Sound	Private
1878–1880	Schwatka	King William Island	American Geographical Society
1923	Rasmussen	King William Island	Private
1930	Burwash	King William Island	Canadian government
1931	Gibson and Skinner	King William Island	Hudson's Bay Company
1967	Project Franklin	King William Island	Canadian Armed Forces
1992	Ranford	King William Island	Private

Without Lady Franklin, the Franklin search would have ended at this point, with just Collinson to complete his voyage back to Great Britain. Lady Franklin, however, was determined that the site of her husband's end must be visited, and in 1857, she organized her fifth expedition to this purpose. What Leopold McClintock discovered is told under his name.

Of these expeditions, only four threw any light on Sir John's fate: those led by Austin and Penny (1850–1851), Rae (1853–1854), and McClintock. Table 1 is limited to those actually reaching the Arctic and thus omits Lady Franklin's fourth and Kennedy's second expedition, which got no farther than Valparaiso before its crew deserted.

After McClintock's voyage, the location of the disaster was known, as were the broad outlines of Sir John's voyage. Much about his expedition, however, remained mysterious, and a number of explorers have since visited King William Island to search for more information, especially the location of Sir John's grave, any kind of written record, and to interrogate the Inuit. Table 2 lists some of the more notable attempts. As recently as 1992, Barry Ranford discovered the remains of six more bodies, but no further documents have ever been found, and it is now generally assumed that Sir John was buried at sea.

William James Mills

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s); Northwest Passage; Rasmussen, Knud (1879–1933); Ross, Sir James Clark (1800–1862)

Further Reading

Cookman, S. *Ice Blink: The Tragic Fate of Sir John Franklin's Lost Polar Expedition*. New York: John Wiley and Sons, 2000.

Cyriax, R. *Sir John Franklin's Last Arctic Expedition*. London: Methuen and Company, Ltd., 1939.

Sutherland, P., ed. *The Franklin Era in Canadian Arctic History, 1845–1859.* Ottawa: National Museum of Man, 1985.

Woodman, D. *Unravelling the Franklin Mystery: Inuit Testimony*. McGill-Queen's Native and Northern Series (Book 5). Montreal: McGill-Queens University Press, 1991.

Franz Josef Land

Franz Josef Land (80° 34′N 54° 47′E) encompasses 191 uninhabited ice-covered islands. It is the northernmost archipelago. These islands are located in the Arctic Ocean, north of Novaya Zemlya Archipelago, west of the Severnaya Zemlya Archipelago, and east of Svalbard Archipelago. Franz Josef Land is about 560 miles (900 km) from the North Pole. Franz Josef Land covers an area around 6,200 square miles (16,000 sq. km). Cape Fligely (81° 50′ 35″N 59° 14′ 22″E) on Prince Rudolf Island is the northernmost point of the archipelago.

There are five major islands in Franz Josef Land, which are Alexandra Land, Prince George Land, Hall Island, Wilczek Land, and Graham Bell Island. The largest of the islands, Prince George Land (80° 26′ 43″N 49° E), is more than 70 miles (115 km) in length covering an area of almost 1,100 square miles (2,821 sq. km). The second largest island, Wilczek Land, covers an area of 850 square miles (2,200 sq. km). Alexandra Land is the westernmost island of the Franz Josef Land. Hall Island is nearly covered by glaciers and covers an area of 405 square miles (1,049 sq. km). Graham Bell Island during the cold war was an outpost and airstrip. This island covers an area of 600 square miles (1,500 sq. km). In the middle of the archipelago is a collection of narrowly separated islands called Zichy Land (81° N 56° E), which includes Champ, Greely, Jackson, Karl-Alexander, Luigi, Payer, Rainer, Salisbury, Wiener Neustadt, and Ziegler.

This remote archipelago is characterized by volcanic mountains and is predominately glaciated. It is estimated that 85 percent of the Franz Josef Archipelago is covered by glaciers. The tallest peak is just more than 2,000 ft. (600 m) on Wiener Neustadt Island of Zichy Land. There are very few plants on the islands, with about 300 lichens, about 150 bryophytes (nonvascular plants), and 50 tracheophytes (vascular plants). Terrestrial animals found on the island include Arctic fox and polar bears. Marine mammals in the waters include whales (beluga, bowhead, humpback, narwhal, and white) and seals (bearded and harp). It is estimated that about 5 million birds annually nest on the islands of Franz Josef Land. Common nesting birds include little auks, guillemots (thick-billed and black), and gulls (glaucous; the Ivory gull).

Julius Johannes Ludovicus Ritter von Payer (1841–1915) and Carl Weyprecht (1838–1881) are credited with being the first two Europeans to discover the archipelago, in 1873 while on the Austro-Hungarian North Pole Expedition (1872–1874). Some suggest that Norwegian sealers discovered the archipelago in 1865. In 1926, the Soviet Union claimed the archipelago. It is presently part of the Russia Federation territory.

Andrew J. Hund

See also: Bear Island (*Bjørnøya*); Greenland; New Siberian Islands; Victoria Island; Svalbard Archipelago

Further Reading

Christoph, H. *Exepdition Franz Josef Land. In der Spur der Entdecker nach Norden.* Munich, Germany: Frederking-Thaler, 2007.

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Gates of the Arctic National Park and Preserve

On December 2, 1980, the Alaska National Interest Lands Conservation Act was passed, and the Gates of the Arctic National Park and Preserve was created in the state of Alaska to keep this remote place safe as a wilderness area. The Park and Preserve is larger than the state of Maryland; all of its 13,228 square miles (34,260 sq. km) (approximately 8.47 million acres) lies north of the Arctic Circle in the Brooks Range, the most northernmost extension of the Rocky Mountains. The Park and Preserve straddle both sides of the Continental Divide and run north toward the Beaufort Sea and Arctic Ocean and south to Kotzebue Sound and the Bering Sea. Today, evidence of the glaciation period can be found as passes have been carved into the mountains and eroding rivers have carved out valley floors. Although still a remote place, it has a long history of occupation by animals and people.

Two basic environments can be found within the Park and Preserve: 68° N is tundra composed of grasses, sedges, and cotton grass; and 68° S is boreal forest comprising birch, poplar, white spruce, aspen, black spruce, blueberry, lichens, alder, and willow. Temperatures are extreme ranging from −70°F (−57°C) in winter to 90°F (32°C) in summer.

Thousands of years ago, now extinct mammoths, mastodons, giant sloths, giant beaver, and moose-elk, roamed the area. Today's fauna include caribou, moose, bears, foxes, weasels, hares, sheep, coyote, wolf, muskrat, beaver, ground squirrels, migratory waterfowl, and fish.

People from the Old World are believed to have crossed Berginia, land now covered by water but then the land bridge between Asia and North America, at least 12,000 years ago. The area now called "Alaska" would have been the first land in North America they would have encountered. Archeological finds in non-glaciated sites throughout the Park and Preserve contain micro blades (very small thin blades made from rock), small wedge-shaped cores used for chopping, and projectile points showing that the land supported hunters. About 4,000–5000 years ago, changes in technology, social organization, and environment resource exploitation began and continued into the mid-nineteenth century. Large long-term camps used in spring–summer and fall have been found in the northern Brooks Range. Sites showing subterranean houses were occupied in the interior for the winter, and most were on the shores of lakes rich in fish that was eaten if the subsistence staple, caribou, could not be obtained.

About 1,050 years ago, the Nunamiut Eskimo were the last of this continuum, and they lived in willow patches along streams in moss or sod houses. By the end of the nineteenth century, three aboriginal cultural groups occupied the lands where the park is now situated: the Nunamiut Eskimos occupied the majority of the area, Koyukuk Athabaskans used the southern portion, and Kobuk Eskimo used the southwestern edge. All of these people lived in small groups in a series of camps moving to their various camps throughout the year to harvest what was seasonally available.

By the 1880s, Europeans began to visit the area although trade with Russia had been occurring since the 1770s. By 1885, the military began to explore and map the river areas. In the late 1800s, hundreds of men arrived as part of the gold rush. The U.S. Geological Survey mapped the area in the early twentieth century.

Today, the Park and Preserve is still a remote place without any road access. Visitors must carefully plan their trip into the Park and Preserve and enter by bush plane from local villages or hike in from the Dalton Highway or Anaktuvuk Pass, the last remaining settlement of the Nanamiut people. It is the only community found within the park boundaries, but there are 11 resident zones around the park and several residents continue their subsistence activities in the Park and Preserve.

Leslie McCartney

See also: Arctic National Wildlife Refuge (ANWR); Chamisso Wilderness; National Petroleum Reserve–Alaska (NPR-A); Northeast Greenland National Park; Tuktut Nogait National Park; Vuntut National Park of Canada

Further Reading

Brown, W. *Giant Beautiful, Tenuous Life.* Historic Resources Study. Gates of the Arctic National Park and Preserve. Anchorage, AK: National Park Service, 1988.

Kunz, M. *Cultural Resource Survey and Inventory: Gates of the Arctic National Park and Preserve, Alaska.* Anchorage, AK: United States Department of the Interior National Park Service, 1991.

Gauss Expedition (1901–1903)

The main goal of the First German Antarctic Expedition, better known as the Gauss Expedition, was the scientific exploration of South Polar regions, in particular on the Indo-Atlantic side of Antarctica. The expedition was led by Erich von Drygalski (1865–1949), a well-known geographer, geophysicist, and polar scientist, who had already led expeditions to the Arctic between 1891 and 1893 including an overwintering on Greenland in the winter 1892/1893. Instead of modifying an existing ship, von Drygalski asked for a research vessel based on the design principles of the Norwegian polar research vessel *Fram.* The new ship was 150 ft. (46 m) in length and 36 ft. (11 m) in width. The vessel displaced 1,450 tons of water at a draft around 16 ft. (4.8 m) and was equipped with an auxiliary steam engine as well as with steam heating and electric light. The *Gauss* left Germany on August 11, 1901, after being equipped for Antarctic research including two moored balloons for aerial reconnaissance. Captain of the *Gauss* was Hans Ruser, and the crew consisted out of 5 scientists, 5 officers, and 22 crew members.

On the way south, the *Gauss* disembarked a group of scientists on Kerguelen Island and continued via Heard Island to Antarctica. During the visit to Heard Island, the first comprehensive scientific information about the geology, flora, and fauna of the island was gathered. After reaching Antarctica, von Drygalski and his crew explored substantial amounts of uncharted territory that was named after the German emperor Wilhelm II (Kaiser Wilhelm II Land). While the G*auss* was trapped for nearly 14 months in ice, a good deal of information about Antarctica was gathered, most of which was gathered from the moored balloons. Several sledge expeditions completed the scientific program. In February 1902, an extinct volcano was discovered and named "Mount Gauss" (Gaussberg). The Gauss broke free from the ice, in February 1903, and returned to Germany in November 1903.

Upon returning, von Drygalski published the narrative of the expedition and edited a significant amount of scientific data gathered during the expedition. These scientific results were published between 1903 and 1905 and consisted of 20 volumes with scientific data and 2 atlases. The Gauss Expedition marked the beginning of the German Antarctica research. It was the shift from exploration to scientific research of the polar regions. In addition, the Gauss expedition is recognized as one of the early successful examples of aerial reconnaissance in Antarctica. In 1904, the *Gauss* was sold to Canada and continued with polar research for nearly two decades, and von Drygalski became professor in Munich. He never returned to Antarctica but continued with his polar research in the Arctic. For example, he participated in 1910 in Ferdinand Count Zeppelin's airship expedition to Spitsbergen.

Ingo Heidbrink

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

Further Reading

Drygalski, E. *The German South Polar Expedition, 1901–3*. Norwich, UK: Erskine Press, 1991.

Mill, Hugh R. (Ed.). "Chapter XX: Early Expeditions of the Twentieth Century." In *The Siege of the South Pole: The Story of Antarctic Exploration*. Ann Arbor: University of Michigan Library, 1905.

Murphy, D. *German Exploration of the Polar World: A History, 1870–1940.* Lincoln: University of Nebraska Press, 2002.

Gentoo Penguin

The gentoo penguin (*Pygoscelis papua*) is a large penguin that nests on the Antarctic Peninsula, islands in the subantarctic, and even in small numbers off of South America. It is often lumped in with the Antarctic penguins, which include its two cousins in the *Pygoscelis* genus, Adélie and chinstrap, as well as the most distant cousin emperor. However, the fact that it breeds as far north as the Falkland Islands, southern Argentina, suggests that it is less purely adapted for the Antarctic and more cosmopolitan in its abilities to breed in different places and under different conditions. Evolutionary advantages, including high levels of blubber and specially adapted blood vessels, allow it to live on the Antarctic Peninsula but do not preclude it from living in the warmer waters of southern South America. Mitochondrial DNA work suggests that the gentoo penguin is the oldest of the *Pygoscelis* genera, splitting off from the chinstrap/Adélie progenitor 19 million years ago (mya) and off of the main penguin tree 38 mya.

The gentoo was first described in 1781 by Johann Reinhold Forster, a German Calvinist clergyman who devoted all of his free time to the natural world, particularly to classification. Although his contributions to ornithology would largely involve describing birds shipped to him from North America, where several bird species still carry his name 200 years later, it was on Captain James Cook's Second Voyage that Forster discovered and described the penguin on the Falkland Islands. Several theories exist regarding the origin of the name "gentoo," including an English colonial term used to reference Hindus, and a mistranslation of the Portuguese word *gentio*, which means "savage" or "wild."

Although height varies widely due to sex and subspecies, adult males can reach 3 ft. in height, making the gentoo larger than any penguin species other than emperor and king. Dependent on not only sex and subspecies but also breeding cycle, birds can range between 10 and 20 pounds (4.5–9 kg). As with all other penguin species, they are flightless but well suited for swimming underwater, largely due to powerful flippers. Gentoos are known for being particularly strong and adept swimmers, as their tails, the longest in the penguin family, facilitate maximal power, speed, and steering. Individuals have been clocked at swimming at more than 22 mph (32 km/h). The length of the tail has drawbacks on land, however. The genus name *Pygoscelis*, literally "rump-tailed," was named for the manner in which they waddle on land in an effort to keep from dragging their tail. Plumage-wise, the gentoo is black above and white below with a long orange bill with a black line atop the culmen of the upper mandible. A prominent white patch begins above each eye and runs across the top of the crown, and as with the other *Pygoscelis* penguins, black flippers are edged with white. There is no sexual dimorphism in plumage.

In keeping with a breeding range that encompasses different Antarctic and even non-Antarctic zones, Gentoos colonies are found on grass, dirt, shale, and barren rock. Most colonies are situated on the immediate coastline, although some are located miles inland. Despite their cosmopolitan nature, colonies tend to be relatively small. Regardless of having one of the largest ranges of any penguin species, the global gentoo population is less than a million birds; by way of comparison, the gentoo's *Pygoscelis* cousin Adélie has a population 5–10 times and the Chinstrap 15 times as large. The low number of gentoos is not due to severe population decline; even though the species was recently reclassified from least concern to near threatened, it is one of the few penguin species not seriously affected by the triple threats of climate change, commercial overfishing, and oil contamination due to increased shipping in the subantarctic regions. Instead, the species appears to thrive in smaller colonies, which may explain why the archaeological record suggests that the move into southern South America may have occurred in more recent history, with birds pushed out of colonies already at a maximum capacity exploring further afield. As with most penguin species, gentoos feed largely on krill, augmenting their diet with shrimp and fish. Natural predators include leopard seals and orcas; adults have no land-based predators, although skuas and giant petrels commonly predate both eggs and chicks.

Andrew J. Howe

See also: Adélie Penguin; Chinstrap Penguin; Emperor Penguin; King Penguin; Macaroni Penguin; Rockhopper Penguin

Further Reading

Baker, A., S. Pereira, O. Haddrath, and K. Edge. "Multiple Gene Evidence for Expansion of Extant Penguins Out of Antarctica Due to Global Cooling." *Proceedings of the Royal Society: Biological Science* 273, no. 1582 (2006): 11–17.

Williams, T. *Bird Families of the World: The Penguins.* British Antarctic Survey. Oxford: Oxford University Press, June, 2008.

Woods, R. *The Birds of the Falkland Islands.* Shropshire, UK: Anthony Nelson, 1975.

Geomagnetic Poles

The magnetic field of the earth was first discovered by the Chinese and Greeks as far back as 2000 BC. In those times, this mysterious force was held in mystery and fascination. The source was considered primarily extraterrestrial and somehow showing sympathy with the North Star, Polaris.

The first record of the earth's field being used for navigation comes from China in AD 271. Alexander Neckam's *De naturis rerum* (1190) provides the first known Western reference to the use of magnetism for navigation. Fairly early on, scientists recognized that the compass needle did not necessarily point to true north. The deviation, called "declination," was recognized in Europe in the fifteenth century.

It was not until the sixteenth century that scientists realized that the field pointed downward at various angles (dip).

By 1600, William Gilbert had measured the direction and dip in enough places to recognize the field's essential dipolar nature—published in *De Magnete*. Gilbert found that near the equator, the field lines point essentially horizontally. But near the poles, the field lines point down into the earth. During those early years, the source of field remained unknown, but some hypothesized it to result from a mountain of magnetic rock (rather than being extraterrestrial). By this time, observers had noted that a difference existed between true north and magnetic north, and that this declination changed slightly from year to year—though this was not proven until 1634 (by Gellibrand and Marr).

The observed changes in the magnetic field direction dispelled the notion of a fixed surface source illuminating the idea of an internal source (displaying a tilted dipole). The field is now known to be somewhat more complicated. But based on this simple model, the locations where field lines point straight down was originally referred to as North and South Magnetic Poles. The actual field intensity was not measured until 1832.

Early Arctic Explorers

Early Arctic explorers sought to find the North Magnetic Pole, but initially their quests were focused on finding the Northwest Passage for easy navigation between Europe and Asia. The Englishman John Ross (1777–1856) set off in 1829 in search of the Northwest Passage, with his nephew James Ross as second-in-command. During a mild season, they steamed across Baffin Bay, through Lancaster Sound to Prince Regent Inlet, but due to steam plant problems, they resorted to sail. Upon not finding the outlet to the Inlet, they retreated to a safe harbor where they were had to overwinter. This lasted for four winters before they were able to free themselves from the ice. During the winters, James Ross explored the coastlines by dogsled, reaching a position with a magnetic dip of 89° 59′ near the west coast of the Boothia Peninsula.

The Dip Pole

This position of 90° dip of the field is now known by geophysicists as the "Magnetic Dip Pole," or just "Magnetic Pole" by many geographers. The local field, however, is affected by not just the earth's internal magnetic field, but also local rock magnetism and extraterrestrial magnetic variations. These factors contribute to non-dipole variations in the field, as well as short-term perturbations.

The North Magnetic Dip Pole was next visited by Roald Amundsen (1872–1928) on the first trip through the Northwest Passage in 1904. As expected from more distant observations, the Magnetic Dip Pole had moved northward. The corresponding South Magnetic Dip Pole (then in Antarctica) was first visited by Edgeworth David, Douglas Mawson, and Alistair Mackay in January 1909.

MAGNETIC FIELD AND LONGITUDE

Early navigators knew that latitude could easily be determined from celestial observations, but longitude could not be determined without accurate timing over long distances. Many navigators tried to use magnetic observations to determine longitude, but these attempts were mostly thwarted by inadequate measurement of time and the fact that the magnetic field changes slowly with time.

Ultimately, John Harrison's chronometer (mid-eighteenth century) provided the (Western world's) solution for determining longitude. Captain Cook carried one such chronometer on the *Discovery*. The Chinese, however, solved the question of synoptic observations much earlier, by making observations during lunar eclipses, which appear to begin and end at the same time for observers anywhere on earth.

William (Bill) F. Isherwood

Paleomagnetism Records Past Field

Rocks containing iron contain magnetized domains—remnant magnetism. These domains do not exist above a temperature called the Curie point (temperatures near 1400°F [760ºC]). As molten rock cools, these domains are frozen in, orienting parallel to the local magnetic field at that time. Similarly, magnetic particles in sedimentary rocks orient along the local magnetic field as they are deposited and locked into the eventually solid rock. Oriented samples indicate the orientation of the magnetic field when the rock was formed. These records provide a geologic history of the field. Records show both movement of poles and reversals of the earth's field.

Paleomagnetism has been used to understand continental drift. However, distinguishing between movement of the magnetic pole and continental drift can be tricky. Reconstructions based on synchronous paleomagnetic poles show how continents have moved relative to each other and the geomagnetic field. Data from about 550 million years BP (Cambrian) are even more difficult to interpret, because of true polar wander, when the earth's rotational axis seems to have shifted in response to gravitational imbalances.

What We Now Know of the Earth's Magnetic Field

Full spatial observations of the earths' magnetic field were not available until *Magsat* was launched in 1979. These show that the observed field is very complex and a product of several sources. Both dipole and higher-order components of earth's internal field (quadrupole, octopole) contribute to the total geomagnetic field. Both extraterrestrial field fluctuations and local rock magnetism contribute to the field measured at any given point.

Nature of the Internal Field

A dynamo effect caused by the movement of conducting materials in liquid iron core, plus the earth's rotation within the sun's magnetic field, creates the earth's internal field. The fluid core moves in the order of 15–30 km/yr (1.7–3.4 m/h). The distance between our surface measurements of the field and its deep source smoothes the field. Mathematical downward continuation of the field to the surface of the core shows much greater complexity. The internal field caused by the movement of conducting materials in liquid iron core creates a dynamo effect. The liquid core moves in the order of 15–30 km/yr (1.7–3.4 m/h).

North and South Geomagnetic Poles

Approximately 90 percent of the field can be accounted for by the dipole. Additional complexity can be represented by higher-order spherical coordinate terms (quadrupole, octopole, etc.). Many features move, grow, and decay in short time period, while others stay relatively constant. The actual best-fit dipole field is offset somewhat from the axis of rotation and does not pass through the center of earth. Because of this, the Magnetic (Dip) Poles on maps have minimal significance to the earth's overall magnetic field.

Other Magnetic Poles

An international body of geomagneticians regularly meets to discuss magnetic observations and fit mathematical best-fit solutions to determine an International Geomagnetic Reference Field (IGRF) for the period of data observation. Attempting to screen out extraterrestrial and local effects, these IGRFs define (among other things) the Geomagnetic Poles and the Eccentric Geomagnetic Poles from the first-order (dipole) moments of the field. Geomagnetic Poles are determined from the best-fit dipole axis passing through the center of the earth—the North Geomagnetic Pole currently lies near Qannaq Greenland. The Eccentric Geomagnetic Poles are not constrained by their axis passing through the center of the earth.

Popular Poles

Most popular attention has been paid to the Magnetic Dip Poles, shown on most maps simply as the "Magnetic Poles." These Dip Poles have been visited over time and been extrapolated back in time by the use of paleomagnetic data. The vertical dip actually varies over the time of day, due to the earth's precession and extraterrestrial effects, by as much as 80–100 km. Helen Thayer visited the vicinity of the North Magnetic Dip Pole solo in 1988, when it was located between Bathurst Island and King Christian Island (see *Polar Dream*, by Helen Thayer). In 2000, a dogsled party reached the Dip Pole when it was located northwest of Ellef Ringness Island. No one seems to keep track of people reaching the mathematically determined positions of either the North Magnetic Pole or the Eccentric Magnetic Pole, which could be identified only by the geographic coordinates of the most recently derived point locations.

William (Bill) F. Isherwood

See also: North Pole; South Pole; Three-Pole Concept

Further Reading

"International Geomagnetic Reference Field: The Eleventh Generation." International Association of Geomagnetism and Aeronomy, Working Group V-MOD. Participating members: C. Finlay, et al. *Geophysical Journal International* 183, no. 3 (2010): 1216–30.

McElhinny, M., and P. McFadden. *Paleomagnetism: Continents and Oceans.* New York: Academic Press, 2000.

Merrill, R. *Our Magnetic Earth: The Science of Geomagnetism.* Chicago: University of Chicago Press, 2010.

Georg von Neumayer Station, Neumayer Station, Neumayer III Station

The Georg von Neumayer Station (70° 40′S 8° 16′W), today called the "Neumayer III" station, is a year-round Antarctic research station operated by the German Alfred Wegener Institute—Helmholtz Centre for Polar and Marine Research (AWI), the federal German polar research institute. The station is located on the Ekström Shelf Ice in Atka Bay on the northeastern side of the Weddell Sea.

The original Georg von Neumayer Station was constructed during the season 1980/1981 and inaugurated on February 24, 1981. The station was built in a tube design with two main tubes each of 160 ft. (50 m) in length housing the actual station consisting of standardized containers for labs, infrastructure, and crew-quarters. Due to snow accumulation on top of the tubes, an actual sinking of the tubes into the ice, and the movement of the surrounding ice sheet toward the coastal ice edge, the original Georg von Neumayer station needed to be given up in 1993 when the new Neumayer station began operations.

The design for the new station followed basically the same principles as for the original station, but the research program for the new station was expanded and included significant activities related to ozone and atmospheric research, sea-ice research, and acoustic monitoring of ocean mammals. In addition, the new station was designed to serve as a supply base for various temporary summer stations and included an ice runway for research aircraft, in particular the Dornier 228 airplanes operated by the AWI. In 2004, the AWI announced plans to build again a new Neumayer station, as the station has sunk substantially into the ice. When the station was finally abandoned in 2008, it was more than 10 m below the actual ice surface.

Opposite to the two previous stations, today's Neumayer III station is located above surface and based on hydraulic jacks so that the station can be lifted to compensate for the annual snow and ice accumulation. In early 2009, the construction of Neumayer III began. It is designed to last for about 25–30 years. Designed for an overwintering crew of nine scientists and summer operations of up to 50 scientists, the crew is basically the same as for the two previous stations, but laboratory space (1,300 sq. ft. or 120 sq. m) is roughly double the size. Annual consumption of polar-diesel fuel for the operation of the station is approximately 83,000 gallons (315,000 liters).

The Neumayer III station and its predecessors are together with the polar research vessel *Polarstern*, the centerpiece of the various German Antarctic research programs. Main research areas of the Neumayer station include meteorology, geophysics, and atmospheric chemistry supplemented by various other areas like marine hydro-acoustics. Neumayer III station is considered as one of the most sophisticated permanent research stations in Antarctica.

The operation of the Neumayer station is the base for the consulting status of the Federal Republic of Germany within the Antarctic Treaty System, despite Germany's relinquishing territorial claims in Antarctica (i.e., New Swabia) after the end of World War II.

Ingo Heidbrink

See also: Antarctic Programs and Research Stations/Bases

Further Reading

Alfred Wegener Institute for Polar and Marine Research. Neumayer Station III: The New German Research Station in the Antarctic. 2000. http://www.awi.de/en/infrastructure/stations/neumayer_station/. Accessed January 9, 2014.

Augstein, E. *The Observatories of the Georg von Neumayer Station: [(70° 37′ S 08° 22′ W)].* [Bremen]: [Kamloth], 1984.

Neumayer Antarctic Research Station. http://WWW.AWI-Bremerhaven.DE/MET/Neumayer/. Accessed January 9, 2014.

Reinke-Kunze, C. *Antarktis: Aufzeichnungen von einer Überwinterung auf der Forschungsstation Georg von Neumayer.* Blieskastel, Germany: Gollenstein, 1998.

Rootes, D. "The Design and Serviceability of Antarctic Stations." M. Phil. thesis, University of Cambridge, 1987.

Geospace

The space immediately around the earth, including the upper atmosphere, ionosphere, and magnetosphere, is known as *geospace.* This region is of considerable scientific interest since it is the environment inhabited by most artificial (communication, navigation, meteorological, etc.) satellites. In addition to in situ measurements, observations of geospace are commonly made at high latitudes because the earth's magnetic field focuses phenomena from a large volume of space down onto a relatively small portion of the earth's surface. Both the Arctic and Antarctic are suitable sites. However, the Antarctic continent provides a better environment for the construction of research facilities. A significant number of countries with bases in Antarctica are engaged in geospace research.

Geospace is filled with plasma, which is a partially or fully ionized gas. As the fourth state of matter, plasma has characteristics that are completely different from those of neutral gas: the motions of charged particles in plasma are strongly influenced by externally imposed magnetic fields, as well as the electric fields from other charged particles and electromagnetic waves. This has important consequences for charged particle dynamics as well as the propagation of electromagnetic waves.

The plasma in geospace is permeated by the earth's magnetic field and largely controlled by it. The earth's intrinsic magnetic field is roughly dipolar (similar to that of a bar magnet). Magnetic field lines radiate outward from the surface of the earth near the North Magnetic Pole and extend a great distance into space before converging near the South Magnetic Pole. The magnetic field lines therefore cluster near the poles but are widely separated in the equatorial plane. For example, field lines separated in latitude by 60 miles (100 km) near the magnetic latitude of 60° on the surface of the earth are separated by about 900 miles (1500 km) in the equatorial plane. This means that a relatively small area on the earth's surface maps to a very large volume of geospace. The magnetic field lines near the magnetic poles therefore act like an enormous funnel, concentrating the influences of most of geospace down onto only a small portion of the surface of the planet. Somewhat surprisingly, the earth's North Magnetic Pole is currently located in the Southern Hemisphere (64° S 138° E), which is off the coast of Antarctica. The South Magnetic Pole is in the Canadian Arctic territory.

The geospace environment is linked to the sun by the interplanetary magnetic field (IMF) and the solar wind. The solar wind is plasma that flows at supersonic speeds (typically around 400 km/s) from the surface of the sun. The solar wind exerts pressure on the earth's magnetic field, confining it to a cavity known as the *magnetosphere.* The orientation of the IMF and the speed and density of the solar wind, which vary with solar activity, have a marked effect on the state of the magnetosphere. The magnetosphere forms an enormous plasma physics laboratory, orders of magnitude larger than any terrestrial laboratory. This means that large-scale plasma physics phenomena, which are impossible to replicate on earth, can be studied.

Charged particles move easily parallel to magnetic field lines. However, the Lorentz force causes them to gyrate in a plane perpendicular to magnetic field lines. As a result, ions and electrons in the magnetosphere move on spiral paths along magnetic field lines. As a charged particle approaches a magnetic pole, the magnetic field strength increases and the speed of the particle along the magnetic field line is reduced. At some point, the particle is reflected back up the magnetic field line into the magnetosphere. This *mirror point* is at an altitude determined by the particle's velocity. If the mirror point is within the neutral atmosphere, then there is a high probability that the particle will collide with a neutral atom or molecule, in which case it will lose energy and will not return to the magnetosphere. Such a particle is said to have *precipitated.* Positive and negative charged particles also drift in opposite directions around the earth, forming a *ring current* that causes measurable magnetic effects on the earth's surface.

The *aurora australis* and *aurora borealis* (the southern and northern lights) are caused by energetic electron precipitation. Collisions between these electrons and neutral atoms or molecules in the upper atmosphere leave the neutrals in an excited state from which they subsequently decay by emitting light. Typically, the light is either green, red or violet, depending on the altitude of the emission. Green aurora, the most common, is due to the excitation of atomic oxygen.

Cosmic rays are extremely high-energy particles originating from outer space, generally outside the solar system. Most cosmic rays are atomic nuclei (predominantly hydrogen and helium atoms stripped of their electrons). They produce a cascade of secondary particles when they enter the earth's atmosphere. Some of these secondaries are able to penetrate the earth's surface. Since cosmic rays are charged particles, they too are able to access the earth's lower atmosphere more readily near the magnetic poles. Only the most energetic cosmic rays can penetrate to the ground near the equator.

Certain electromagnetic waves are also affected by the earth's magnetic field. Whistler-mode waves propagate along magnetic field lines through a plasma. Lightning strokes are the main source of whistler-mode waves. Some electromagnetic energy from lightning penetrates through the ionosphere and enters the magnetosphere, where it propagates in the whistler mode. Magnetic field lines guide the waves to the opposite hemisphere where they penetrate down through the ionosphere to reach the ground. The whistler mode is dispersive, which means that distinct frequencies travel at different speeds. The brief electromagnetic pulse generated by lightning is thus transformed as it passes through the magnetosphere into a unique signal that emerges in the opposite hemisphere. This is called a "whistler." Measurements of whistler dispersion are used to determine plasma densities at great distances from the earth, which otherwise could be measured only by satellites.

Andrew B. Collier

See also: Arctic Observatories; Ionosphere, Polar; Space Weather

Further Reading

British Antarctic Survey. The Sun and Geospace. 2010. http://www.antarctica.ac.uk/about_antarctica/teacher_resources/resources/schoolspack/10geospace_dl.pdf. Accessed January 9, 2014.

German Antarctic Expedition (1938–1939)

After the completion of the first and second German Antarctic Expeditions, it took up to the mid-1930s before Germany participated again in the exploration of Antarctica with a full-scale expedition. In particular, the German interests in the Antarctic whaling industry fostered the plans for a new expedition to Antarctica with the ultimate goal of identifying an area suitable for establishing a German whaling base in Antarctica. The focus of the expedition was on the sector between 20° W and 20° E in the eastern part of Antarctica.

Based on the experiences with the operation of seaplanes and catapult-ships gathered by the German airline Lufthansa in the context of South American operations, the design of the expedition asked for the use of seaplanes and a

Aerial view of the GAUSS in the ice during the German Antarctic Expedition. This picture was obtained from a balloon and is one of the first aerial photographs of the Antarctic environment. (National Oceanic and Atmospheric Administration) catapult-ship for the exploration of large regions of Antarctica. The expedition left Hamburg on December 17, 1938, with the catapult-ship *Schwabenland* and two seaplanes of the type Dornier-Wal (Do J-II). Leader of the expedition was Alfred Ritscher (1879–1963), a sea captain with substantial experience in the operation of seaplanes. After their arrival in Antarctica, the two seaplanes were deployed for a number of reconnaissance flights and a total of more than 11,000 aerial photographs of up to now unknown territory could be made. In addition to the aerial photographs, German flags were placed at various locations within the area of the expedition for substantiating a German territorial claim. A huge number of names were attributed to geographic features newly explored during the expedition, with many names still to be found on the maps of Antarctica of today. Finally, the region between 12° W and 18° E and 70°–75° S was claimed by the Nazi authorities under the name of New-Suebia (Neuschwabenland), with the claim being contested by Norway, which claimed the same region under the name "Dronning Maud Land" (more commonly called "Queen Maud Land"). The expedition returned to Germany on April 11, 1939, after charting a substantial part of Antarctica.

The immediate perception of the expedition by the Nazi authorities and the public after the return to Germany was poor despite substantial geographic achievements. After the end of World War II, the Federal Republic of Germany abandoned all territorial claims for New-Suebia but continued the claims of the geographic names attributed during the expedition.

After the war, the German Antarctic Expedition of 1938/1939 also became the center of a widespread conspiracy theory or myth, basically consisting of the idea that the expedition was a cover for establishing a Nazi military base in Antarctica that should have served as a U-Boat base and shelter for Nazis after the end of the war. According to all archival documents, there is no evidence of the expedition being anything else than a scientific endeavor, reconnaissance for the establishing of a whaling station, and staking a territorial claim.

Ingo Heidbrink

See also: First German North Polar Expedition (1868); Heroic Age of Antarctic Exploration (ca. 1890s–1920s); Second German Antarctic Expedition (1911–1912)

Further Reading

Lüdecke, C., and C. Summerhayes. *The Third Reich in Antarctica: The German Antarctic Expedition, 1938–39.* Norwich: Erskine Books, 2012.

Schön, H. *Mythos Neu-Schwabenland: für Hitler am Südpol: die deutsche Antarktisexpedition 1938–39.* Selent, Germany: Bonus-Verlag, 2004.

Summerhayes, C., and P. Beeching. "Hitler's Antarctic Base: The Myth and the Reality." *Polar Record* 43, no. 1 (2007): 1–21.

Gerritsz, Dirck (a.k.a. Dirck Gerritszoon Pompor) (1544–1608)

In 1598, a fleet of five ships left Europe from the port of Rotterdam to find a westward route to Asia. A reshuffle of commands occurred following the death of the expedition leader Jacques Mahuin 1598. Dirck Gerritsz received command of the ship named *Annunciation* (Blijde Boodschap). Storms dispersed the fleet when it risked the Straits of Magellan late in 1599. The *Annunciation* passed the straits, but was blown off course southward. Then, the *Annunciation* was so short of supplies that the Dutch ship had to enter the port of Valparaíso, where it was captured by the Spanish enemy. Interrogations of Dirck Gerritsz and some of the other leaders have been preserved in national libraries of Spain.

How far southward did Gerritsz come? The written Spanish records mention as far south as merely 56° S or 57° S. But later on, Le Maire, a Dutch explorer who would discover Cape Horn, wrote that it was as far as 64° S: "Due to all the headwinds it is apparent that Dirck Gerritsz, having lost his BowSprit and Forward JibMast, was driven so far southwards, namely at four and sixty degrees southern of the Strait, being at that latitude, saw in the south lying very high mountainous Land, full of snow, as the land of Norway, very white covered." Those in favor of the latter 64° S argue that Dirck Gerritsz was intentionally misleading his Spanish interrogators so as to conceal strategic information. Dirck Gerritsz was freed as part of a small group of prisoners in the final stage of a prisoners' exchange five years later in 1604. He headed for home where he once again established himself as a merchant in the town of Enkhuizen. In 1606, he signed on for another expedition and reportedly died at sea in 1608.

The city of Amsterdam included Dirck Gerritsz's discovery in the newly built (1648–1665) town hall (nowadays the Royal Palaceor Dam Palace). Two brass hemispheres are inlaid in the white marble floor of the large Citizen's Hall (Burgerzaal). In one hemisphere, the then known small part of Antarctica's coastline is present. This extra piece of the puzzle has never been published in scientific literature but confirms that the Antarctic coastline was already known at that time and strongly supports the claim that Dirck Gerritsz was the first to see Antarctica (Islands, i.e., the South Shetlands). Indeed, for a long time in charts of Antarctica, these were called the Dirck Gerritsz Archipelago. No matter what truly happened in 1599, Dirck Gerritsz—who had previously been in China, India, and Japan—has led the amazing adventure aboard *Annunciation* and was definitely one of the most remarkable and daring explorers of his time.

D. (Dick) A. van der Kroef

See also: Dirck Gerritsz Laboratory, the Netherlands

Further Reading

de Baar, H.J.W. *The Dirck Gerritsz Laboratory: The Story Behind the Name* (*Het Dirck Gerritsz Laboratorium: het verhaalachter de naam*). Bilingual ed. Edited by R. Prop, L. Noor, and D. A van der Kroef. The Hague, the Netherlands: NWO, printed by Oranje van Loon, 2013.

Grasshopper Effect

The Arctic is affected by human industrial and agricultural activities that originate in other regions of the hemisphere. One process that leads to the northward atmospheric transport and eventual accumulation of contaminants like persistent organic pollutants (POPs) has been nicknamed the "grasshopper effect." This effect is described as a global distillation process in which a molecule is evaporated at the warmer latitudes. When it travels to an area of lower temperature, the molecule condenses out and settles back to the land or the water. The result is POPs are transported from the warmer regions to the colder, Arctic region. This cold condensation theory describes the movement of molecules like POPs and is used to explain the unexpected concentrations of POPs that have been found in Arctic people and animals. Especially troubling is the presence of POPs in Arctic breast milk, implying the possibility of intergenerational impacts. Based, in part, on this grasshopper effect of POPs, the United Nations created the Stockholm Convention in May 2001 calling for the elimination of 12 of the more problematic POPs from production and use.

Arctic lands and seas are occupied by mammals that are highly adapted to Arctic temperatures and seasonal cycles. Many species use fat stores for both insulation and energy throughout the long winter. Large drops in temperature during the winter season results in a global fractionation based on vapor pressures, lipophilicities, molecular weight, solubility, and rates of degradation, resulting in a redistribution of molecules from tropical and temperature regions to polar regions. Since the octanol/water coefficients of POPs vary and are related to their lipophilicity, POPs move at different rates northward to the Arctic. The grasshopper effect is a relatively slow seasonal process that occurs over successive cycles of evaporation and condensation. This process is most effective for semivolatile chemicals that break down very slowly in the environment. POPs, with very high lipophilicity, are bound more tightly to plants and soil so they spend less time in the atmosphere, resulting in a slower movement toward higher latitudes. For example, hexachlorobenzene, polychlorobiphenyls, and lindane accumulate in higher concentrations in the Arctic. The grasshopper effect can explain why Arctic indigenous people, living a subsistence lifestyle, have high body burdens of certain POPs. Thus, despite their distance from heavy industry and agriculture, Arctic peoples are one of the most at-risk populations for the accumulation of PCBs and pesticides.

Since the far north is vulnerable to air pollution moving northward, Arctic people face a greater risk both as individuals and as groups. Little was known of POP components until the 1980s and 1990s, when these pollutants, with no local sources, were observed to have accumulated in the Arctic food webs. Wild foods sustain indigenous peoples in this region both physically and spiritually. Hundreds of remote communities are financially dependent on their subsistence resources. Precautionary regulation of persistent toxic substances for Arctic people who eat wild food was realized by diplomatic efforts such as the Rio Declaration and the Stockholm Convention.

Lawrence K. Duffy

See also: Arctic Air Pollution; Arctic Haze

Further Reading

Godduuhn, A., and L. Duffy. "Multi-Generational Health Risks of Persistent Organic Pollution in the Far North." *Environmental Science and Policy* 6, no. 4 (2003): 341–53.

Newman, M. *Fundamentals of Ecotoxicology.* Ann Arbor, MI: Ann Arbor Press, 1998.

Simonovich, S., and R. Hites. "Global Distribution of Persistent Organochlorine Compounds." *Science* 29. 1995: 269(5232): 1851–1854.

Wania, F., and D. Mackay. "Tracking the Distribution of Persistent Organic Pollutants." *Environmental Science and Technology* 30 (1996): 390–96.

Gray's Beaked Whale

Gray's beaked whale (*Mesoplodon grayi*) is a member of the family Ziphiidae. The group is composed of 21 recognized species most of which are known largely from stranded or beached specimens. The whale was described in 1876 by Julius von Haast, director of the Canterbury Museum in Christchurch, New Zealand. In 1874–1875, Julius received three skulls from a group of 28 stranded whales on Waitangi Beach, Chatham Island, New Zealand. Von Haast honored British taxonomist, John Edward Gray, with the species name. Other common names are Scamper down whale and southern beaked whale.

The beaked whales are wide ranging with *M. grayi's* distribution being circumpolar and in the temperate waters of the Southern Hemisphere, south of 30° latitude. They have been sighted in Antarctic and subantarctic waters, and, in summer, along the shores of the continent. Stranded or beached specimens and groups have been recorded along the coasts of New Zealand, southern Australia, Argentina, Chile, Peru, and South Africa. They are a deepwater species primarily living off the colder continental shelf edges and canyons. An area between the south island of New Zealand and the Chatham Islands has the reputation of being a hot spot for sighting Gray's beaked whales. There appears to be no indication of a North Atlantic population.

M. grayi are generally seen in waters deeper than 6,500 ft. (2,000 m). However, they frequent shallow waters as indicated by the number of sick animals that beach or strand along the coasts of Australia and New Zealand from December to April. Sightings are infrequent, and there are no estimates on abundance.

M. grayi are dark brown to gray on back and sides and white to dark gray on the underside. The beak is white or light colored with lighter flecks or specks. Flippers are short and broad. Gray's beaked whales feed on cephalopods usually smaller than 500 g found in deep waters. They are strong swimmers and divers capable of pursuing prey at depths of 650 ft. (200 m) or more. They are thought to be suction feeders because they lack functional teeth. This exclusivity in diet suggests that *M. grayi* affect squid populations.

The life cycle and habits of *M. grayi* are largely unknown. According to Ross (2006), *M. grayi* reaches sexual maturity at about 15 ft. (4.5 m). Both sexes have a single pair of enlarged triangular tusks in the lower jaw. Scarring on both males and females suggests that there may be physical competition among the males for females. The gestation period is unknown; calves are born from summer through autumn. Birth length is about 7 ft. (2.1 m). Weaning occurs at about 12 ft. (3.6 m). The calving interval is at least three to four years, which limits population growth.

The whales exhibit sexual dimorphism. Generally, females are larger than males. Courtship and mating typically include belly contact between the pair. They may interlock vertically, or the male swims upside down underneath the female. Chasing, breaching, and flipper contact are behavioral clues, which convey readiness to mate.

Human impacts are the primary threats to this species. They are captured by gillnet and longline fisheries throughout their range. As are other beaked whale species, they are likely to be affected by navy sonar and seismic exploration. Gray's beaked whales, a cold water species, may be vulnerable to ocean warming due to the effects of climate change.

Joyce M. Shaw

See also: Beluga Whale; Bowhead Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Northern Bottlenose Whale; Southern Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Australian Museum. Animal Species: Gray's Beaked Whale. 2009. http://australianmuseum.net.au/Grays-Beaked-Whale. Accessed October 10, 2013.

Ross, G.J.B. *Review of the Conservation Status of Australia's Smaller Whales and Dolphins*. Report to the Australian Department of the Environment, 2006. http://www.environment.gov.au/resource/review-conservation-status-australias-smaller-whales-and-dolphins. Accessed January 9, 2014.

Wang, A. Animal Diversity Web. "*Mesoplodon grayi.*" 2004. http://animaldiversity.ummz.umich.edu/accounts/Mesoplodon_grayi/. Accessed November 1, 2013.

Gray Whale

The gray whale (*Eschrichtius robustus*) is the sole member of the family Eschrichtiidae. The common name comes from their grayish skin color. All other members of this family are known only from fossil material. Gray whales are easily recognizable by their mottled grayish appearance and lack of dorsal fin; instead, they have knobs or small humps on the final third of the back. The gray whale is a medium-sized baleen whale that can reach more than 45 ft. (14 m) in length and weigh more than 66,000 pounds (30,000 kg). Adult females on average are larger than males. They have 130–180 yellowish baleen plates, each about 18 inches (45 cm) long. Gray whales are usually grayish black when born. Over the time, they acquire barnacles that form large colonies embedded in the whale's skin and produce scars and scratches. They are also hosts to large concentrations of whale lice that result in white, orange, or yellow patches and spots that give the whale a grayish appearance. Gray whales live between 50 and 70 years.

The population of gray whales is about 20,000–22,000 individuals. There are two populations of gray whales: one in the eastern North Pacific, migrating between Alaska and Baja California, and the other in the western Pacific that is critically endangered. The latter consists of about 130 individuals, and they migrate between the Sea of Okhotsk and southern Korea. Gray whales in the North Atlantic populations were extirpated, probably by whaling on the European coast before the fifth century and on the American coast around the early eighteenth century.

Gray whales feed in shallow water over continental shelves in the Bering and Chukchi Seas. They dive up to 550 ft. (170 m), but usually prefer 165–195 ft. (50–60 m) depths and can stay under water up to 25 minutes, but usually 3–10 minutes. They turn on their side and scoop up mouthfuls of mud and small benthic crustaceans, and, after forcing the mud and water out through baleens that act as a sieve, swallow the crustaceans. Plates on the right side are shorter and more worn because gray whales mainly bottom-feed on the right side. More scars appear on the right side of the head, and many older animals are losing eyesight in the right eye over the time. This particular feeding habit and need for large amounts of certain crustaceans may restrict their distribution to coastal environments in the Chukchi and Bering Seas. Gray whales primarily feed on amphipods as well as mysids. An individual gray whale gains about 16–30 percent of its body mass during a five-month stay feeding in the Arctic and consumes about 900 pounds (409 kg) per day of benthic prey, or more than 61 tons during the whole feeding period along Chukotka. The access to abundant benthic food resources during summer is likely critical for survival and reproduction.

Gray whales are highly migratory, and each year, many whales from the eastern North Pacific population undertake long seasonal migrations between summer feeding grounds in the Bering and Chukchi Seas and winter breeding grounds in Baja California. However, only one-third of the estimated northeastern population, mainly pregnant and mature females, males, and some juveniles, make the longest well-known migration southward (a 9,900-mile [16,000-km] round-trip). The rest of the population spreads out along the coast of North America, from Alaska to California. The gray whales bear young in warm, shallow coastal areas, and lagoons. Gray whales become sexually mature between 5 and 11 years of age. Females usually give birth to a single calf every other year. Calves are about 15 ft. (4.5 m) long when born and are nursed for eight to nine months. Mother and calf stay together and remain active inside the lagoons and start migration to the feeding grounds at the end of breeding season when the calf is about two months old. When traveling, gray whales tend to be gregarious, but are not highly social. Larger aggregations in tens or even thousands can occur in a particularly rich feeding area. In the breeding areas, large aggregations of mothers with young and courting/mating whales are common.

Gray whales are hunted only by killer whales (calves and young ones) and humans. Gray whales are under protection from commercial hunting since 1949 by the decision of International Whaling Commission and are no longer hunted on a large scale. Limited hunting is permitted for the eastern North Pacific gray whales under an aboriginal/subsistence whaling exception to the commercial hunting ban, primarily by native people of Chukotka and Washington State. A total catch of 620 whales was allowed for the years 2008–2012 with a maximum of 140 in any one year.

Monika Kędra

See also: Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Northern Bottlenose Whale; Southern Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Berrett-Lennard, L., et al. "Predation on Gray Whales and Prolonged Feeding on Submerged Carcasses by Transient Killer Whales at Unimak Island, Alaska." *Marine Ecology Program Series* 421 (2010): 229–41.

Heide-Jørgensen, M., et al. "Identifying Gray Whale (*Eschrichtius Robustus*) Foraging Grounds along the Chukotka Peninsula, Russia, Using Satellite Telemetry." *Polar Biology* 35 (2012): 1035–45.

Salvadeo, C., et al. "Impact of Climate Change on Sustainable Management of Gray Whale (*Eschrichtius Robustus*) Populations: Whale-Watching and Conservation." *Archives of Biological Sciences* 65 (2013): 997–1005.

Great Auk

Once widely distributed in the North Atlantic region, the flightless great auk (*Pinguinus impennis*) rapidly decreased during early modern times and became extinct due to unsustainable hunting. It was an excellent diver in the sea, but almost helpless on land during the breeding season. The great auk was killed in mass for food as well as for its fat for the European train oil market. Its size combined with being flightless made the goose-sized bird an easy prey for human predators.

The species has been hunted for a long time. For example, the prehistoric Dorset hunted the great auk for centuries. Funk Island, outside northeastern Labrador, had a large breeding population, which was harvested by the Canadian indigenous group the Beothuks without any effect on the colony. However, the take was not always sustainable, and already in prehistoric time, it was being overexploited, causing a local reduction in range in some areas.

The Danish missionary Otto Fabricius, in 1780, provided a unique insight into Kalaallit hunting of the great auk. The Kalaallit knew the bird under the name *isarukitsoq* "the stump-winged." Fabricius writes that the great auks were driven in flocks around the sea and were forced by loud cries to stay under the water surface. The stressed birds thereby became exhausted, which greatly facilitated the catch. The Kalaallit used all parts of the bird: meat and intestines for food; the fat for food and for fuel; the hides were used by the locals in the furs, which they wore close to the body; the windpipe was inflated and mounted as a bladder on the bladder dart; and the black hide from the feet was used for ornamental purposes in sealskin bags. It was obviously of great economic importance for the locals.

The increase in killings quickly reduced the population. The species survived on some remote islands in the subarctic region until the nineteenth century, when the last specimens were killed for museum collections. The last record of great auks being killed, in Greenland, was from 1815. In 1844, the small islet of Eldey off the coast of Iceland was where the last known specimens were killed.

Ingvar Svanberg

See also: Arctic Seabirds; Little Auk

Further Reading

Fuller, E. *The Great Auk.* Southborough, UK: Privately Published, 1999.

Jordan, R., and S. Olson. "First Record of the Great Auk (*Pinguinus impennis*) from Labrador." *The Auk* (University of California Press) 99, no. 1 (1982): 167–68.

Milne, J. "Relics of the Great Auk on Funk Island." *The Field* (1875).
Montevecchi, W., and D. Kirk. "Breeding-Great Auk (*Pinguinus impennis*)." *The Birds of North America Online.* Cornell Lab of Ornithology, 1996.

Greenland

Greenland is the world's largest island with an area of 836,330 square miles (2,166,086 sq. km). It is called Kalaallit Nunaat ("Land of the Greenlanders") by its inhabitants. This northernmost country, which lies between the Arctic Ocean and the North Atlantic Ocean, northeast of Canada, is bordered by Davis Strait, Baffin Bay, and Nares Strait to the east and by Denmark Strait to the west. The North Pole is only 460 miles (700 km) away from Odaap Qeqertaa (Odak Island) at 83° 40′N near Cape Morris Jesup. From this northernmost point, the southern tip of Greenland, Nunap Isua (Cape Farewell) at 59° 46′N, is located about 1,660 miles (2,670 km) off. From west to east, there is a maximum distance of more than 650 miles (1,050 km). With its mountainous, rugged, rocky coast and its long deep fjords, Greenland owns a coastline of approximately 24,855 miles (40,000 km) in length. The Arctic Circle crosses the country at 66° 33′N and brings about north of it the experiences of both midnight sun in summer and periods of polar night with polar dark and polar light in winter.

Physical Geography and Climate

The cold Arctic climate gives Greenland a distinct physical landscape, which is dominated by the Greenland Ice Sheet (inland ice or *sermerssuaq*, meaning "great ice cover"), which can grow up to 9,800 ft. (3,000 m) in height. Only about 20 percent of the country along the coastal strip is free from ice. The rest is covered by a massive ice cap, which is the second largest compared with the size of the Antarctica Ice Sheet. With an area of 700,000 square miles (1,800,000 sq. km), the ice cap contains 9–10 percent of the world's resources of freshwater. There are only a few places where the ice cap in terms of glaciers reaches all the way to the sea and produces about 300 cubic km of icebergs per year. About 10 percent of these large blocks of freshwater ice originate from the glacier Sermeq Kujalleq near the town Ilulissat (meaning "icebergs") in Disko Bay at the west coast. This most productive glacier in the Northern Hemisphere moves at a rate of 65 ft. (20 m) a day. Around 20 million tons of icebergs calve every year and get to the Baffin Bay through the 25-mile (40-km) long Ilulissat Ice fjord, a UNESCO World Heritage Site since 2004. The ice-free coastal areas are mainly characterized by highlands. With 12,139 ft. (3,700 m), the mountain Gunnbjørn Field represents the highest point of Greenland and is situated in the east of the island. The natural resources of Greenland include zinc, lead, coal, molybdenum, gold, silver, platinum, uranium, and possibly oil and natural gas. Climatic, ecological, and financial concerns have limited the exploitation of these resources until now.

Due to the country's location in the Arctic, the average temperature in the annual average never rises above 50°F (10°C). Greenland is characterized by several climatic zones including the High Arctic, the Arctic, the Low Arctic, and the subarctic. In North Greenland, the mean temperature in winter times reaches −22°F to 5°F (−30°C to −15°C), while in summer, the mean temperature rises up to 41°F (5°C). In South Greenland, in winter, the mean temperature ranges between 23°F and 32°F (−5°C and 0°C), and in summer, it can reach 45°F or 54°F (7°C or 12°C). Greenland is a country that has very extreme seasons and high differences in temperature: With −0.2°F (−17.9°C), Kangerlussuaq in West Greenland has the lowest average temperature in March, and, with 54.5°F (12.5°C), the highest average temperature in July. With −8.1°F (−22.3°C), Qaanaaq in North Greenland has the lowest average temperature in February, and, with 47.5°F (8.6°C), the highest average temperature in July.

Flora and Fauna

The country's vegetation is generally limited. As a result of the low temperatures in Greenland, the soil is dominated by permafrost defined as a layer of permanently frozen earth, which occurs in Greenland in continuous, discontinuous, and sporadic patterns. In summer times, only the top soil layers thaw. As a result of short summers combined with reduced precipitation, no real forests grow; just single trees and bushes in South Greenland, which are often only as tall as a man. As an exception applies the Qinngua valley (Nanortalik District in South Greenland) as the only true forest in Greenland, consisting of mountain birch and northern willow, which grow from 19 to 26 ft. (6–8 m). To a limited extent, agriculture is possible in South Greenland. The main characteristics of the plant life are low-growing mountain plants and tundra vegetation including plants like lichens, dwarf willow, and dwarf birch, sedges, grasses, and many varieties of flowering plants, mosses, and herbs. During the years, these plants are more or less covered by snow for 9–11 months.

In the rich Greenlandic water, there are several species of marine mammals, such as ringed seal, harp seal, hooded seal, and bearded seal, polar bear, walrus, narwhal, beluga (white whale), fin whale, minke whale, and humpback whale, and harbor porpoise and various species of dolphins. In Greenland, more than 150 species of fish can be identified, for instance, species of cod, Greenland halibut, salmon, Arctic char, lumpfish, capelin, and catfish. There are only a few terrestrial mammals in Greenland including polar bear, reindeer, musk ox, Arctic hare, Arctic fox, ermines, lemmings, and farmed sheep. The sea and coastal areas of

Greenland, where 235 species of birds can be observed, are rich in bird fauna, as well: whereas raven and snowy owl stay in the country the whole year, other bird species migrate to Greenland during the summer, for example, Arctic tern, snow bunting, different species of goose, guillemot, little auk, and wheatear, and birds of prey such as the white-tailed eagle, the peregrine falcon, and the gyrfalcon. Altogether, more than 9,400 different species of plants and animals are explored in Greenland to date.

People, Self-Government, and Society

Greenland has a total population of 56,749 persons (2012) of which 51,294 persons have strong family ties to Greenland either because they were born in Greenland themselves or at least one parent was born in Greenland. As 53 percent of the total populations are male, there are more males (30,041) than females (26,708). Only 8,517 persons reside in settlements (January 2012) compared to 48,232 persons in urban environments. The biggest town is the Greenlandic capital Nuuk with 16,181 inhabitants (January 2012). The next main towns are Sisimiut (5,571), Ilulissat (4,621), Qaqortoq (3,297), and Aasiaat (3,146).

The Greenlandic Inuit, which call themselves Kalaallit (singular Kalaaleq, meaning "Greenlander(s)"), are one group of indigenous peoples in the Circumpolar North. In contrast to other indigenous communities in the world, the Greenlanders make up the majority of the country's population: 89 percent of the total population was born in Greenland. Historically, they originated from three distinct cultural and linguistic groups: the Kitaamiut (West Greenlanders), the Tunumiut or Iit (East Greenlanders), and the Inughuit of North Greenland (Thule people).

The emergence of the collective identity Kalaallit as an imagined political community owes its origins to colonization: in 1721, Greenland became a Danish Norwegian colony and a Danish colony in 1814. During that time, the (Western) Greenlandic language was established as the official written language used in schools and in the national newspapers. Furthermore, the relationship between colonizers and colonized supported an articulation of a common collective identity. The official end of the colonial era was proclaimed in 1953 when Greenlandic citizens were granted the same status as Danish citizens within the Kingdom of Denmark. However, all important decisions were made by Denmark—in this case against the will of Greenlanders (e.g., joining the European Economic Community in 1972). Due to the introduction of the Greenland Home Rule Act signed on May 1, 1979, this was changed. The Home Rule act (Hjemmestyre) guarantees more rights for Greenlanders than other self-governance arrangements for indigenous populations in the circumpolar North.

The process of Greenlandization is ongoing; just recently on June 21, 2009, Greenland opted for self-rule in lieu of home rule (Selvstyre). Over time, the national solidarity of a postcolonial Greenlandic society is expressed by national symbols as the hymn “Nunarput utoqqarsuanngoravit” (“You Our Ancient Land”) (since 1979), the national flag (since 1985), the National Day celebrated in June 21 (since 1985), and the symbol of the bear as the national emblem (since 1987). Furthermore, Greenland had a revival of its own native language, which today represents the official language and the local Greenlandic food *kalaalimernit.*

SIRIUS SLEDGE PATROL

Prior to World War II, only a dozen hunters and a number of weather observers occupied northeast Greenland. Each hunter used a small cabin near the middle of an approximately 60-square-mile hunting territory as a base.

Greenland was a Danish territory at the outbreak of the war. When Denmark capitulated to the Germans in April 1940, however, the Greenland governor (Eske Brun) did not concede defeat. After consulting with the Americans (who did not have resources to spare, but were anxious for intelligence), he asked for volunteers from among the hunters to keep an eye out for any German activity along the coast. They undertook this task as well, as their previous hunting, to become the “Sledge Patrol.”

One open conflict occurred after a couple of hunters deputized into the Sledge Patrol discovered a German weather station at Hansa Bay on the northeast coast of Sabine Island. This led to the Germans following the hunters and attacking them. One of the hunters was accidentally killed by the Germans, leading to a crisis of conscience by the German leader (see *The Sledge Patrol* by David Howarth). The German base at Hansa Bay was eventually destroyed by U.S. Air Force bombers from Iceland.

After the war, the unit was renamed the “Sirius Sledge Patrol” (more commonly called just the “Sirius Patrol”) and now operates within the Greenland Command, administratively under the Royal Danish Navy. The Sirius Patrol currently consists of six dogsled teams, each consisting of 2 men and 11–15 dogs. When traveling, each team carries approximately 770–1100 pounds (350–500 kg), depending on the distance to the next depot.

The Sirius Patrol also acts effectively as wardens for the Northeast Greenland National Park. Currently, there are 14 officers and men serving with the patrol. One major base lies on Ella Island (not too far from the southern boundary of the Park) and another at Daneborg, a couple of hundred miles further north. Many of the old-hunting cabins still exist as refuges along the coast, some more habitable than others.

William (Bill) F. Isherwood

The political system in Greenland is based on the division of Inatsisartut (Parliament of Greenland) as legislative power and Naalakkersuisut (Government of Greenland) as the governing power. The Premier (president of Naalakkersuisut) is elected by Inatsisartut, where a number of parties have been elected for a period of four years by all adults aged 18 or older. Among them are Siumut (Forward), a social democratic party that promotes self-determination while being loyal to the Kingdom of Denmark; Inuit Ataqatigiit (United Inuit), a left-wing party that favors full independence from Denmark; Demokraatit (Democrats), a social liberal party, which aims for a self-governing society; Atassut (Solidarity), a liberal party that supports for self-government taking Greenland's historical relations with Denmark into account. As a single constituency, the voters of Greenland also elect two members to the Danish parliament (Folketing). Consequently, a high commissioner represents the Danish government in Greenland. The introduction of self-government allowed additional fields of responsibility to be assumed by Greenland, except for judicial, defense, and monetary policy. In 2009, the 18 municipalities of Greenland, which existed until then, were aggregated to only four: Kommune Kujalleq, Kommuneqarfik Sermersooq, Qeqqata Kommunia, and Qaasuitsup Kommunia.

Economy

Fishing is the primary industry of Greenland, whereas tourism is gradually developing. The primary sector of employment is the public administration and the fishing industry. Greenland is still dependent on substantial financial aid (3.4 billion Danish kroner per annum) from Denmark. Greenland is characterized by a mixed subsistence-based economy. Despite the rapid economic, social, and cultural changes, most of the Greenlandic households make a living by a combination of subsistence activities of hunting and fishing, gainful occupation, and transfer payments. Only 2,081 full-time hunting licenses were issued in 2010 compared with 5,550 leisure-time hunting licenses.

Frank Sowa

See also: Greenland, U.S. Bases in; Greenland Ice Sheet; Greenland Sea; Greenland Shark; Inuit; Inuit and Yup'ik Concepts of "Ihuma" and "Qanruyutet"; Inuit Concepts of "Naklik" and "Ilira"; Inuit Language; Inuit Qaujimajatuqangit; Inuit Worldviews and Religious Beliefs

Further Reading

Born, E., and J. Böcher. *The Ecology of Greenland.* Ilinniusiorfik: Ministry of Environment and Natural Resources, 2001.

Gad, F. *The History of Greenland.* 3 vol. London: Hurst; Montreal: McGill Queens University Press, 1970–1982.

Nuttall, M. *Arctic Homeland: Kinship, Community, and Development in Northwest Greenland.* Toronto: University of Toronto Press, 1992.

Greenland, U.S. Bases in

Early in World War II, before formal American entry in the conflict, Washington identified Greenland as a key approach to the American continent and an essential platform to keep communications with Great Britain open. The uncertainty prompted by the Danish surrender in April 1940 accelerated moves to set up bases in the island. This was a harbinger of things to come during the Cold War, in which Washington sought to deploy a worldwide network of forward bases to protect the homeland in depth and be able to project power in any theater. The American bases in Greenland had a major impact on the island's economy, society, and culture, and their impact is felt to this day.

Following air and sea surveys to select suitable locations, and an agreement with the Danish authorities in exile on April 9, 1941, the United States started work on three large air bases, together with smaller facilities including radio and weather stations. These three bases were known as "Bluie West One" (Narsarsuaq), "Bluie West Eight" (at the bottom of Søndre Strømfjord), and "Bluie East Two" (Ikateq, near Ammassalik in East Greenland). Code names were employed to make it difficult to Germans to learn their true locations, while the three bases were far away from each other to make sure that at least one could enjoy good weather and be operated at any time.

Base construction was challenging due to the lack of local equipment and supplies, plus the weather and the distances involved, but it proceeded successfully. Some of the associated infrastructure was of a dual nature, and it contributed to the civilian economy, both during and after the war.

Work began before the United States formally entered World War II, with Admiral Samuel Eliot Morison describing American moves as an example of short of war operations. Moving carefully, the U.S. president Roosevelt had to frame the occupation of Iceland and Greenland in terms of continental defense, linking it to the Monroe Doctrine that sought to exclude extra-continental powers from the Americas.

Although Denmark had surrendered, the king's message to his subjects ordering them to cooperate contained no reference to the colonies, and the Greenland governor Eske Brun took advantage of this to keep the island away from the Reich, ignoring instructions from Copenhagen while the metropolis was occupied. In a way, this was a precedent for the post-1979 home rule.

Broadly speaking, the goal of the bases was to sustain an air bridge to Great Britain, as well as sea communications with the United Kingdom and the USSR, and facilitate the control of the waters and skies around Greenland, denying the island to the Germans, whose presence was feared. This included the conduct of aerial antisubmarine patrols. One of the reasons why Greenland was of interest to both sides was the possibility of gathering meteorological intelligence. In the longer run, America feared that should the island fall into hostile hands, it could serve as a springboard to attack the continent. Also, the island was a key source of cryolite for the U.S. and Canadian aluminum industry. To prevent German landings in East Greenland and the setting up of weather stations, it was decided to evacuate the northern half of the coast and set up a sledge patrol, a small group of local volunteers tasked with patrolling the region from 70° to 77° N and warning of any German presence. At the same time, the U.S. Coast Guard set up a Greenland patrol. Berlin managed to deploy only a few stations, including some automatic ones. The United States kept its presence in Greenland during the Cold War, and the need for this was already stated in a 1946 State Department report.

The arrival of the Americans to Greenland had an extensive impact on society, culture, and the economy. At that time, the population was rather small, concentrated on a few areas, and the economy was heavily geared toward a narrow range of industries. The war opened up Greenland to the outside world, as not just servicemen but also all sorts of unheard-of products started arriving, among them mail-order catalogs from Sears, Roebuck and co., Hollywood films, and American Aladdin lamps. These allowed Greenlanders to say farewell to blubber lamps, a major step forward. The other side of the coin was that some basic consumer goods had to be rationed due to lack of shipping. With regard to popular culture, country music from the United States became prevalent and is still popular, and two English words became widespread and are still in use: *aluu* (hello) and *baaj* (bye-bye).

Alex Calvo

See also: Greenland; Greenland Ice Sheet; Greenland Sea; Greenland Shark; Thule Air Base, Greenland, B52G Stratofortress Crash of 1968

Further Reading

Balchen, B. *War Below Zero: The Battle for Greenland.* London: Allen and Unwin, 1945.

Fleischer, J. *A Short History of Greenland.* Copenhagen, Denmark: Aschehoug Dansk Forlag, 2003.

Franz, F., and A. Glen. "Arctic Meteorological Operations and Counter-Operations during World War II." *Polar Record* 21, no. 135 (1983): 559–67.

Howarth, D. *The Sledge Patrol.* London: Collins, 1957.

Skarstein, F. "'A Cursed Affair'—How a Norwegian Expedition to Greenland Became the USA's First Maritime Capture in World War II." *Polar Research* 26 (2007): 181–94.

Greenland Ice Sheet

Greenland is a frozen island country located at the far Arctic latitudes of North America, contiguous with the northeastern fringe of the Canadian Archipelago.

It is the largest island on earth, supporting the planet's second largest ice sheet. The mainland of Greenland is located within the Arctic region, a squiggly, uneven circumpolar zone that refers to areas where the warmest average temperatures do not rise above 50°F (10°C). Its northern coastlands, buried in icecap, look out to the Arctic Ocean. Moving counterclockwise around the island's 27,340-mile (44,087-km) coastline, the Queen Elizabeth Islands and Baffin Island dominate the northwestern shoals of Canada's Baffin Bay; Thule is a main city on the far western Greenland coast. Moving southwest down the coastline, a string of settlements along Davis Strait lead to the capital city of Nuuk. The Labrador Sea flows around the southern cape of the island into Denmark Strait; both connect to the North Atlantic Ocean on Greenland's southern border. Iceland and the United Kingdom lie across the ocean, to the far southwest of the island; across the Norwegian Sea lie the Scandinavian nations of Denmark, Norway, Sweden, and Finland. The islands of Jan Mayen and Bjørnøya, the Svalbard Archipelago, and the isles of Franz Joseph Land are important landmarks on Greenland Sea. Beyond them lie the expanses of the Russian mainland with its contiguous seas, the Barents, Kara, Laptev, East Siberian, and Chukchi, ending at the Beaufort Sea along the Alaskan/Canadian border.

The Greenland landmass is of 840,003 square miles (2,175,600 sq. km) and is supported by the Greenland plate, a tectonic subplate of the North American plate. Its ancient craton is composed of rocks dated 3.7–3.8 billion years; these are the oldest known rocks in the world. Eighty-five percent of its central terrain is dominated by a sloping ice sheet covering an estimated area of 708,072 square miles (1,833,900 sq. km). The remainder of its rugged landscape is covered in permafrost. The Greenland Ice Sheet (GrIS) contains nearly 24 ft. (7.4 m) sea-level equivalent or nearly 10 percent of earth's water reserves. The center of the sheet lies roughly 1000 ft. (300 m) below sea level, a result of the immense weight of the accumulated ice and snow. This expanse of ice plays a prominent role in the regulation of global climate. Its impacts include ocean circulation, regional atmospheric circulation, and global heat transfer. These factors are the foundations of ongoing research to accurately gauge the mass balance and climatic sensitivity of Greenland's icy interior. The meridional overturning circulation (MOC) is governed by density differentials characteristic of freshwater transfers into the world's oceans. Greenland's glacial runoff has an important effect on the MOC equilibrium. Its icy inland landscape cools warm air as it rises. As the ice sheet melts, the temperature gradient separating the equator and the poles flattens, slowing the rate of heat transfer. This, in turn, has a marked effect on the jet stream, whose path determines climatology worldwide.

From the 1960s to 1990, ongoing polar research did not indicate any correlation between Southern Greenland coastal and Northern Hemisphere summer temperatures. That relationship changed markedly during the 1990s, directly attributed to anthropogenic global warming. Specifically, marked changes to the area's glacial dynamics include a meltwater percolation dynamic feedback mechanism and oceanic erosion of calving fronts. Conversely, spatial distribution models of changes in Greenland's ice mass loss are moderated by the high thermal inertia of the ice mass, atmospheric cooling, and changes in meteorological patterns. Polar survey technologies include remote-sensing laser and radar altimetry; global positioning systems and interferometric synthetic aperture radar data measurements of melt rates, ice thickness, and velocities; and satellite data (Gravity Recovery and Climate Experiment, ICESat and Cryosat satellite missions), including Seasat, Geosat, and European Remote Sensing Satellites ERS-1 and -2.

Ice core extractions have provided an essential timeline for understanding climate change in Greenland. A series of extractions were begun in 1971 and continued through the early 1980s. The GrIS Project was funded by the National Science Foundation, supported by interested partners in Switzerland and Denmark. The Greenland Ice Core Project was a later initiative sponsored by the European Science Foundation and funded by eight nations: Belgium, Denmark, France, Germany, Iceland, Italy, Switzerland, and United Kingdom. From 1989 to 1992, researchers successfully drilled an ice core down to almost 10,000 ft. (3,028 m) at Summit in central Greenland. Studies of the ice core have provided valuable comparative data regarding climatic variation during the Holocene. Three cores were extracted by the Niels Bohr Institute, funded by the Carlsberg Foundation under the Greenland Ice Core Counted Chronology 2005 (GICC05). More than 18,700 ft. (5,700 m) of ice was studied to create a template of climate change over the past 62,000 years.

During June, July, and August 2012, an unusually devastating series of fires ravaged the State of Colorado, burning an area greater than 316 square miles (818 sq. km). Dr. Jason Box, 2007 Nobel Peace Prize laureate, is a research scientist affiliate of the Byrd Polar Research Center, who specializes in the study of the GrIS. He is renowned for his work with the Extreme Ice Survey project, the subject of the recent National Geographic documentary, *Chasing Ice*. During the summer of 2012, NASA satellites captured the unprecedented thaw of nearly 97 percent of the GrIS. Dr. Box watched televised coverage of the Colorado wildfires en route on a Greenland expedition on June 25, 2012. He was struck by the coincidence of the two global climate phenomena and arranged for an analysis of the Greenland snow cover. His hunches proved correct; residual soot from the Colorado fires were evident on the mainland, contributing to substantial losses in albedo and creating a self-reinforcing feedback loop that has doubled melt rates in the past decade. Dubbed the Dark Snow Project, Dr. Box initiated one of the first crowd source appeals for funding for a Greenland expedition in 2013 to document the effects of smoke and soot on the GrIS. On July 9, 2013, Dr. Box took ice core samples for the project. Just days before, the Moderate Resolution Imaging Spectroradiometer on NASA's Aqua satellite recorded the drift of wildfires burning in Quebec, Canada, across the Atlantic Ocean. On July 8, the wildfire residuals were documented in Scandinavia, passing over Greenland during the Dark Snow Project expedition.

Victoria M. Breting-Garcia

See also: Greenland; Greenland, U.S. Bases in; Greenland Sea; Greenland Shark; Ice Cap; Ice Core Climatic Data Proxies; Ice Core Collection and Preservation Issues; Ice Sheet; Inuit

Further Reading

Hanna, E., P. Huybrechts, K. Steffen, J. Cappelen, R. Huff, C. Shuman, T. Irvine-Fynn, S. Wise, and M. Griffiths. "Increased Runoff from Melt from the Greenland Ice Sheet: A Response to Global Warming." *Journal of Climate* 21 (2008): 331–41.

Harig, C., and F. Simons. "Mapping Greenland's Mass Loss in Space and Time." *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 109, no. 49 (2012): 11934–9937.

Kelly, S., J. Briner, N. Young, G. Babonis, and B. Csatho. "Maximum Late Holocene Extent of the Western Greenland Ice Sheet during the Late 20th Century." *Quaternary Science Reviews* 56 (2012): 89–98.

Vinther, B., S. Buchardt, H. Clausen, D. Dahl-Jensen, S. Johnsen, D. Fisher, R. Koerner, D. Raynaud, V. Lipenkov, K. Andersen, T. Blunier, S. Rasmussen, J. Steffensen, and A. Svensson. "Holocene Thinning of the Greenland Ice Sheet." *Nature* 461, no. 17 (2009): 385–8.

Greenland Sea

The Greenland Sea is a marginal sea of the Arctic Ocean and is located off the coast of Greenland (west) and the west coast of the Svalbard Archipelago (east) (78° N 16° E) running along the Norwegian Sea and Jan Mayen Island. The northern border is the Fram Strait, while the southern border is the Denmark Strait, the northern coast of Iceland, and the Norwegian Sea. The Greenland Sea is commonly referred to as being part of the Nordic Seas that includes the Norwegian and Iceland Seas.

The borders of the Greenland Sea are based on the points selected. Thus, the exact area of the Greenland is an estimate. The total area of the Greenland Sea is estimated at about 460,000 square miles (1.2 million sq. km). The average depth is about 4,750 ft. (1,450 m) with a maximum depth of around 16,000 ft. (4,800 m). There are a number of uninhabited islands in the Greenland Sea, such as Edvards (76° 37′N 21° 20′W), Eila (73° 10′N 25° 10′W), Godfred Hansens (76° 27′N 20° 55′W), Île-de-France (77° 46′N 17° 54′W), Lynns (80° 7′N 19° 13′W), Norske (79° 5′N 17° 48′W), and Schnauders (78° 49′N 19° 27′W). Jan Mayen (70° 59′N 8° 32′W) and Shannon (75° 10′N 18° 20′W) Islands are also in the Greenland Sea and are occasionally inhabited by either hunters, researchers, or military personnel.

There are several rivers emptying into the Greenland Sea, such as the Børglum Elv, Gods (Gudenelv), Schuchert (Marrakajik), Primulaelv, and Zackenberg Rivers. There are also several fjords along the Greenland Sea coast including the Denmark, Gunnbjorn, Ingolf, and Independence Fjords. The Greenland Sea supports a number of different marine species and seabirds, such as walrus, seals (bearded and ringed), polar bears, fish (cod, Arctic char, herring, halibut, and redfish), gulls (Sabines, Ivory, and Glaucous), common eider, murre, skua (Arctic, long-tailed, and pomarine), ravens, and little auks.

An interesting historic feature of the Greenland Sea was the Odden ice tongue, the Odden ice spit resembling a tongue. It was a winter ice feature of the Greenland Sea, with a length up to about 800 miles (1,300 km) covering an area around 127,000 square miles (330,000 sq. km). The Odden ice tongue formation is the result of the recurring northern winds coupled with consistent temperatures seldom above 32°F (0°C). This combination produced an eastward extension of the East Greenland winter ice out to around 73° N. Since 1997, the Odden ice tongue has not been observed.

Andrew J. Hund

See also: Arctic Basin; Arctic Ocean; Benthic Community; Greenland, U.S. Bases in; Greenland Ice Sheet; Greenland Shark

Further Reading

Meincke, J., B. Rudels, and H. Friedrich. "The Arctic Ocean–Nordic Seas Thermohaline System." *ICES Journal of Marine Science* 54, no. 3 (1997): 283–99.

Greenland Shark

The Greenland shark (*Somniosus microcephalus*) is a large, docile, and slow-moving shark that inhabits the North Atlantic waters around Canada, Greenland, and Iceland. It is the furthest northern shark species in the world and has occasionally been seen as far south as North Carolina and even Antarctica. The shark is less commonly referred to as the gray, gurry, ground, and sleeper shark and known to the Inuit as *Eqalussuaq*. The shark is a member of the family *Somniosidae* ("sleeper sharks") and a close relative to the Pacific sleeper shark.

Inuit legend notes the Greenland shark as a shaman helping spirit, its creation as skalugsuak, and an inhabitant of Sedna's urine pot as well as occasionally attacking kayakers. The shark attacking humans has not been witnessed or verified. There is only one suspected case of a Greenland shark eating a human in 1859 near Pond Inlet, Canada, where fishermen, while gutting a shark, claimed to have found a human leg in its stomach. The case has not been verified, and if true, it is not clear whether the shark ate the human as carrion or killed the human. Even though the shark is large enough to devour a human, it is presently not considered dangerous to humans, but the shark's cold water habitat limits interactions with people.

These sharks are comparable in size with the Pacific salmon shark and the great white shark. The average Greenland shark is 8–16 ft. (2.4–4.8 m) in length, with the maximum length being estimated at 24 ft. (7.3 m). Females are slightly larger than males. The cold temperatures they live in result in a slow growth rate. The average weight of an adult shark is around 900 pounds (405 kg), with a maximum weight estimated at 3,100 pounds (1,400 kg). The cruising speed of the shark is around 0.76 mph (1.2 km/h), and maximum speed is 1.6 mph (2.6 km/h). This is slightly faster than a giant Galapagos tortoise, which has a maximum speed about 1 mph (1.6 km/h). It is estimated that the Greenland shark can live up to 200 years of age, making the longest life span of any vertebrate. Greenland sharks have live births with a litter of up to 10 pups that measure around 35 inches (90 cm). The mating rituals (if any) and gestation period are presently unknown.

The Greenland shark appears meandering and slow moving due to its large thick body shape. The color of the shark is brown, gray, or black with some having dark lines or light-colored marking on its back and sides. It has a short round snout, small eyes, and thin lips with different upper and lower teeth. It has 48–52 upper teeth that are thin and pointed, while the bottom teeth number 50–52 and are wide and square with hook-like points turned outward. The shark has small dorsal and pectoral fins. Its gills are unusual because they are located low on the head and are small openings for its large size.

The preferred habitat of the Greenland shark has temperatures between 31 and 50°F (−0.6 to 10°C). The shark will migrate to waters in this temperature range depending on the season. In the winter, the sharks are found near the surface, while they are at depths of 600–1,800 ft. (180–550 m) in the summer. A submersible vehicle has observed a Greenland shark at a depth of more than 7,200 ft. (2,200 m).

Their diet consists of other small sharks and various fish (e.g., Arctic char, capelin, flounders, herring, lumpfish, redfish, sculpins, skates, and wolfish). These sharks are known to scavenge and feed on carrion. Some Greenland shark stomachs have contained parts of seals, horses, moose, porpoises, polar bears, and even an entire carcass of a caribou. It is not certain whether the shark killed these mammals or fed on their dead carcass. The slow speed of the sharks makes taking a live marine mammal suspect, especially seals. Some have theorized that the Greenland shark captures marine mammals by ambush while they sleep.

Humans generally do not eat the Greenland shark because its flesh is considered poisonous with high levels of urea ($CO[NH_2]_2$) and the toxin trimethylamine oxide ($[CH_3]_3NO$). The consumption of the flesh is reported to have an intoxicating effect on humans similar to being drunk on alcohol. The Inuit of Greenland refer to someone that is inebriated as being "shark-sick." The Greenland shark flesh can be made edible by drying, fermenting, or burying it in the ground for several months or even seasons. Traditionally, the Inuit dried the shark's skin to make boots and the teeth to cut hair.

Greenland sharks are preyed on or colonized by a parasitic copepod (*Ommatokoita elongata*). The 1.2-inch (30-cm) copepods permanently attach to and eat the cornea of the shark's eye resulting in vision impairment or even partial blindness. This is not detrimental to the shark, because they are not sight hunters. Some have speculated that the copepod may attach prey to the mouth region of the shark, while others reject this theory due to the lack of supporting evidence.

Andrew J. Hund

See also: Greenland; Greenland, U.S. Bases in; Greenland Ice Sheet; Greenland Sea; Pacific Sleeper Shark; Salmon Shark

Further Reading

Bjerkan, P., and E. Koefoed. "Notes on the Greenland shark *Acanthorhinus carcharias* (Gunn.)." *Fisk.-Dir. Skr., Serie Havundersøkelser* 11, no. 10 (1957): 1–12.

Gallant J., C. Harvey-Clark, R. Myers, and M. Stokesbury. "Sea Lamprey (*Petromyzon marinus*) Attached to a Greenland Shark (*Somniosus microcephalus*) in the St. Lawrence Estuary, Canada." *Northeastern Naturalist* 13 (2006): 35–38.

Grytviken

Grytviken is a former whaling station located on South Georgia at King Edward Cove in the Cumberland East Bay region and the capital of the British territory of South Georgia. Named by the Swedish surveyor Johan Gunnar Andersson (1874–1960) in 1902, it is today the prime destination for tourism in South Georgia with the remains of the whaling station as its main attraction. In 1904, the Norwegian entrepreneur Carl Anton Larsen (1860–1924) established a whaling station at Grytviken for his company Compañía Argentina de Pesca, which became an immediate economic success. The first whale was processed on December 24, 1904, less than two months after Larsen's arrival.

The whaling station developed rapidly, and a complete whale-processing factory as well as numerous workshops were built up during the following years. At its peak, the whaling operation employed up to 300 men during the summer months, and the compound had a cinema and a church. Over the decades, the factory changed its ownership several times with the operations finally shut down as late as 1966 in consequence of the depleted whale stocks and decreased global demand for whale oil.

Due to the wide use of asbestos, most of the buildings of the former whaling station have been dismantled, leaving the pure machinery as a skeleton of the industrial heritage of the South Sandwich Islands. The dismantling of the factory has caused a good deal of discussion among international industrial archaeologists dealing with nineteenth- and twentieth-century heritage of Antarctica, with many specialists recognizing Grytviken as a negative example of how to deal with the industrial heritage.

Grytviken has been the starting and/or endpoint for a number of well-known Antarctic expeditions and was kind of a hub for Antarctic expeditions due to its well-developed infrastructure, even including a small floating dock.

On April 3, 1982, Grytviken was attacked and occupied by Argentinean forces in the context of the Falkland War between Argentina and the United Kingdom. The occupation ended after a couple of days with the recapture of Grytviken by British troops during Operation Paraquet.

Today, cruise ships regularly visit Grytviken on the way to Antarctica with the South Georgia Museum in the office building of the former whaling station, the church, the grave of Sir Ernest Shackleton at the cemetery, and the post office as the main touristic attractions. The former military post at King Edward's Point, in close proximity to Grytviken itself, serves today as a base for the British Antarctic Survey after the last military detachment left the island in 2001. Infrastructure has been updated recently, most notably by the construction of a new hydropower station for local electricity production. As the capital of the British territory of South Georgia, Grytviken is the administrative center for the territory despite its lack of permanent inhabitants.

Ingo Heidbrink

See also: Antarctic Programs and Research Stations/Bases

Further Reading

Andersson, J. *Antarctic.* Stockholm, Sweden: Saxon and Lindström, 1944.

Gwich'in

The Gwich'in are a group of tribes with the suffix of "-Gwich'in" and are spread out over 15 communities in northern Alaska and the Yukon and Northwest Territories of Canada. As of the 2010 census, there were around 9,000 Gwich'in. These tribes reside in the northern regions of the Yukon and Peel River Basins on the western side of the Mackenzie River. Culturally, the Gwich'in are similar to the Hankutchin, Tutchone, and Tanana. The Inuit and Tlingit have influenced the Gwich'in culture through close proximity and interactions. The Gwich'in are also called the "Kutchin" or "Gwichin." The Gwich'in are widely known for their craft work. Gwich'in males are known for their crafting of sleds, canoes, and snowshoes, while Gwich'in females are known for beadwork.

History

Scottish explorer Sir Alexander Mackenzie (1764–1820) encountered the Gwich'in on his expedition up the Mackenzie River in search of a passage to the Cook Inlet in Alaska, in 1789. At the time, they were called the "Loucheux." The company that Alexander Mackenzie worked for (the North West Company based out of Montreal) set up a trading post at Fort Good Hope in 1806. In 1840, Fort McPherson was established on the Peel River. In 1847, the Hudson Bay Company established Fort Yukon. The Gwich'in engaged in mostly fur trading with the Forts. They worked as middlemen in fur trade between Inuit and Athabaskan groups that opposed outsiders establishing trading posts in their territories. The Catholic and Protestant missionaries arrived in the middle of the nineteenth century. The missionaries created a reading and writing system called "Tukudh."

In the 1860s and 1870s, several epidemics swept through the Gwich'in communities. Many Gwich'in joined whaling crews in the late nineteenth century resulting in many leaving the region. The Klondike gold rush brought many foreigners to the region. The interactions with outsiders had significant positive and negative effects on the Gwich'in. The Gwich'in of Arctic Village, Alaska, opted out of the Alaska Native Claims Settlement Act of 1971. They chose to take title over their traditional lands and not have a village corporation. In 1992, the Canadian Gwich'in communities of Inuvik, Aklavik, Fort McPherson, and Tsiigehtchic agreed to the Gwich'in Comprehensive Land Claim Agreement. This land agreement transferred title of about 8,700 square miles (22,422 sq. km) and about 2,400 square miles (6,158 sq. km) of subsurface rights in the Northwest Territories, and 600 square miles (1,500 sq. km) of land in the Yukon. Monetary compensation of the Gwich'in Comprehensive Land Claim Agreement included about $9.5 million a year tax free for 15 years. Historically and modern-day Gwich'in are dependent on the Porcupine caribou herd that migrate to the Arctic National Wildlife Refuge (ANWR) and the Yukon Flats National Wildlife Refuge. The Gwich'in are opposed to opening ANWR and the Yukon Flats to oil drilling for fear of disrupting the Porcupine caribou herd nursery.

Language

The Gwich'in language is part of the Athabaskan language family. There are two Gwich'in dialects, which are the eastern (Canada) and western (Alaska). There are also minor dialect differences between communities. The United Nations Educational, Scientific, and Cultural Organization lists the Gwich'in language as severely endangered with fewer than 400 fluent speakers (150 in Alaska and 250 in Canada).

Tribes and Communities

The Gwich'in tribes include the Danzhit Hanlaii Gwich'in, Deenduu Gwich'in, Di'haii Gwich'in, Draanjik Gwich'in, Ehdiitat Gwich'in, Gwichyaa (Kutchakutchin) Gwich'in, K'iitl'it Gwich'in, Nihtat Gwich'in, Neetsaii Gwich'in, Tetlit Gwich'in, and Vantee Gwich'in. Gwich'in communities are found in the Northwest Territories (Aklavik, Inuvik, Tetlit Zheh, and Tsiigehtchic); Yukon (Old Crow); and Alaska (Arctic Village, Beaver, Birch Creek, Chalkyitsik, Circle, Fort Yukon, and Venetie).

Belief System/Christianity

The traditional Gwich'in belief system was that all natural things (animate and inanimate) have a spirit (i.e., an animistic worldview) and must be respected as a living being. Under this worldview, it is taboo to disrespect nature. The arrival of the Catholic and Protestant missionaries had a significant influence on the Gwich'in worldview. The Gwich'in were largely converted to Christianity.

Andrew J. Hund

See also: Alaska Native Claims Settlement Act (ANCSA) 1971; Aleuts/Unangax; Eyak

Further Reading

Gilbert, M. "Farewell, Sweet Ice—Hunters Feel the Heat in Gwich'in Country." *The Nation* 284, no. 18 (2007): 26.

Nelson, R. *Hunters of the Northern Forest: Designs for Survival among the Alaskan Kutchin.* Chicago: University of Chicago Press, 1973.

Wallis, V. *Raising Ourselves: A Gwich'in Coming of Age Story from the Yukon River.* Kenmore, WA: Epicenter Press, 2002.

Gyrfalcon

The gyrfalcon (*Falco rusticolus*) is the largest falcon in the world. It lives almost exclusively above 60° N in the Arctic and subarctic regions of Alaska, Canada, Europe, Greenland, and Iceland. Nesting pairs can be found below 55° N in the coastal areas of eastern Canada, but this is fairly rare. The gyrfalcons' preferred habitat is High Arctic tundra, rocky cliffs, and mountainous areas that are close to water. As a species they are not migratory, even though some have been known to travel considerable distances during the winter or breeding season. It is very rare to find gyrfalcons below the northern border of the continental United States.

The silhouette of the gyrfalcon is similar to that of other falcons. Like other falcons, the gyrfalcon has long pointed wings and tail, and a short strong beak with a tomial tooth for killing prey. A key difference of the gyrfalcon to other falcon is that its wings do not fold up and extend beyond its tail feathers as commonly found in other falcon species. The reason for the appearance of shorter wings is due to their large size. The gyrfalcon is sometimes mistaken for the peregrine falcon (*Falco peregrinus*) or the Northern Goshawk (*Accipiter gentilis*). Like all falcons, the gyrfalcons' eyes are dark appearing black.

Male gyrfalcons are smaller than females. Gyrfalcons' weight ranges between 2 and 4.5 pounds (0.9–2 kg). An average adult male weighs between 1.7 and 2.85 pounds (800–1,300 g), while an average adult female weighs between 3 and 4.5 pounds (1,400–2,100 g). The length of adult gyrfalcons ranges between 20 and 25 inches (50–63 cm). Adult male's average length is approximately 21 inches (53 cm), while female's average length is about 22 inches (56 cm). The gyrfalcons wingspan ranges between 4 and 4.5 ft. (1.2–1.3 m). The gyrfalcons' preferred meal is ptarmigan, but they also feed on ducks, geese, fulmars, skuas, buntings, redpolls, and so forth, and some small mammals.

There is no difference between males and females in plumage; however, individual birds differ in plumage. There are three colors common in gyrfalcons, which are white, blackish, and gray brown. The white gyrfalcon is almost completely white except for a few markings on its wings. The white gyrfalcon is found mostly in Greenland. The blackish-colored gyrfalcon appears as dark gray to almost black. This gyrfalcon is mostly found in northern Canada. In between the white and dark-colored gyrfalcon is the gray-brown morph. The gray-brown gyrfalcon is the most common type and is found throughout the Arctic and subarctic regions.

Sexual maturity is about two to three years of age. Mating starts around late January to early February, when the male selects and defends a nest. Gyrfalcons use other birds' unused nests, such as eagles, ravens, rough-legged hawk, and so on, rather than building their own. A female arrives around the end of February to the beginning of March. Courtship and bonding take place over six weeks. In April, a female lays two to seven eggs and incubates them for 28–34 days until they hatch. After about 10 days, the hatchlings have enough feathers to endure the cold temperatures, and the female leaves the nest to hunt. The hatchlings are fed throughout the day, and the female will store food in caches. At about 50 days, the chicks fledge, and they leave the nest after about 100 days. A gyrfalcon couple will breed only if enough food is stored or available in the spring. The gyrfalcons' life span is between 25 and 30 years of age.

Andrew J. Hund

See also: Arctic Loon; Arctic Seabirds; Arctic Skua; Arctic Tern; Common Raven; Lapland Longspur; Red-Throated Loon; Snow Bunting; Snow Goose; Snowy Owl; Sooty Albatross; Wandering Albatross

Further Reading

Clum, N., and T. Cade. "Gyrfalcon (*Falco rusticolus*)." In A. Poole and F. Gill, eds. *The Birds of North America*, No. 114. Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union, 1994.

H

Hans Island Dispute

The Hans Island (80° 49′N 66° 27′W) dispute is between Canada and Denmark over the ownership of a small area in the Nares Strait that includes Hans Island. At dispute are claims to the fishing areas, management, and jurisdiction over the Northwest Passage. Hans Island is a barren uninhabited knoll measuring 0.5 square mile (1.3 sq. km) in area and is 0.8 mile (1.3 km) long by 0.75 mile (1.2 km) wide. Hans Island is positioned in the middle of the Kennedy Channel of the Nares Strait (sometimes called "Robson Channel"). The Nares Strait connects Baffin Bay to the Lincoln Sea and separates Ellesmere Island, Nunavut, Canada, and northern Greenland (owned by Denmark). Hans Island is roughly in between the territories of Canada and Greenland (Denmark). The island was named for Native Greenlander and Arctic explorer Hans Hendrik (1834–1889).

The dispute started in 1973, when Canada and Denmark established the coordinates of the continental shelf of their respective countries. The treaty established 127 points based on latitude and longitude coordinates from Davis Strait to the end of Robeson Channel, where Nares Strait merges into the Lincoln Sea. Between point 122 (80° 49′N 66° 29′W) and point 123 (80° 49′N 66° 26′W), a line was not drawn because the two countries could not agree on a maritime boundary. Both countries claimed Hans Island as being within their respective territory. The distance between these points is 0.54 mile (0.87 km). Hans Island is located roughly in the center of this area. Canada, however, has claimed that Hans Island is in their respective territory based on a 1967 geographic map used in establishing the latitude and longitude coordinates in 1973.

Since 1973, Canada and Denmark have been unable to resolve the dispute, and it has been a minor diplomatic friction point between the countries. Over the years, Canadians and Danish have been to Hans Island with most of these visits fueling this territorial dispute. From 1980 to 1983, Dome Petroleum, a Canada-based company, conducted research on the island. On several occasions, Danish flags have been placed on the Hans Island. The first was when the Danish minister of Greenland, Tom Høyem, landed on the island and planted a Danish flag. Danish flags have also been placed on Hans Island in 1988, 1995, and 2003. In 1988, members of the Danish cutter HDMS *Tulugaq* (Y388), a Danish Arctic Ocean patrol, made a stack of stone (called a cairn) and placed a flagpole with a Danish flag on the island. A Danish liaison officer and earth science mathematician placed a flag on the island, in 1995. Another cairn, flagpole, and Danish flag were placed on the island by the members of the HDMS *Vædderen* (F359), a Danish inspection ship, in 2002. Around a year later, the members of the HDMS *Triton* (F358), a Danish frigate, placed a new Danish flag on the island. Each time a Danish flag is placed on the island, the government of Canada has formally protested.

In 2005, Canadian soldiers built an *inukshuk*, placed a plaque, and planted a Canadian flag. A major diplomatic dispute occurred when Bill Graham, a Canadian defense minister, made an impromptu stop on the island while on an Arctic visit, in July 2005. Denmark and Canada engaged in another diplomatic tiff until a truce was established in September 2005. In 2007, satellite images showed that the territorial line is roughly in the middle of Hans Island. Since 2012, both countries are negotiating, and it is suspected that Hans Island will be divided roughly in half between the countries.

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See also: Arctic Territorial Claims and Disputes; Beaufort Sea Dispute

Further Reading

United Nations. Delimitation Treaties. *Agreement between the Government of the Kingdom of Denmark and the Government of Canada Relating to the Delimitation of the Continental Shelf between Greenland and Canada.* December 17, 1973.

United States Department of State. Bureau of Intelligence and Research. *Limits in the Seas.* No. 72. *Continental Shelf Boundary: Canada—Greenland.* Issued by the Geographer, August 4, 1976.

Harp Seal

Harp seals (*Pagophilus groenlandicus*) are a member of the family Phocidae. They are the most abundant seal in the Northern Hemisphere and are found in the northernmost part of the Atlantic Ocean and in the Arctic Ocean. They are named harp seals because their harp-shaped pattern that starts at their pelvis runs along the dorsal side of their flanks, and curves and comes together across their shoulders. Another name of the harp seal is "saddleback seal." Harp seals are a true or earless seals. There are two recognized subspecies of harp seals, which are *Pagophilus groenlandicus groenlandicus* and *Pagophilus groenlandicus oceanicus.*

Distribution

Harp seals are migratory species that can migrate up to 1,600 miles (2,500 km). They live in the pack ice of the Finnmark, Norway, and the Arctic and Northern Atlantic Ocean from Newfoundland to the Russian Federation. Of the two subspecies, there are three distinct breeding populations, which are the Barents Sea, northwest Atlantic, and the East Greenland. The Barents Sea harp seals breed in the

White Sea, while the northwest Atlantic group breeds in the western North Atlantic. This northwest Atlantic group is sometimes split into two subgroups, which are the gulf and the front. The gulf subgroup breeds in northeastern Newfoundland in the Gulf of Saint Lawrence, while the front subgroup breeds off the coasts of southern Labrador. The East Greenland group breeds in a place called "West Ice" near Jan Mayen Island. The White Sea group is the subspecies *Pagophilus groenlandicus oceanicus* and the other two subgroups of Newfoundland, Labrador, and West Ice are the *Pagophilus groenlandicus groenlandicus.* The preferred habitat of harp seals is large ice floes and pack ice, which is used for molting, hauling out (resting), and breeding. Population estimates are between 5.5 and 7.5 million, with about 300,000 from the East Greenland group, 4–6.5 million from the northwest Atlantic group, and just more than 1 million in the Barents Sea group.

Description

The harp seal have a robust body and small broad flat head with a narrow snout. Adults have a light gray or silver-gray body with a black face and black markings behind the shoulder resembling a harp or a saddle. They have short narrow fore flippers with large claws. Newborn pups are born with a white fur coat and are called "whitecoats." Some are born with a yellowish coat because of being stained by amniotic fluid at birth. After weaning, the harp seal pup molts resulting in them losing tufts of fur and being referred to as "ragged-jackets." After molting, this fur coat is replaced by a juvenile coat that is silver-white with patchy black spots and lasts for about a year. After this, the spots grow larger until they form the characteristic harp-shaped pattern at around five years of age. Male harp seals have a more pronounced harp shape than females. Not all harp seals' pelage is the same. Some seals develop a spotted pelage, called "spotted harps"; others develop a gray pelage, called "sooty harps"; and still others develop a black head, and/or black markings on their hind flippers.

Male and female adults are sexually dimorphic in size and pelage. The adult male average weight is about 300 pounds (135 kg) and measure between 5 and 6.3 ft. (1.7–1.9 m). The adult female average weight is about 260 pounds (120 kg) and measure between 5.5 and 6 ft. (1.6–1.8 m). Harp seals' life span ranges from 30 to 35 years.

Reproduction

Adult pelage is an indication of sexual maturity of harp seals, which occurs between four and six years of age. Females give birth to pups on the pack ice in mid-February to mid-March. They nurse the pup for almost two weeks. Mating occurs just after the pups are weaned in late March to early April. During mating season, harp seals are very sociable and gather together in dense breeding groups of a couple of 1,000 per 0.5 mile (1 km). Male harp seals court females by making mating calls, blowing bubbles, and pawing gestures. They also chase females on the ice. Once a male locates a receptive female, they are territorial and fend off other would-be suitors. Mating takes place in the water. After mating, the harp seals molt from April to May and then migrate. The female, pregnant for about 11 months, gives birth to a single pup. She mates again at the end of the nursing period.

Diet

Harp seals feed on a variety of amphipods, fish (polar, Arctic, and saffron cod, and herring), krill, sculpins, and decapods (shrimps and prawns). Their diet varies by area and age of the seal. Harp seals regularly dive to depths of 300 ft. (100 m) to acquire food. Harp seals are preyed on by polar bears, orcas, and Greenland sharks. Pups are also preyed upon by walrus. Indigenous groups have been harvesting harp seals for thousands of years.

Threats

The International Union for Conservation of Nature lists the harp seal as least concern. They presently do face a number of threats, including being caught in commercial trawlers' gear and climate change. Climate change is a serious concern because most harp seals are dependent on large ice floes and pack ice. The present effect of climate change on harp seals is being assessed. Harp seals, especially whitecoats, have been commercially harvested for oil and fur since 1500s. The hunt of harp seal pups is controversial and has led to various management and trade restrictions throughout the world. Various environmental groups have been active in defending the harp seals. The sealing industry is presently dependent on government subsidies since there are few markets for the harp seal pelts or meat.

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See also: Antarctic Fur Seals; Bearded Seal; Crabeater Seal; Hooded Seal; Leopard Seal; Polar Bear; Ribbon Seal; Ringed Seal; Ross Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Spotted Seal, Weddell Seal

Further Reading

Berta, A., and M. Churchill. "Pinniped Taxonomy: Evidence for Species and Subspecies." *Mammal Review* 42, no. 3 (2012): 207–34.

Ronald, K., and P. Healey. "Harp Seal." Chapter 3 in S. H. Ridgeway and R. J. Harrison, eds. *Handbook of Marine Mammals.* Vol. 2: *Seals.* London: Academic Press, 1981.

Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

The Heroic Age of Antarctic Exploration describes an era in Antarctic history ranging roughly 20–25 years. Historians commonly agree that the start of the heroic age

The *Belgica* frozen in ice on November 19, 1898, during the Belgian Antarctic Expedition, the first voyage to the region undertaken for the purpose of scientific observation. (National Oceanic and Atmospheric Administration)

is 1897 with the Belgian Antarctic Expedition (1897–1899). When this heroic age ended is not as agreed on with some noting the Imperial Trans-Antarctic Expedition or Endurance Expedition (1914–1916) as the end of the era, while others claim Shackleton's death on January 5, 1922, during the Shackleton–Rowett Expedition (1921–1922) as the end of the era.

The Heroic Age was ushered in by the Sixth International Geographical Congress (1895) passing a general resolution that claimed that the Antarctic was the last unexplored area on the earth. This resolution sparked nationalistic rivalries, launched 16 major expeditions, and numerous scientific and geographical quests. Newspapers of the Antarctic explorations popularized and highlighted the difficult or seemingly hopeless rescues in the harsh frozen Antarctic region as well as personified individual courage, bravery, and at times impetuous actions. The primitive nature in regard to the modes of transportation and technology of these expeditions resulted in many being heroic feats of human endurance. The expeditions resulted in 17 people losing their lives (13 died during service and 4 from expedition-related illnesses).

The 16 Expeditions

The first expedition of the Heroic era was the Belgian Antarctic Expedition (1897–1899) and was led by Belgium Baron Adrien Victor Joseph de Gerlache de Gomery (called "Adrien de Gerlache," for short) (1866–1934). This expedition team was the first to overwinter in Antarctic Circle after the vessel *Belgica* became trapped in the ice. While icebound, the scientific members made climatological annual cycle observations. The furthest south, the expedition reached was at 71° 30′S. Two crew members who died on the Belgian Antarctic Expedition were Émile Danco of heart disease and Carl August Wiencke, who was washed overboard and drowned.

The second expedition was the Southern Cross Expedition (1898–1900) under the direction Norwegian Carsten Egeberg Borchgrevink (1864–1934). The expedition vessel was the *Southern Cross.* This expedition was the first to overwinter on the Antarctic mainland at Cape Adare (71° 17′S 170° 14′E). They were the first to use dog sledges to explore Antarctic mainland. The Southern Cross Expedition set a new record for being furthest south at 78° 30′S. Scientific members determined the location of the South Magnetic Pole. Nicolai Hansen, a crew member, died of an intestinal disease on the expedition.

In 1901, three Antarctic expeditions were launched, which were the British National Antarctic Expedition (called the "Discovery Expedition"), the First German Antarctic Expedition (called the "Gauss Expedition"), and Swedish Antarctic Expedition. Robert Falcon Scott (1868–1912) was appointed as commander of the *Discovery* vessel and the leader of the British National Antarctic Expedition (1901–1904). The expedition operated under a military structure and followed a similar path as the Southern Cross Expedition up to Cape Adare, then went southward. A hut was established on Ross Island near what is now called the "Ross Ice Shelf." The Discovery Expedition team discovered King Edward VII Land and ascended the western mountains reaching the polar plateau. The Discovery Expedition set a new record for being furthest south at 82° 17′S, but it was an arduous sledge journey for Scott, Shackleton, and Wilson.

The Discovery Expedition contributions to Antarctic science were significant across many disciplines, such as biology, geology, and meteorology. Major discoveries were the McMurdo Dry Valleys, the Cape Crozier emperor penguin colony, possibility that the ice barrier was floating, and a more accurate estimate of the location of the South Magnetic Pole. Noteworthy crew members of the Discovery Expedition were Ernest Shackleton (1874–1922), Tom Crean (1877–1938), and John Robert Francis "Frank" Wild (1873–1939). The scientific team consisted of Louis Bernacchi (meteorologist and magnetic observer), Hartley Ferrar (geologist), Thomas Hodgson (marine biologist), Edward Wilson (junior doctor and zoologist), and Reginald Koettlitz (senior doctor). Two crew members died as a result of accidents. Charles Bonnor, who fell from the *Discovery's* mast, and George Vince, who slipped on an ice-covered cliff to his death.

The First German Antarctic Expedition or Gauss Expedition (1901–1903) was led by German Erich von Drygalski (1865–1949) and explored the Indo-Atlantic side of Antarctica. The vessel of the expedition was the *Gauss* and was equipped two moored balloons for aerial reconnaissance. The *Gauss* was trapped in ice for 14 months. Even though trapped in ice, the moored balloons and sledge teams helped the Gauss expedition push into unexplored areas. The Gauss Expedition team discovered/charted Kaiser Wilhelm II Land (87° E–91° E) and Mount Gauss (66° 48′S 89° 11′E), and identified more than 1,400 species living in Antarctic waters. In 1903, the *Gauss* broke free from the ice and returned back to Germany.

The Swedish Antarctic Expedition (1901–1903) was led by Swedish Nils Otto Gustaf Nordenskjöld (1869–1928) under the command of Norwegian Carl Anton Larsen (1860–1924). This expedition focused on the eastern side of the Graham Land. The vessel of the expedition was the *Antarctic.* In January 1902, Larsen off-loaded Nordenskjöld and his team on Snow Hill Island. In late December 1902, Larsen returned to gather Nordenskjöld and his team, but the *Antarctic* became trapped in ice. Larsen ordered three men to locate Nordenskjöld and his team, but they were not able to reach Snow Island. In February 1903, Larsen had ordered the men to abandon ship just before the *Antarctic* was crushed in the ice near Paulet Island. After walking and sledging for 16 days, the crew made it to Paulet Island, where they built a stone hut and prepared to overwinter. Their main food source was Adélie penguins (*Pygoscelis adeliae*), of which they stocked up on thousands to overwinter. The crew at Snow and Paulet Islands were rescued by the Argentinean vessel *Uruguay* in November 1903.

The Scottish National Antarctic Expedition (SNAE) (1902–1904) was led by William Speirs Bruce (1867–1921). Bruce organized this expedition, since he was delayed from being accepted to the Discovery Expedition due to the president of the Royal Geographical Society, Sir Clements Markham, avoiding communication with Bruce. The vessel of the expedition was the *Scotia.* The SNAE was low-key in comparison with the Discovery Expedition. In 1903, Bruce established the Ormond House, which was a manned meteorological station on Laurie Island. In 1903, Bruce sold the meteorological station to the Argentine government for 5,000 pesos and was named Base Orcadas. The meteorological station is still operational today. The SNAE discovered Coats Land and delineated much of the Weddell Sea. A crew member, Allan Ramsey, died of heart disease in 1903.

The Third French Antarctic Expedition (1903–1905) was led by Frenchman Jean-Baptiste Charcot (1867–1936). The original focus of the expedition was to rescue the stranded Nordenskjöld team. The vessel of the expedition was the *Français.* The expedition also delineated Graham Land on the west coast of the Antarctic Peninsula. In 1905, this expedition reached Adelaide Island, photographed the Palmer Archipelago and an unexplored Antarctic coast named the "Loubet Land" (76° S 66° W) after the then president of France, Émile Loubet (1838–1929).

The first expedition led by Ernest Shackleton (1874–1922) was the British Antarctic Expedition 1907–1909 (now called the "Nimrod Expedition"). The vessel of the expedition was the *Nimrod.* This expedition was based out of the McMurdo

Sound. Shackleton and his team was the first to traverse the Transantarctic Mountains via the Beardmore Glacier. The Nimrod Expedition's southern team consisting of Eric Stewart Marshall (1879–1963), John Robert Francis "Frank" Wild (1873–1939), and Ernest Shackleton set a new record for being furthest south at 88° 23′S, which was just under 100 miles (160 km) shy of the South Pole. The Nimrod Expedition's northern team consisting of three Australian scientists, Tannatt William "Edgeworth" David (1858–1934), Douglas Mawson (1882–1958), and Alistair Mackay (1878–1914), who were the first humans to reach the South Magnetic Pole. In addition, five members of the expedition climbed 12,447 ft. (3,794 m), making them the first to summit Mount Erebus (77° 31′S 167° 9′E), which is a composite volcano and the largest on Ross Island.

Frenchman Jean-Baptiste Charcot returned to Antarctica as leader of the Fourth French Antarctic Expedition (1908–1910). The vessel of the expedition was the *Pourquoi-Pas* IV. This expedition was primarily focused on exploring the coastline of Bellingshausen Sea to roughly 124° W. It led to several discoveries of Marguerite (68° 30′S 68° 30′W) and Mikkelsen Bays as well as several islands, including Charcot (69° 45′S 75° 15′W), Renaud (65° 40′S 66° W), and Rothschild (69° 36′S 72° 33′W).

The first non-European expedition was the Japanese Antarctic Expedition (1910–1912). This expedition was led by Nobu Shirase (1861–1946) of Japan. The vessel of the expedition was the *Kainan Maru.* The expedition was primarily focused on exploring the coast of King Edward VII Land and the eastern side of what is now called the "Ross Ice Shelf" (then called the "Great Ice Barrier"). Commander Shirase and his crew were the first to step on the Edward VII Peninsula. The *Kainan Maru* encountered Amundsen's vessel the *Fram* in the Bay of Whales during their coastal exploration. The crew members of the *Fram* were waiting Amundsen's return from the South Pole.

The South Pole Expedition (1910–1912) was led by Roald Engelbregt Gravning Amundsen (1872–1928). The vessel of this expedition was the *Fram.* The expedition set up a base on what is now called the "Ross Ice Shelf" (then called the "Great Ice Barrier"). Amundsen and his team discovered a new route through the Transantarctic Mountains to the polar plateau, which was through the Axel Heiberg Glacier. On December 14, 1911, Norwegians Roald Amundsen, Helmer Hanssen (1870–1956), Olav Bjaaland (1873–1961), Oscar Adolf Wisting (1871–1936), and Sverre Helge Hassel (1876–1928) were the first humans to reach the South Pole (90° S).

Robert Falcon Scott (1868–1912) returned to Antarctica with the British Antarctic Expedition (1910–1913). This expedition is commonly called the "Terra Nova Expedition." The vessel of this was named the *Terra Nova.* The objective of the expedition was to be the first to reach the geographic South Pole. Scott, along with Edward Adrian "Uncle Bill" Wilson (1872–1912), Lawrence Edward Grace

"Titus" Oates (1880–1912), Henry Robertson "Birdie" Bowers (1883–1912), and Edgar Evans (1876–1912), reached the South Pole (90° S) on January 17, 1912, which was 33 days after Amundsen and his team. These five explorers all died while returning from the South Pole with the cause of death being from starvation and exposure to the Antarctic weather. One crew member, Robert Brissenden, drown in August 1912.

The Second German Antarctic Expedition (1911–1913) was led by German Wilhelm Filchner (1877–1957). The goal of the expedition was to be the first to cross the continent of Antarctic. The vessel of this was named the *Deutschland.* The expedition started in the southernmost part of the Weddell Sea reaching 77° 45′S and discovered the Luitpold coast, Vahsel Bay, and the Wilhelm II Ice Shelf (later named in honor of Filchner—Filchner Ice Shelf). The Second German Antarctic Expedition overwintered after being trapped in the ice. The intention of setting up a base on the ice shelf was hindered because of the calving icebergs. One crew member passed on this expedition was Richard Vahsel, who died of syphilis.

Douglas Mawson (1882–1958) led the Australasian Antarctic Expedition (1911–1914). The vessel for this expedition was the *Aurora.* The goal of the expedition was to explore, survey, and map the Antarctic coastline from Cape Adare (71° 17′S 170° 14′E) to Mount Gauss (76° 19′S 162° 2′E). The expedition discovered glaciers (Ninnis (68° 22′S 147° E) and Mertz (67° 30′S 144° 45′E), Commonwealth Bay (66° 54′S 142° 40′E), and Queen Mary Land. The two crew members who died on the expedition were Xavier Mertz (1882–1913), who is assumed to have died from a condition related to eating too much dog meat called hypervitaminosis A, and Belgrave Edward Sutton Ninnis (1887–1912), who fell into a crevasse. The reason Mertz was eating dogs was that when Ninnis fell through the snow-covered crevasse, the supplies were lost and Mertz ate dogs for his survival and later met with death.

The second expedition led by Ernest Shackleton (1874–1922) was the Imperial Trans-Antarctic Expedition (1914–1917) (now called the "Endurance Expedition"). The goal of the expedition was to cross the Antarctic continent, a 1,800-mile (2,900-km) journey, and it consisted of two parties and two ships. The Weddell Sea party would travel on the vessel *Endurance* under Shackleton, and the Ross Sea party (1914–1917) would travel on the vessel *Aurora* under Captain Aeneas Lionel Acton Mackintosh (1879–1916). The plan of the *Endurance* group was to land 14 men in Vahsel Bay and a team of six would cross the continent. The remaining eight men would conduct scientific studies. Three on Graham Land, three on Enderby Land, and two at the base camp in Vahsel Bay. Since it was not possible to carry all the supplies needed to cross the Antarctic continent, the Ross Sea party would lay out a supply line from the other side of Antarctic continent along the Ross Ice Shelf to Beardmore Glacier (83° 45′S 171° E). This was assumed to enable the Weddell Sea party to complete the transcontinental crossing to the Ross Sea.

The plans for the transcontinental trek quickly fell through when the *Endurance* failed to reach the Weddell Sea shore and became trapped in the ice. The *Endurance* was crashed by ice in October 1915. The Weddell Sea party rescued itself by traveling 800 nautical miles (920 miles; 1,500 km) from Elephant Island to the Shetland Islands to South Georgia in a small boat called the *James Caird.* Shackleton along with Frank Arthur Worsley (1872–1943), Tom Crean (1877–1938), Henry "Chippy" McNish (1874–1930), Timothy "Tim" McCarthy (1888–1917), and John William Vincent (1879–1941) made the 16-day journey and got help that rescued the stranded crew on Elephant Island. The voyage of the *James Caird* is considered one of greatest small-boat feats ever. The Ross Sea Party achieved their objective of setting up a supply line, but three expedition members lost their lives: Arnold Patrick Spencer-Smith (1883–1916), who died of exposure and scurvy, and Captain Aeneas Mackintosh and Victor George Hayward (1888–1916), who both fell through the sea ice. The Endurance Expedition/Ross Sea Party is considered by some to mark the end of the Heroic Era of Antarctic exploration. Others add one more which is the Shackleton–Rowett Expedition.

The Shackleton–Rowett Expedition (1921–1922) (sometimes called the "Quest Expedition") was the third expedition led by Ernest Shackleton. The vague goals of

CREAN, TOM (1877–1938)

Tom Crean was born in Annascaul County Kerry, Ireland. He was a crew member in three of the four British expeditions to Antarctica (Discovery, 1901–1904; Terra Nova Expedition, 1910–1913; and Endurance Expedition, 1914–1917). His nickname was the "Irish Giant." Crean walked 35 miles (56 km) solo across the Ross Ice Shelf during the Terra Nova Expedition to save Edward Evans. He received the Polar Medal for his effort (he received three of them). On the Endurance Expedition, he was part of the Weddell Sea party that rescued itself by traveling 800 nautical miles (920 miles; 1,500 km) from Elephant Island to the Shetland Islands to South Georgia in a small boat call the *James Caird*. Crean along with Shackleton, Worsley, McNish, McCarthy, and Vincent made the 16-day journey and got help that rescued the stranded crew on Elephant Island. The voyage of the *James Caird* is considered one of greatest small-boat feats ever. After retiring, Crean married, had three daughters, and ran the South Pole Inn in Annascaul. The town of Annascaul, Ireland, erected a statue in his honor, in 2003.

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the expedition were to explore, survey, and map the Antarctic coastline and perhaps circumnavigate the Antarctic continent. The vessel of this expedition was named the *Quest.* Shackleton died on January 5, 1922, of a heart attack. The expedition completed a few expedition items, erected a cairn in Shackleton's memory, and returned home. This marked the end of the Heroic Era of Antarctic exploration.

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See also: Australasian Antarctic Expedition (1911–1914); British Antarctic Expedition (1910–1913); Discovery Expedition (1901–1904); Gauss Expedition (1901–1903); German Antarctic Expedition (1938–1939); Imperial Trans-Antarctic Expedition (1914–1917); Nimrod Expedition (1907–1909); Ross Sea Party (1914–1917); SANAE IV (South African National Antarctic Expedition); Scottish National Antarctic Expedition (1902–1904); Second German Antarctic Expedition (1911–1912); Shackleton–Rowett Expedition (1921–1922); Swedish Antarctic Expedition (1901–1903)

Further Reading

Brandt, A. *South Pole: A Narrative History of the Exploration of Antarctica.* Washington, DC: NG Adventure Classics, 2004.

Landis, M. *Antarctica: Exploring the Extreme: 400 Years of Adventure.* Chicago: Chicago Review Press, 2001.

Mills, W. *Exploring Polar Frontiers: An Historical Encyclopedia.* Santa Barbara, CA: ABC-CLIO, 2003.

Herschel Island

Herschel Island is located five miles off Canada's Yukon Territory in the Beaufort Sea and measures 116 sq. km. It was inhabited for thousands of years by the Inuvialuit, descendants of the Thule Inuit. From November to July, the island is covered in ice, which connects it to the mainland. Annual temperatures range from winter lows of −58°F (−50°C) and summer highs of 86°F (30°C). Being located north of the Arctic Circle, it experiences the polar night and midnight sun.

John Franklin (1786–1847) was the first European to see the island during a mapping expedition in 1826. American whalers established a station on the island in Pauline Cove in the late 1800s. In the early 1890s, the Anglican Church founded a mission there, and in 1897, Reverend Stringer and his wife, Sadie, set up a permanent Anglican Mission in Pauline Cove.

By 1891, it was evident that the American whalers were heavily engaged in fur trading with the Inuvialuit. The American base on the island created problems for the Hudson's Bay Company and was competing with the Fort McPherson post. In trading fur at Herschel Island, the Eskimos were receiving higher prices than they would get at other posts and receiving larger quantities of rifles and ammunition.

In 1894, John Firth, the Hudson's Bay factor at Fort McPherson, offered to carry the mail for the whalers if they discontinued their fur-trading activities. This worked, but by 1897, the whaling industry started to decline, and by 1907, the whaling market had collapsed. The community of 500 whalers on Herschel Island started to decline. The Inuvialuit left for the Mackenzie Delta or elsewhere. The Royal Canadian Mounted Police, which had established a detachment there in 1903, left in 1964. The residential school established there for the Inuvialuit in 1928 was moved to Aklavik in 1936.

Today the windswept treeless polar island has no permanent settlement. It is now known as Herschel Island Qikiqtaruk Territorial Park. It was designated as a Natural Environment Park in 1987 as a result of the Inuvialuit Final Agreement. Under this agreement, the Yukon North Slope and Herschel Island are designated as a special conservation area with a purpose to conserve wildlife and habitat while providing for traditional aboriginal use such as hunting, sealing, fishing, and trapping. Because the island is situated between land and sea and has a dry polar climate, it contains unique plants, animals, and sea life. It has the largest colony of black guillemots, also called Tystie (*Cepphus grylle*), medium-sized alcid birds, in the Western Arctic. Several structures from the whaling stations can still be found there. The park was created because of its unique natural and human heritage. The island is composed of silt, sand, and clay and lacks bedrock. Because of this, the island is slowly being eroded by the ocean. With the rise in global temperatures, the erosion process has been accelerated.

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See also: Abandoned Arctic Islands; Bear Island (*Bjørnøya*); New Siberian Islands

Further Reading

Burn, C. *Herschel Island: A Natural and Cultural History of Yukon's Arctic Island Qikiqtaryuk.* Wildlife Management Advisory Council. North Slope, Alaska: Wildlife Management Advisory Council, 2012.

Lantuit, H., and W. Pollard. "Fifty Years of Coastal Erosion and Retrogressive Thaw Slump Activity on Herschel Island, Southern Beafort Sea, Yukon Territory, Canada." *Geomorphology* 95 (2008): 84–102.

Hooded Seal

Hooded seals (*Cystophora cristata*) are large seals from the family Phocidae. They are found in North Atlantic regions of eastern Canada, Greenland, and Iceland, but seasonally, they extend their range north into the Arctic Ocean and south into the North Sea. They are the most abundant pinnipeds in this region. They comprise two stocks that are estimated to be about 600,000 hooded seals that live in the

Northwest Atlantic and about 90,000 in the Northeast Atlantic, breeding off the western and eastern coasts of Greenland, respectively. However, both populations are decreasing. Although they breed on pack ice and are associated with it over the year, they spend significant periods of time pelagically, without hauling out.

Hooded seals are robust, whitish to pale silver gray, with irregular black spots and patches covering most of their body with large, broad, and relatively compressed head. They have relatively short, slightly pointed flippers and short whiskers. Their common name comes from the bladder, which occurs only in mature males and is inflated with air to form characteristic hood. Also, males can blow a bright red, balloon-like structure out of one nostril by closing the other one. Both structures are used during courting and to intimidate rival males. Pups are dark blue-gray on the back with white bellies, accounting for the name "blueback." They lose the blueback coat after 14 months of age when they molt for the first time.

Males are larger than females, and although on average they are 8 ft. (2.5 m) and 660 pounds (300 kg), large animals can reach about 880 pounds (400 kg) and more than 9 ft. (3 m). Females are smaller, on average more than 7 ft. (2.2 m) and 350 pounds (160 kg), but can reach up to 66 pounds (300 kg) and almost 8 ft. (2.4 m). Except for breeding and molting, hooded seals are solitary animals. There are four major pupping areas: in the Gulf of St. Lawrence, north of Newfoundland, in the Davis Strait, and in the Greenland Sea near the Jan Mayen Island. Pups are born on the pack ice from mid-March to early April. As soon as the female gives birth, males compete with visual nasal displays and even aggressive fights for the right to mate. Breading season is very short, only about 2.5 weeks. Mating takes place in the water. Fertilization is followed by an embryonic diapause lasting about 4 months. Newborns are about 1 m long and weigh about 53 pounds (24 kg). Hooded seals are fed only four days, which is the shortest lactation period among mammals. Pups gain about 15 pounds (7 kg) every 24 hours on 60 percent fat milk. Hooded seals molt in July, with each breeding stock congregating at a separate traditional site, north of their whelping areas. Hooded seals live about 35 years, and females probably live longer than males.

Hooded seals are highly migratory pelagic animals that forage mainly on fish like Greenland halibut, polar and Atlantic cod, herring, capelin, and on squids and shrimps along shelf edges over large parts of the North Atlantic. They are considered important predators. Their feeding preferences vary between males and females as well as between seasons and geographical areas. They are very capable divers, and most of their dives are from 330 to 2,000 ft. (100–600 m) in depth and last 5–25 minutes. However, dives to more than 3,200 ft. (1,000 m) and lasting almost an hour have also been recorded. Hooded seals are hunted by polar bears and killer whales, as well as Greenland sharks that may take young ones. Hooded seals have been harvested commercially and for subsistence since the late seventeenth century, and intensively in the nineteenth and twentieth centuries. After World War II, hunting was mainly focused on pups because of their valuable blueback pelt; however, many adult females were taken when defending their pups. Since 1998, the hooded seal hunt for both stocks has been regulated by quotas, set at 10,000 seals per year, but catches are in fact only a few hundred animals. Hooded seals are also taken by native people of Greenland and Canada for subsistence purposes every year. Another factor limiting their abundances is likely competition for food with commercial fisheries and other predators. The Northeast Atlantic stock has declined by 85–90 percent over the past 40–60 years, and decline is probably continuing despite protective measures. In 2007, to keep the low Northeast Atlantic stock stable, hunting of this stock was closed, and the species has been classified as vulnerable in the Red List of Threatened Species of the International Union for Conservation of Nature since 2008.

Monika Kędra

See also: Antarctic Fur Seals; Bearded Seal; Crabeater Seal; Harp Seal; Leopard Seal; Polar Bear; Ribbon Seal; Ringed Seal; Ross Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Spotted Seal, Weddell Seal

Further Reading

Folkow, L., and A. Blix. "Diving Behavior of Hooded Seals (*Cystophora cristata*) in the Greenland and Norwegian Seas." *Polar Biology* 22 (1999): 61–74.

Kovacs, K. "Mating Strategies in Male Hooded Seals (*Cystophora cristata*)?" *Canadian Journal of Zoolo*gy 68 (1989): 2499–502.

Kovacs, K., and D. Lavigne. "Mass-Transfer Efficiency between Hooded Seal (*Cystophora cristata*) Mothers and Their Pups in the Gulf of St. Lawrence." *Canadian Journal of Zoology* 70 (1992): 1315–20.

Report of the Joint ICES/NAFO Working Group on Harp and Hooded Seals (WGHARP). ICES Document CM 2006/ACFM: 32.

Human Impacts and the Antarctic Wilderness

Antarctica is the only continent without indigenous human inhabitants and where humans are unable to survive without technological support. By any measure, most of Antarctica is wilderness and easily the world's largest terrestrial wilderness. Human impacts on Antarctica vary from global (climate change), to regional (ozone depletion), to local (disturbance of flora and fauna), starting from when people first set foot on the Antarctic continent in the early nineteenth century. Exploitation of marine living resources, including sealing (early to mid-nineteenth century), whaling (late nineteenth to mid-twentieth centuries), and finfish fishing (mid-twentieth century to present day), has led to significant modifications to species and ecosystems. These activities, together with geographical exploration (early to mid-twentieth century), scientific research and its associated logistics (the twentieth to twenty-first centuries), and commercial tourism (late twentieth and twenty-first centuries), have left a range of impacts on the Antarctic wilderness. Mineral resource exploitation is banned from the Antarctic Treaty area (60° S) under the terms of the Protocol on Environmental Protection to the Antarctic Treaty of 1991.

The first construction of a building on the continent was by the expedition led by the Anglo-Norwegian explorer Carsten Borchgrevink (1864–1934) in 1899. This was one of the first expeditions that engaged in geographical exploration and scientific study in various parts of the Antarctic continent during the Heroic Age, the period roughly between 1895 and 1922 (Figure 1). Over 100 years later, fuel and chemical spills from this era are still detectable in the soil around historic huts. Similarly, shore-based whaling stations built around the same time have also polluted the near-shore marine environment through the discharge of whale refuse and fuel oil.

Immediately after World War II, annual national expeditions to the Antarctic began, and human presence expanded significantly during the 1957/1958 International Geophysical Year (IGY). Fifty-four research stations operated in Antarctica and the peri-Antarctic islands during the winter of 1957 (Figure 2). Since the IGY, the number of research stations has expanded to 81. In addition, more than 550 items of infrastructure are standing in Antarctica today (Figure 3), much of it having been abandoned. These include stations, aircraft runways, field camps, field huts, refuges, scientific equipment, depots, and historic sites and monuments. The construction of modern research stations has invariably affected the surrounding environment, resulting in disturbance to bird and seal breeding grounds, physical disturbance to soils, and destruction of vegetation. Among the most widespread contaminants around research stations are heavy metals and polycyclic aromatic hydrocarbons from combustion processes and fuel and oil spills. Contaminated soil and waste from abandoned waste disposal sites and fuel spills was estimated to be of the order of 1–10 million cubic meter in the late 1990s. Contaminants associated with synthetic chemicals are likely to persist for decades to centuries. Waste and contaminants left on the polar plateau will remain in the ice for thousands of years. Noise, fumes, and the physical presence of aircraft and vehicles disturb the silence and the landscape of the wilderness. Around research stations and at popular tourist sites, wildlife can be disturbed by or become habituated to humans.

Technological advances are allowing stations and research activities to reach further into remote parts of Antarctica. New stations are built in previously unoccupied areas. Stations and field camps are used as bases to access more remote locations. Scientists have drilled to the bottom of the Antarctic ice sheet that is several kilometers thick. In some instances, ice is retrieved from the drill holes and petroleum-based lubricants are left in the ice sheet for tens of thousands of years. In other cases, drilling has punched through to lakes lying beneath the ice sheet. Water samples have been retrieved from these pristine lakes that have been isolated from the atmosphere for millions of years.

Most tourists visit the northern Antarctic Peninsula by ship, normally landing at a small number of well-known locations in rapid succession, mostly between November and March. Some land-based tourism infrastructure has been developed in the form of accommodation at research stations and logistics facilities run by commercial entities. The concentration of thousands of people at a few sites over a short period of time has led to erosion of footpaths, vandalism of historic buildings, disturbance to wildlife, and concentration of vessels in small areas, although systematic and comprehensive monitoring of the impacts of tourism activities is lacking.

All humans, whether tourists, scientists, support staff, or fishers, depend on fossil fuel as their main energy source. The most significant fuel spills in Antarctica have been caused by shipwrecks (e.g., the *Bahia Paraiso*) fuel leaks and accidents during bunker fuel transfer. Driving and walking on Antarctic soils and vegetation can lead to soil compaction and vegetation damage. In ice-free areas, semipermanent tracks are often created near stations that persist for decades. A small number of inland stations are resupplied by tractor trains that travel over long distances (more than 600 miles [more than 1,000 km]). They cause unavoidable though transient physical disturbances to the snow and ice surface and alter the wilderness values of the area as snow surfaces are groomed, unstable snow bridges over crevasses are collapsed (sometimes with explosives), and exposed crevasses are filled with snow harvested from the surrounding area.

The Protocol on Environmental Protection to the Antarctic Treaty designates Antarctica as a natural reserve and provides protection to "the Antarctic environment and dependent and associated ecosystems and the intrinsic value of Antarctica, including its wilderness and aesthetic values and its value as an area for the conduct of scientific research, in particular research essential to understanding the global environment." However, as more people travel to the Antarctic to visit and work, the absence of proactive actions to limit the expansion human footprint in Antarctica equates to a de facto decision to allow the erosion and fragmentation of the world's largest and most remote wilderness.

Tina Tin and Rupert Summerson

See also: Climate Change and Invasive Species in the Arctic; Climate Change and Permafrost; Climate Change in the Arctic; Environmental Concerns, Arctic Mining Operations

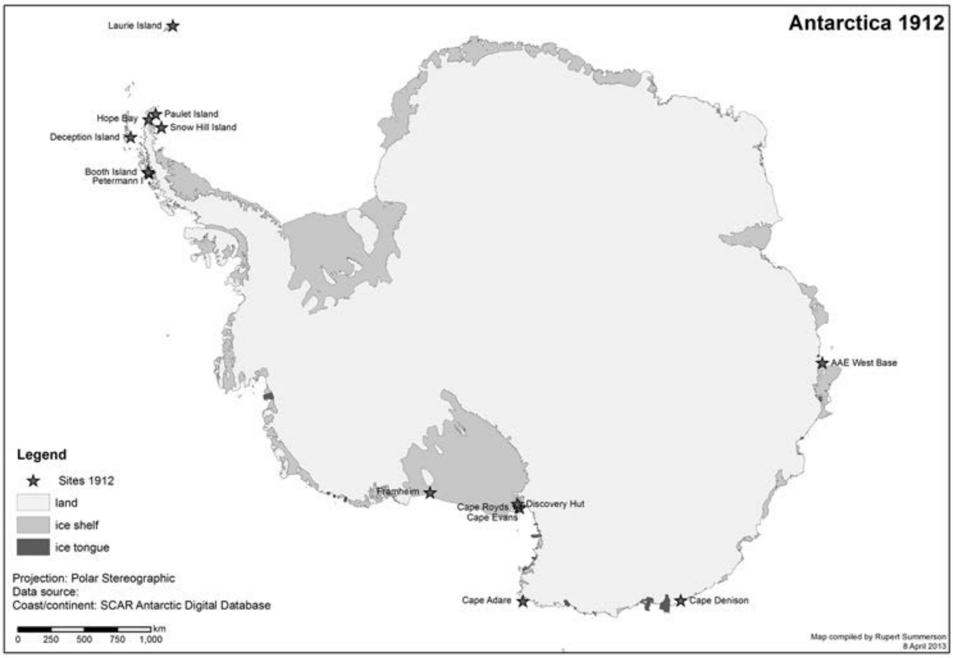


Figure 1 Human infrastructure in Antarctica in 1912. Size of symbols is not to scale.

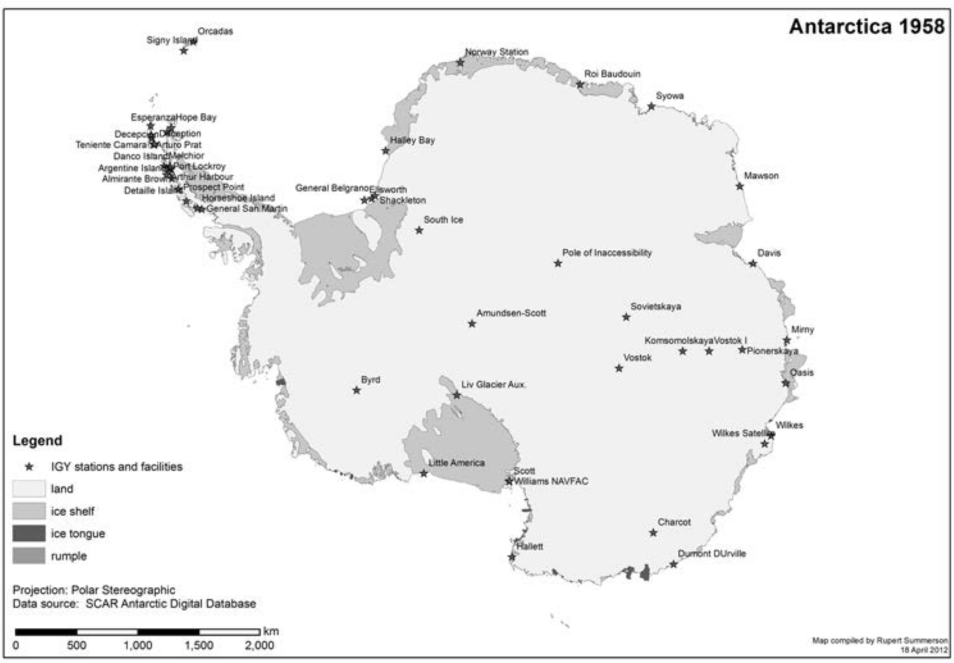


Figure 2 Human infrastructure in Antarctica in 1958.

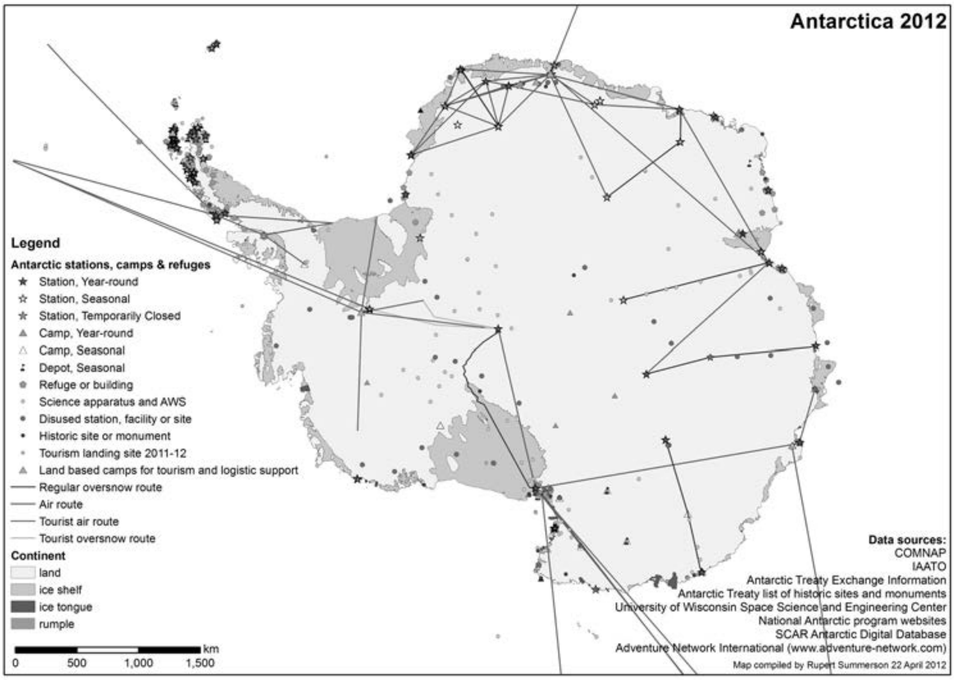


Figure 3 Human infrastructure and activity in Antarctica in 2012. Not all human activities that take place in Antarctica are marked on the map; for example, trajectories of individual field parties, routes of marine vessels, and helicopter routes are not shown. Size of symbols is not related to physical size of infrastructure or duration of activity.

Further Reading

Bargagli, R. *Antarctic Ecosystems: Environmental Contamination, Climate Change, and Human Impact.* Berlin: Springer, 2005.

Huettmann, F., ed. *Protection of the Three Poles.* Tokyo: Springer, 2012.

Secretariat of the Antarctic Treaty. Site guidelines for visitors. 2012. http://ats.aq/e/ats_other_siteguidelines.htm. Accessed January 9, 2014.

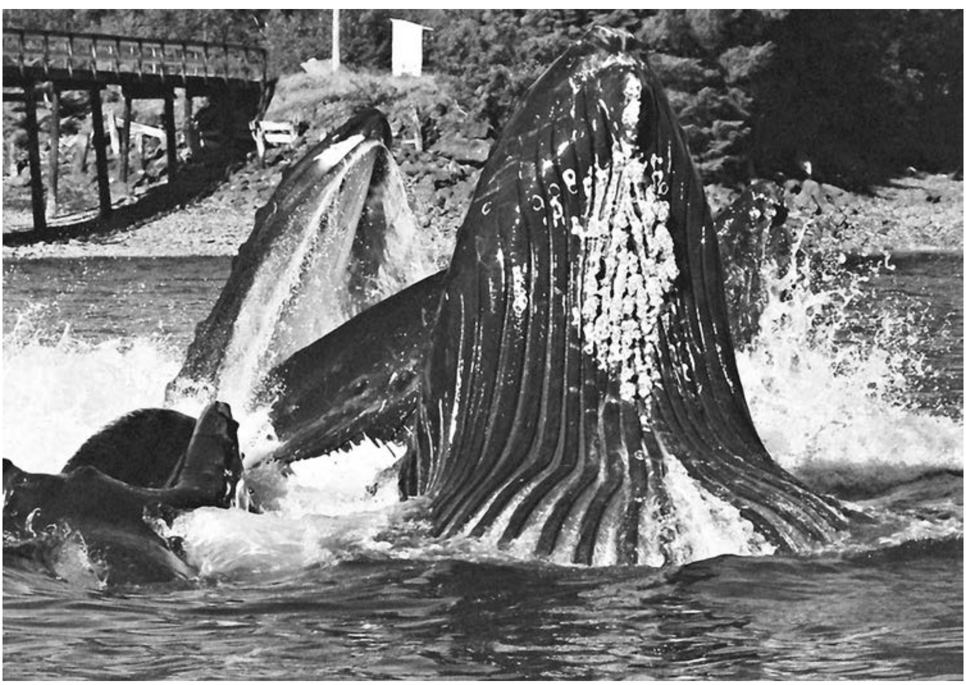
Tin, T., D. Liggett., P. Maher, and M. Lamers, eds. *Antarctic Futures: Human Engagement with the Antarctic Environment.* Dordrecht, the Netherlands: Springer-Verlag, 2013.

Tin, T., Z. Fleming, K. Hughes, D. Ainley, P. Convey, C. Moreno, S. Pfeiffer, J. Scott, and I. Snape. "Impacts of Local Human Activities on the Antarctic Environment." *Antarctic Science* 21 (2009): 3–33.

Humpback Whale

The humpback whale (*Megaptera novaeangliae*) is a member of the suborder Mysticeti, or baleen whales, and the rorqual family (Balaenopteridae). Although older sources note animals weighing as much as 88,000 pounds (40 tons) and being as long as 62 ft. (19 m), mature humpback whales today are typically 36–55 ft. (11–17 m) long and weigh about 44,000–77,000 pounds (20–35 tons). Females are somewhat larger than males. The oldest-known humpback whale is thought to have lived to be 95 years with the estimated life span being between 45 and 100 years.

The back and sides are black or dark gray, with some sections of the blubber showing a lighter hue. There are often light-colored spots on the lower belly near the genital slit. The massive head has a blunt snout, the jaws and the top of the head being covered in knobby bumps. The flippers are distinctive and can reach a length of about 16 ft. (5 m). The fluke can be as wide as 18 ft. (5.5 m), divided at the center by a large notch. When preparing to deep-dive, the whale often lifts this well above the surface of the ocean. The coloration pattern of the underside differs from animal to animal, sometimes being of a dark hue but mostly white or light colored. White, oval-shaped scars can be seen on the skin of some whales. These are caused by parasitic sea lampreys or are the evidence of some wound now healed. Humpback whales have from 10 to 35 ventral pleats or grooves on the underside of the body. These run from rostrum to naval and are broader and coarser



Humpback whales lunge feeding. (Andrew J. Hund) than those of other baleen whales. The dorsal fin is usually fairly small and varies in shape and size: it can be broad and triangular or narrow and crescent shaped, but usually lies somewhere in between. It can also appear as only a tiny hump. The humpback has 270–400 baleen plates on each side of the upper jaw. These are relatively short, dark gray or olive green in color, and with black edges. The spout is usually 8 to almost 10 ft. (2.5–3 m) tall—wider and shorter than that of most other rorquals.

Humpbacks have a varied diet, which depends on the oceanic area and season, but they generally live on krill and pelagic schooling fish. Food is usually gleaned close to the surface and down to 50 ft. (15 m), although they are known to dive to depths of around 500 ft. (150 m). Unlike other rorquals, hunting is a cooperative effort. However, food intake is low in their mating and breeding grounds.

Deep dives are usually less than 10 minutes in duration during summer and about 15–20 minutes during the winter, although the latter can last for as long as 45 minutes. The whale blows three to six times between deep dives. The humpback prefers to travel slowly, at about 3–6 mph (5–10 km/h), but can also demonstrate surges of energy when required. It sometimes escorts boats and ships and is well known for breaching and slapping the water with its tail and pectorals.

Distribution of the humpback whale is worldwide. Seasonal migration takes place between the cold seas and warmer oceanic areas (animals in the Arabian Sea being the exception). In summer, they forage right up to the ice edge in the polar seas of both hemispheres, and in winter, the mating season is underway. Not all humpbacks choose to migrate, and a certain number remain behind.

Humpback whales are usually solitary but can travel in small groups of two to five animals. However, the richest feeding grounds attract many animals, and during the breeding season, fierce competition for the fairest female can erupt between as many as 20 males. During mating and migration, humpbacks emit a variety of sounds, but the reason for this is not fully understood. Both males and females take part, but only males produce the intricate haunting arias for which the species is famous. Mating in the Northern Hemisphere peaks in early February, but normally spans the period from October to May in the North Atlantic and among the western population in the Caribbean Sea. Where the bulk of the eastern population resides is unclear, although it is known that some animals can be found near Cape Verde. In the Southern Hemisphere, mating takes place from April until September (peaking in August). The gestation period is 11–12 months, the females giving birth every second or third year.

Some estimate that there are at least 60,000 humpback whales in the world, although other sources say 35,000–40,000 (about 12,000 in the North Atlantic, 6,000–8,000 in the North Pacific, and about 17,000 in the Southern Hemisphere).

Sigurður Ægisson

See also: Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Gray Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Northern Bottlenose Whale; Southern Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Lammers, M., P. Fisher-Pool, A. Whitlow, C. Meyer, K. Wong, and R. Brainard. "Humpback Whale Megaptera Novaeangliae Song Reveals Wintering Activity in the Northwestern Hawaiian Islands." *Marine Ecology Progress Series* 423 (2011): 261–68.

Lee, J. "Do Whales Have Culture? Humpbacks Pass on Behavior." *National Geographic* (2013): 1. http://news.nationalgeographic.com/news/2013/13/130425-humpback-whale-culture-behavior-science-animals/.

Whitehead, H. "Updated Status of the Humpback Whale, *Megaptera novaeangliae*, in Canada." *Canadian Field-Naturalist* 101, no. 2 (1987): 284–94.

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I

Iceberg Monitoring and Classification

Shortly after the sinking of the *Titanic* in 1912, an international group was started in 1914. This group is operated by the U.S. Coast Guard with the focus of identifying and tracking icebergs in the North Atlantic. It is called the International Ice Patrol. Seventeen countries presently participate in this international program, which are Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, the Netherlands, Norway, Panama, Poland, Spain, Sweden, United Kingdom, and the United States. The International Ice Patrol used aircraft and radar to track icebergs that drift into major Atlantic shipping lanes.

In 1995, the U.S. National Ice Center (NIC) started a worldwide iceberg-monitoring program with remote sensors on polar-orbiting satellites. The NIC tracking program is primarily focused on icebergs in Antarctic, Arctic, Great Lakes, and Chesapeake Bay. Only icebergs that are more than 5,400 sq. ft. (500 sq. m) or 11.5 miles (18.5 km) in length are tracked. The U.S. NIC has created a naming system for icebergs that is based on a four-quadrant system.

In the Antarctic, icebergs are classified by a letter and a number. The letter represents an origination point from one of four quadrants in Antarctic, which are symbolized as A, B, C, and D. An "A" classification represents roughly the areas with the Bellingshausen and Weddell Seas or roughly from Abbot to the Fimbul Ice Shelves. This area includes the Antarctic Peninsula. The longitude coordinates are from 0° to 90° W. A "B" classification is approximately the Amundsen and the eastern part of the Ross Seas. The area includes the Abbot Ice Shelf to most of the Ross Ice Shelf. The longitude coordinates are from 90° W to 180°. A "C" classification includes western part of the Ross Sea near Ross Island to the Wilhelm II coast in between the Shackleton and West Ice Shelves in Wilkes Land. The longitude coordinates are from 90° E to 180°. The "D" classification is approximately from the Wilhelm II coast in between the Shackleton and West Ice Shelves in Wilkes Land to the middle of the Fimbul Ice Shelf and the eastern portion of the Weddell Sea. The longitude coordinates are from 0° to 90° E. The numbering is continuous, where each new iceberg gets the next number on the list.

The largest iceberg to date is the B15, which calved from the Ross Ice Shelf in 2000. This massive iceberg was tracked using the U.S. NIC. Based on its classification, it is from 90° W to 180° or quadrant B. It is also the 15th recorded iceberg. The B15 was 4,200 square miles (11,000 sq. km) measuring about 180 miles

(295 km) in length and 22 miles (37 km) in width. For two years, the iceberg remained intact, and then broke apart in 2002 and again in 2003. The iceberg was reclassified as B15A with an area of 1,200 square miles (3,000 sq. km). The pieces that broke off were identified and classified with a letter after B15, such as B15J and B15K. The main iceberg B15A floated away from Ross Island into open water. As the iceberg B15A drifted along Scott Coast of Victoria Land, it collided with the Drygalski Ice Tongue (75° 24′S 163° 30′E) resulting in breaking off tongue tip. The B15 iceberg continued along the coast until Cape Adare (71° 17′S 170° 14′E) where it broke into multiple pieces in October 2005. The B15A piece was reduced to 650 square miles (1,700 sq. km), with three new pieces named B15M, B15N, and B15P. As the icebergs moved off the Pennell

B15 ICEBERG

The largest iceberg to date is the B15 iceberg; it was the 15th recorded iceberg and calved from the Ross Ice Shelf near Roosevelt Island in Antarctica in 2000. The B15 iceberg was 4,200 square miles (11,000 sq. km) measuring about 180 miles (295) in length and 22 miles (37 km) in width. For two years, the iceberg remained intact, and then broke apart in 2002 and again in 2003. The iceberg was reclassified as B15A with an area of 1,200 square miles (3,000 sq. km). The pieces that broke off were indentified and classified with additional letters after B15, such as B15J and B15K. The main iceberg was renamed B15A. B15A floated away from Ross Island into the Ross Sea drifting along Scott Coast of Victoria Land. On its path, B15A collided with the Drygalski Ice Tongue (75° 24′S 163° 30′E) resulting in breaking off the tongue tip.

The B15 iceberg continued drifting along the coast until reaching Cape Adare (71° 17′S 170° 14′E) where it ran aground and broke into multiple pieces in October 2005. The suspected reason for B15A breaking apart was a significant storm in Alaska. The Alaska storm resulted in a large swell that caused the B15A iceberg to break apart. The B15A piece was reduced to 650 square miles (1,700 sq. km), with three new pieces named B15M, B15N, and B15P. As the icebergs moved off the Pennell and Oates coasts, the icebergs splintered into smaller pieces and melted. By 2006, the B15 iceberg pieces had disintegrated into many smaller pieces.

Based on the United States National Ice Center classification system, it is between 90° W and 180° or in quadrant B.

Andrew J. Hund

and Oates coasts, the icebergs splintered into smaller pieces melted. By 2006, the B15 iceberg pieces had disintegrated into many smaller pieces.

Andrew J. Hund

See also: Antarctic Ice Sheet; Ice Cap; Ice Domes: Argus, Charlie, and Fuji (Valkyrie); Ice Shelf; Ice Shelves of Antarctica

Further Reading

U.S. National Ice Center/Naval ice Center Website. http://www.natice.noaa.gov/. Accessed January 10, 2014.

Ice Cap

An ice cap is a large mass of ice that is formed by the compression and recrystallization of snow. By definition, an ice cap is a mass of ice that covers a land area that is less than 19,300 square miles (50,000 sq. km). A mass of ice more than 19,300 square miles is referred to as an ice sheet. An ice cap is not confined by geographic features and can be found in highland areas or on a mountain top. A characteristic of an ice cap is that it submerges the underlying land area, and there are no peaks or ridges protruding through the surface. An ice mass, by contrast, of comparable size but that which is confined by geographic features and/or has bedrock protrusions or outcrops called "nunataks" is identified as an ice field. An ice cap is sometimes confused with the generic term "polar ice cap"; however, a polar ice cap does not have a size component as with an ice cap and ice sheet.

Ice caps are a dome-shaped canopy over the geographic area and typically situated on the highest point of an individual mountain (massif), covering the entire area with accumulated snow and glacier ice. The thickest ice of an ice cap is in the dome area and can be up to 3,000 ft. (1,000 m) thick. Ice from an ice cap flows outward in a radial pattern from the highest point or dome to the edges. Ice caps are drained by multiple outlet glaciers that move in one direction.

An ice cap is formed by the yearly accumulation of snow over time and under the right climatic conditions. As the layers of snow accumulate and the snow freezes and refreezes, crystals become larger and air spaces between crystals are diminished, resulting in the snow becoming granular in texture called "firn." The firn is changed into ice and is buried into the accumulation zone of a glacier. In the ablation zone, the yearly snow fall is lost by calving ice as well as by melting and runoff.

An ice cap in a stable climate will remain roughly unchanged because the accumulation of ice is in balance with the melting. Ice caps are also susceptible to advancing and retreating. An advancing or growing ice cap is the result of reduced melting due to several colder summer conditions. The colder summer reduces the amount of melting and results in a thickening of the ice and growth of the ice cap over time. Conversely, if summer temperatures increase or there is a decrease in snowfall, the ice cap surface becomes thinner and ultimately results in the ice cap retreating around the periphery over time. Ice caps in the Arctic include Vatnajökull (64° 24′N 16° 48′W), Iceland, and Agassiz Ice Cap on northern coast of Ellesmere Island, Canada. Other notable large Arctic ice caps are the Devon Ice Cap (75° 20′N 82° 10′W), on the eastern side of Devon Island, Nunavut, Canada, and the Barnes Ice Cap (70° N 73° 30′W) located on Baffin Island, Nunavut, Canada.

Andrew J. Hund

See also: Antarctic Ice Sheet; Ellesmere Island Ice Shelves; Ice Core Climatic Data Proxies; Ice Core Collection and Preservation Issues; Ice Domes: Argus, Charlie, and Fuji (Valkyrie); Ice Sheet; Ice Shelves of Antarctica; Sea Ice

Further Reading

Bennett, M., and N. Glasser. *Glacial Geology: Ice Sheets and Landforms.* Chichester, UK: John Wiley and Sons Ltd, 1996.

Haeberli, W. "Glaciers and Ice Caps: Historical Background and Strategies of World-Wide Monitoring." In J. L. Bamber and A. J. Payne, eds. *Mass Balance of the Cryosphere.* Cambridge: Cambridge University Press, 2004, 559–78.

Ice Core Climatic Data Proxies

Inside the ice core layers are a number of climatic proxies (or substitutes) that provide evidence about the past climate. For example, the annual layer thickness indicates the precipitation rate. Ice core layers with sulfate (SO_4) concentration peak and ash indicate volcanic activity. Radioactive isotopes of beryllium-10 (^{10}Be), chlorine-36 (^{36}Cl), and iodine-129 (^{129}I) are characteristic of solar activity as well as nuclear explosions as with ^{36}Cl and ^{129}I. Temperature is determined by levels of oxygen-16 (^{16}O) and oxygen-18 (^{18}O). The greenhouse gases of carbon dioxide (CO_2) and methane (CH_4) provide evidence of past climates. Dust particles and pollen substantiate strength and wind speed and can be chemically analyzed to determine their origin. These proxies are examined through a number of basic and complex scientific processes. In addition, the number of climatic proxies in ice core samples makes them superior to the other climate archives.

Thickness and Temperature

A basic analysis of the ice core is achieved by examining the thickness of the layers. Examining the thickness reveals the historic temperature and precipitation. For example, a thicker layer indicates increased precipitation, while a thin layer denotes warm temperatures. When examining ice core layers, the summer layers are narrower and squeezed in between darker wider layers, which correspond to winter.

There are limitations to this method, because as noted before, the deeper layers become more compressed making the layers indistinguishable.

Isotopes and Temperature

Isotopic analysis examines the isotopes found inside bubbles making it an effective method to reconstructing past temperatures and the atmospheric composition of past and present climates. The process of determining the isotopic composition of ice and the gases in the bubbles is mass spectrometry. Mass spectrometry weighs molecules and detects how many isotopes and gases are in a sample by determining the mass-to-charge ratio and the composition of the elements. The process works as follows: an ice core sample is loaded in a mass spectrometry instrument and the sample is vaporized, the components are ionized, and ions (charged particles) are created; these ions are separated by their mass-to-charge ratio in an electromagnetic field, the ions are then quantified, and the ions signal the mass spectra. The mass spectrometry has three modes, which include determining the ion source, categorizing the ions by its mass (mass analyzer), and qualifying the ions present (detector). The concentrations of isotopes and gases in ice core samples are valuable because they reveal the composition of the atmosphere at the time they were entombed. They also provide estimates of the amount of solar radiation trapped in the atmosphere (greenhouse effect). In ice core samples, some of the common isotopic tests examine oxygen-16 (^{16}O) and oxygen-18 (^{18}O), and radioactive isotopes, such as beryllium-10 (^{10}Be), chlorine-36 (^{36}Cl), and iodine-129 (^{129}I).

Radioactive Isotopes

Ice cores have radioactive isotopes present, such as beryllium-10 (^{10}Be), chlorine-36 (^{36}Cl), and iodine-129 (^{129}I). The presence of ^{10}Be and ^{36}Cl concentrations is generally associated with the intensity of cosmic ray fluctuations moderated by solar activity. These cosmogenic isotopes are the result of cosmic ray particles interacting with the earth's atmosphere and distributed locally or extensively depending on their geochemical composition with some being trapped in falling snow and becoming part of ice sheets and glaciers. Cosmic ray particles contain all the elements found in the periodic table, with 89 percent of the nuclei being protons, 10 percent being helium, and approximately 1 percent being heavier elements (i.e., carbon, oxygen, and iron). A limited amount of these cosmic particles seep into the earth's atmosphere and interact with argon (Ar), nitrogen (N), and oxygen (O), resulting in the creation of secondary particles, such as carbon-14 (^{14}C), ^{10}Be, and ^{36}Cl. ^{14}C easily mixes with other particles and distributes throughout the atmosphere. In addition, ^{14}C reacts with O creating radioactive CO_2, which readily dissolves in water and thus permeates the main reservoirs of the carbon cycle, such as the atmosphere and ocean. Isotopes (^{10}Be and ^{36}Cl) also attach to aerosols or can transform into gaseous form ($H^{36}Cl$) and are given off. Both ^{10}Be and ^{36}Cl are washed from the atmosphere by precipitation. Recent elevated levels of ^{36}Cl on ice sheets and glaciers correspond to atmospheric nuclear weapon testing and are frequently used to synchronize ice core layers from different locations. ^{36}Cl is persistent and has remained on glaciers that have thawed and refrozen.

Trapped Gases

The gases trapped in ice bubbles are important in understanding past and recent climates. The process of determining these greenhouse gases uses a melted ice core sample in a closed system (gas chromatography) that detects the concentration of gases prior to the compounds exiting the instrument. The concentrations of gases

OXYGEN-16 (^{16}O) AND OXYGEN-18 (^{18}O)

^{16}O is made up of 8 protons and 8 neutrons and is referred to as light oxygen; while ^{18}O is made up of 8 protons and 10 neutrons and is referred to as heavy oxygen. These different weights can be determined by mass spectrometry. The study of oxygen atoms in ice core samples uncover past temperatures, ocean volume, and the earth's past climate. The ratio of ^{18}O or ^{16}O is basically temperature dependent or dependent on the thermometer of past and present climates, because as one goes up, the other goes down. For example, in cold temperatures, such as winter, the environment is enriched with ^{16}O and depleted of ^{18}O. When temperatures increase, ^{16}O evaporates first as it is lighter than ^{18}O. Summer, a warm temperature period, is an ^{18}O-enriched environment because the ^{16}O has evaporated due to increased temperatures. As the seasonal cycle continues, ^{18}O condensates and the environment returns to an ^{16}O environment in the colder temperatures. In short, the volume of ^{18}O or ^{16}O correlates with the seasonal cycles and helps determine the length of a season or the climatic variation of colder or warmer trends across years, decades, centuries, or millenniums. The changes in oxygen level are also useful for understanding climatic trends. For example, ice core samples with high level of ^{18}O indicates the earth had warmer temperatures, and because ^{18}O is heavier and requires higher temperatures to evaporate than less heavy isotopes like ^{16}O. Conversely, ice core samples with high level of ^{16}O indicate the earth had cooler temperatures. Oxygen molecules can also determine ocean temperatures, because higher amount of ^{18}O represents increased ocean temperatures, while more ^{16}O represents decreased temperatures. The temperature-dependent markers are important indicators of the earth's past climates.

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in bubbles are valuable because they reveal the composition of the atmosphere at the time they were entombed. They also provide estimates of the greenhouse effect and the isotopic composition, and can also indicate the gas source. The particular greenhouse gases of interest are carbon dioxide (CO_2) and methane (CH_4).

Carbon Dioxide (CO_2)

The level of carbon dioxide (CO_2) in the atmosphere is crucial in understanding past climates and relative temperatures. The level of CO_2 (and methane) is one of the best methods to determine past temperatures, which is not available with other coring methods. Higher CO_2 (and methane) concentrations correlate with warmer periods in the earth's history. Conversely, lower concentrations of CO_2 (and methane) indicate cooler periods. Ice core data have revealed that CO_2 (and methane) levels remained relatively constant until around 1900 and then went up dramatically in the graphic shape of a hockey stick. This increase in CO_2 (and methane) is indicative of anthropogenic (human) activities, such as the burning of fossil fuels (e.g., *liquid fuels*, such as gasoline or diesel; *solid fuels*, such as coal and wood; and *gaseous fuels*, such as natural gas). The ice core data demonstrate that the concentration of CO_2 is presently higher than it has been in the past 750,000 years.

Methane (CH_4)

The greenhouse gas methane (CH_4) provides evidence about the past climates. Methane is commonly associated with wetland environments, such as marshes, bogs, fens, swamps, and muskegs. Wetlands are a significant natural source of methane in the atmosphere. The release of methane is through the process of methanogenesis and occurs in oxygen-deprived (anaerobic) environments. Anaerobic microbes thrive in warm moist wetland environments, and as these microbes digest organic material, they produce methane as a by-product. The level of methane present in ice core sample indicates how much of the earth was covered by wetlands as well as the type of climate. Increases in methane is also due to anthropogenic (human) activities, such as fossil fuel production, ruminant animal (i.e., cows) manure and enteric fermentation, landfills, and natural gas and petroleum systems, which are in addition to the increased natural emissions from wetlands and other natural sources, such as termites, wild animals, and forest fires. Over the past 200 years, the concentration of methane in the atmosphere has doubled.

Other man-made gases have been found at the firn transition depth, indicating the recent introduction of these gases into the atmosphere. For example, CO_2 is found up to slightly more than 100 m dating to around the turn of the twentieth century. Tests for ozone-depleting substances, such as chlorofluorocarbons, hydrochlorofluorocarbons, halons, methyl chloroform, carbon tetrachloride, and methyl bromide (CH_3Br), were negative in ice core samples before the early 1900s. The exception being methyl bromide, which can be found in earlier ice core samples because it has natural sources such as the ocean and salt marshes.

Trapped Particles (Dust, Pollen, and Volcanic Ash)

The type and quantity of trapped particles in ice core samples provide a snapshot of the climatic and environmental conditions when the snow fell. These types of particles are dust, pollen, and volcanic ash. Commonly, these particles land on ice and remain fixed in the ice core layer. These particles help in the reconstruction of the past conditions, such as determining the prevailing wind patterns, distance traveled, origins of the particles, and the plants and vegetation present at the time they were deposited. Dust particles can be chemically analyzed to determine their original location as well as provide evidence of the relative strength of wind patterns when they were deposited. It is generally hypothesized that colder temperatures result in lower ocean levels and more barren land for which the elevated dust levels originate. Another piece of evidence found in ice cores is pollen. Each piece of pollen has a distinct shape enabling the identification of the plant it came from. Pollen grain analysis consists of examining the profusion and dispersal of pollen, and inferences are made about the precipitation and temperature needs of the plant species. Volcanic ash is distinguished by the ash layer it leaves in the ice core and the chemical sulfate (SO_4) and acidic signature. After the eruption, the volcanic ash is washed down from the atmosphere to the ice sheet by precipitation. Like dust, volcanic ash indicates the prevailing wind patterns after the eruption, and the distance the ash traveled. Volcanic ash is important because it can contribute to climate change, and the layer of ash is used to determine the age of the ice layer.

Proxy data from ice core samples are vital in understanding past environments and climate variability. These records provide direct evidence about past temperatures, precipitation, and the global environment. As methods, dating, and understanding of climate variability improve the precision of paleoclimatology, knowledge will increase over the next 5–10 years and beyond.

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See also: Antarctic Ice Sheet; Ice Core Collection and Preservation Issues

Further Reading

Fischer, H., M. Wahlen, J. Smith, D. Mastroianni, and B. Deck. "Ice Core Records of Atmospheric CO2 around the Last Three Glacial Terminations." *Science* 283, no. 5408 (1999): 1712–14.

Flückinger, J., A. Dällenbach, T. Blunier, B. Stauffer, T. Stocker, D. Raynaud, and J. Barnola. "Variations in Atmospheric N2O Concentration during Abrupt Climate Changes." *Science* 285 (1999): 227–30.

Friedli, H., H. Lotscher, H. Oeschger, et al. "Ice Core Record of the C13/C12 Ratio of Atmospheric CO2 in the Past Two Centuries." *Nature* 324, no. 6094 (1986): 237–38.

Ice Core Collection and Preservation Issues

There are a number of coring processes used to study the earth's climate history, and ice cores are one method. The other types of coring methods are tree coring (tree-ringed dating), rock cores, and sediment cores from the ocean floor, peat bogs, and lake sediment cores. Each of these cores has many small layers that represent an annual cycle, a major event (e.g., a volcanic eruption), or a seasonal cycle. When examining a core sample, the layers closest to the surface are more recent and the descending lower layers are older. This is called "superposition." Like the other cores, cores from ice sheets and mountain glaciers are a vertical timeline of past climates.

There are several methods for obtaining an ice core, which are contingent on the type of ice. Coring up to 100 ft. (30 m) is possible with a hand auger and hollow

DATING OF ICE CORES

The dating of shallow ice cores is relatively precise with each layer representing around a year. Dating of ice cores is similar to counting tree rings. Even though precision in dating varies by methods, the dating of the layers can be accomplished by chemical or isotopic seasonal cycle counting. The deeper layers become thinner and more compressed making the separation of annual layers more difficult and frequently indistinguishable. Therefore, precision of dating deeper ice core layers is challenging, and different methods have resulted in inconsistent dating. For example, glaciologists used five different dating methods for ice cores from Vostok, Antarctica, and the differences ranged from 300 years at 330 feet (100 m), to 5,000 years at 2,600 feet (800 m), to 6,000 years at 5,200 feet (1,600 m). Comparison and synchronizing with ice cores from other regions can be achieved by matching time markers (sometimes called marker events), which are major events such as large volcanic eruptions (e.g., an ash layer, uniquely shaped and colored particles, and more acidic chemistry signature) and sometimes meteorite debris as well as above ground atomic detonations (e.g., radioisotopes). Another consideration is the flow of ice over time. In areas with little flow, there is minimal disturbance, and the ice typically moves down and away. In heavy-flow locations, the deeper layers are prone to distortion and include material from the lower surface. Although dating is imprecise and variable in deeper ice layers, understanding the reasons for the differences is critical in the interpretation of the climate conditions.

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tube in areas that are not extremely cold. Obtaining deep ice core involves the use of an electromechanical, electrochemical, and thermal drills that bore a cylindrical-shaped hole about 3–4 inches (75–100 mm) across into the ice sheet or glacier. Mechanical drills are generally used in very cold areas and are capable of reaching depths of around 650 ft. (200 m). In areas slightly below freezing, the uses of electrochemical or thermal drills are common. Rather than a drill bit, thermal drills use heated coil that drills down by melting the ice. Thermal drills also produce a cylindrical-shaped core about 3–4 inches (75–100 mm) across.

The drill that head cuts, grinds, or melts is located on the front end of the coring device. Behind the drill head is a tube or barrel that varies in length. As the drill bores down between 3 and 18 ft. (1–6 m), the cylindrical core of ice fills the barrel, and once full, the drill and barrel are brought back up. The cylindrical-shaped ice core is removed. The process is repeated until the desired depth is achieved. The depth of these boreholes can range from a few feet to about 10,500 ft. (3,200 m). In ice cores deeper than 980 ft. (300 m), the borehole is under great pressure and can deform or fold in on itself. A fluid or mixtures of fluids are added to boreholes to prevent them from deforming and/or closing. Historic fluids have been toxic, ignitable, and ozone-depleting substances, such as *n*-butyl acetate and brown kerosene mixed with halogenated-hydrocarbon densifier.

BOREHOLE

A borehole is a common name for coring a hole into the earth, ice, or tree. Coring is a process of drilling a cylindrical-shaped hole (called a borehole) from a few feet to about 10,500 feet (3,190 m) at Dome Charlie. The core extracted from the drilled hole is used to study the earth's past climate. For example, scientists and researchers who study past and present climates (climatologists) will obtain an ice core sample from a borehole to estimate past weather and atmospheric conditions. Boreholes from ice sheets allow for better reconstruction estimates of past climatic conditions, because of the thickness and purity of the ice. In ice cores deeper than 300 meters, the borehole is under great pressure and can deform or fold in on itself. A fluid or mixtures of fluids are added to boreholes to prevent them from deforming and/or closing. Historic fluids have been toxic, ignitable, and ozone-depleting substances, such as n-butyl acetate and brown kerosene mixed with halogenated-hydrocarbon densifier. The analysis of the physical process of heat transfer in ice is well understood resulting in accurate estimates of past atmospheric conditions derived from boreholes.

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Deep ice samples when brought to the surface decompress resulting in their volume expanding (referred to as relaxation) due to thermal changes. The ice samples are under considerable pressure and become very fragile and susceptible to breaking or shattering upon handling. Relaxation can last for several months. To prevent the ice cores from fracturing, they are stored at temperatures below 32°F (−10°C) for up to a year. Many sampling sites in Greenland and Antarctica have on-site storage containers. Scientists working with the core samples typically wear protective clothing, respirators, and wrap ice samples in polyethylene bags to prevent sample contamination. Ice core samples are generally wrapped in bubble wrap, and packaged in styrofoam boxes, and placed in a refrigerated container that has an automatic back-up system, called a "redundant container system," for storage and transportation. Drills that use warm temperatures, such as water drills, result in more relaxation compared with electromechanical drills.

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See also: Ice Cap; Ice Core Climatic Data Proxies

Further Reading

Bender, M., M. Souers, J. Dinckson, P. Orchardo, P. Grootes, P. Mayewski, and D. Meese. "Climate Connection between Greenland and Antarctica during the last 100,000 Years." *Nature* 372 (1994): 663–66.

Flückinger, J., A. Dällenbach, T. Blunier, B. Stauffer, T. Stocker, D. Raynaud, and J. Barnola. "Variations in Atmospheric N2O Concentration during Abrupt Climate Changes." *Science* 285 (1999): 227–30.

Küttel, M., E. Steig, Q. Ding, A. Monaghan, and D. Battisti. "Seasonal Climate Information Preserved in West Antarctic Ice Core Water Isotopes: Relationships to Temperature, Large-Scale Circulation, and Sea Ice." *Climate Dynamics* 39, 7–8 (2012): 1841–57.

Reddy, M., D. Naftz, and P. Schuster. "Ice-Core Evidence of Rapid Climate Shift during the Termination of the Little Ice Age." U.S. Geological Survey. Retrieved 2006.

Ice Curtain

Since the United States purchased Alaska from Russia, in 1867, the Big Diomede (65° 46′ 52″N 169° 03′ 25″W) and Little Diomede (65° 45′ 15″N 168° 55′ 15″W) have been the border between the nations. These islands are more than 2 miles (3 km) apart and just called the "Diomede Islands." The Diomede Islands are located between mainland Siberia and Alaska. Big Diomede Island is 11.2 square miles (29 sq. km), while Little Diomede Island is 2.8 square miles (7.3 sq. km). During the Cold War, these remote Bering Sea islands became a significant military and political dividing line between the Russians and Americans. This borderline was called the "Ice Curtain" in reference to the Cold War and the tensions or icy relations between the two countries. The Soviet Union owned the Big Diomede Island, and it was the eastern most point of the USSR. Big Diomede was a Soviet military base during World War II and remained operational during the Cold War. Little Diomede Island is owned by the United States and is part of the state of Alaska. It is located about 25 miles (40 km) from the Alaskan mainland. The local population is predominately Inupiat. Presently, a little more than 130 people inhabit the island mostly in the village of Inalik on the western side. These islands are also referred to as Tomorrow Island (Big Diomede) and Yesterday Isle (Little Diomede) because they are separated by the International Date Line resulting in Big Diomede being 24 hours ahead of Little Diomede.

The Soviets forcibly removed the local indigenous population to the Chukotka Autonomous Okrug during the Soviet and American tensions. This group is believed to have become extinct. There is some disagreement about whether this lost Eskimo group was Yup'ik or Inupiat. Prior to the Cold War tensions, the local indigenous groups frequently traveled back and forth to trade, attend festivals, and socialize. During the Cold War, travel was forbidden between the two islands. In 1987, American swimmer Lynne Cox swam 2.7 miles (4.3 km) in a water temperature of 38ºF (3.3ºC) from Little Diomede to Big Diomede. Her swim across the Ice Curtain was a symbolic gesture of the easing tensions between the Soviet Union and the United States. The U.S. president Ronald Reagan and the general secretary of the Communist Party of the Soviet Union Mikhail Gorbachev jointly congratulated her swimming across the border. Since 1990, travel between the islands by boat and plane is now permitted; however, the traveling requires a visa and/or a military permit to Big Diomede.

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See also: Ice Sheet; Ice Shelf

Further Reading

Iseman, P. "Lifting the Ice Curtain." *New York Times*, October 23, 1988.

Ice Domes: Argus, Charlie, and Fuji (Valkyrie)

There are three major ice domes in Antarctica, which are Argus, Charlie, and Valkyrie (also called "Fuji"). Dome Argus or Dome A (81º S 77º E) is the highest Antarctic ice feature at 13,422 ft. (4,091 m) above sea level. Even though it is the highest ice feature, it is a barren ice-covered plain midway between the tip of the Lambert Glacier and the South Pole roughly in the center of East Antarctica. It rests on more than 7,800 ft. of snow and ice that sits atop the Gamburtsev Subglacial Mountains (80° 30′S 76° E). The Gamburtsev Subglacial Mountains are a 750-mile (1,200-km) long mountain range entombed by more than 2,000 ft. (600 m) of snow and ice. These mountains are estimated to be more than 8,000 ft. (2,700 m) tall. Dome Argus is considered to be the world's coldest places with yearly temperatures estimated to reach −130°F (−90°C). Annual precipitation is between less than half an inch and slightly more than an inch (1–3 cm) making Dome A one of the world's driest places. The University of Cambridge's Scott Polar Research Institute researchers named the dome after Argus, who under Athena's direction in Greek mythology built the ship *Argo*. *Argo* carried Jason and the Argonauts on their journey to Iolcos to obtain the Golden Fleece.

Dome Charlie (75º S 125º E) is an Antarctic ice feature at 10,607 ft. (3,233 m) above sea level. It is located on the polar plateau next to the France/Italian research station Concordia Station (75° 6′S 123° 20′E). The Dome is 680 miles (1,100 km) from the Australian Antarctic Division Casey Station (66° 16′ 54″S 110° 31′E) on the Budd Coast of Wilkes Land and the French Polar Institute Paul-Émile Victor, Dumont d'Urville Station (66° 39′S 140° E) on the Adélie Coast. The Russia Federation Vostok Station (78° 27′S 106° 50′E) in Princess Elizabeth Land is located 350 miles (560 km) from Dome Charlie. Other names for Dome Charlie are "Dome C" or "Dome Circe." Dome Charlie is considered to be the world's coldest places with yearly temperatures estimated to reach −110°F (−79°C). The average yearly temperature is around −66°F (−54°C). Annual precipitation via precipitation and humidity is very low at Dome Charlie. The area of Dome Charlie has very little wind and is considered a polar desert. The European Project for Ice Coring in Antarctica was the first to drill an ice core at Dome Charlie. The ice core went to almost 10,500 ft. (3,190 m) obtaining climate data going back 800,000 years ago and covering eight glacial cycles.

Dome Fuji (77° 30′S 37° 30′E) is commonly called "Valkyrie Dome." It is located in Queen Maud Land next to the Japanese station called "Dome Fuji Station," which was established in 1995 by the Japanese Antarctic Research Expedition (JARE). Valkyrie Dome is about 620 miles (1,000 km) from the JARE Syowa Station (69° S 39° 35′E) on East Ongul Island in Queen Maud Land. Dome Fuji is 12,500 ft. (3,800 m) above sea level making it the second highest in Antarctica (just behind Dome Argus). There have been two deep ice cores drilled at Valkyrie Dome. The most recent was in 2003–2004, and the climate data from the ice go back more than 700,000 years ago. The depth of this core is just more than 9,500 ft. (3,035 m). The first ice core was drilled in 1995–1996, and the climate data from the ice core go back 320,000 years ago.

The ice cores from the Dome Charlie and Fuji provide evidence about the past climate dating back 100,000 years ago. For example, the annual layer thickness indicates the precipitation rate. Ice core layers with sulfate (SO_4) concentration peak and ash indicate volcanic activity. Radioactive isotopes of beryllium-10 (^{10}Be), chlorine-36 (^{36}Cl), and iodine-129 (^{129}I) are characteristic of solar activity as well as nuclear explosions as with ^{36}Cl and ^{129}I. Temperature is determined by levels of oxygen-16 (^{16}O) and oxygen-18 (^{18}O). The greenhouse gases of carbon dioxide (CO_2) and methane (CH_4) provide evidence of past climates. Dust particles and pollen substantiate strength and wind speed and can be chemically analyzed to determine their origin.

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See also: Antarctic Ice Sheet; Ice Core Climatic Data Proxies; Ice Core Collection and Preservation Issues; Ice Sheet

Further Reading

Abdelkrim A., E. Aristidi, M. Azouit, E. Fossat, F. Martin, T. Sadibekova, J. Vernin, and A. Ziad. "First Whole Atmosphere Night-Time Seeing Measurements at Dome C, Antarctica." *Proceedings of the Astronomical Society of the Pacific* 118 (2005): 344–48.

Saunders, W., J. Lawrence, J. Storey, M. Ashley, S. Kato, P. Minnis, D. Winker, G., Liu, et al. "Where Is the Best Site on Earth? Domes A, B, C, and F, and Ridges A and B." *Publications of the Astronomical Society of the Pacific* 121, no. 883 (2009): 976–92.

Ice Sheet

An ice sheet (also "continental glacier") is a body of glacial ice covering more than 19,000 square miles (50,000 sq. km) of land, while an ice cap may have similar attributes but covers a smaller area. Typically, ice sheets have a low-domed profile and may possess multiple summits. Glacial ice is not stationary but flows within an ice body. However, unlike smaller alpine glaciers and ice caps, ice sheets are unconstrained by topography, ice moving independently of the lay of the underlying land.

Generally, ice flow is controlled by ice thickness, ice moving radially outward from the thick center to the thin periphery. Some parts are slow-moving while others (ice streams), frequently at the ice sheet periphery, flow several hundreds of meters per year, often aided by topography, underlying substrate, and unfrozen water at the base. Ice sheet growth (accumulation) is achieved by addition of snow and ice, and loss (ablation) occurs most efficiently through a combination of calving (break-off of pieces [icebergs] into the ocean) and melting. Where an ice sheet enters the sea, its margin may float to form an ice shelf. An ice sheet's mass balance is a function of its annual (or greater) accumulation versus ablation, dictating expansion or retreat. Retreat occurs when ablation exceeds accumulation and/or forward flow. Temperature is not uniform within an ice sheet but depends on heat sources at the surface (air temperature, solar radiation), interior (friction between moving ice crystals, latent heat of crystallization), and base (friction, geothermal heat). Typically, both temperature and pressure increase from the surface to the base.

High pressures at the ice sheet base (due to overburden) may be sufficient to lower the freezing point of water several degrees below 32°F (0°C)—"pressure melting point" (PMP). At temperatures below PMP, ice is frozen to the underlying substrate (cold based), and all motion occurs by internal deformation of the ice alone. Where basal temperatures are at or above PMP (warm based), pressurized liquid water occurs, and motion takes place as a combination of internal deformation and basal sliding. Given their vast size and varying thickness, ice sheets can have both cold-based and warm-based sections.

Ice sheets play an important role in global climate via their influence on large-scale atmospheric circulation, pressure patterns, and albedo. They also control global sea level, as ice sheet growth retains water (as snow and ice) on land that would otherwise return to the oceans. Consequently, global sea level drops during glacial periods in the earth's history marked by ice sheet expansion. For example, during the height of the last glacial period (Last Glacial Maximum, approximately 20,000 years ago), sea level was globally 390–425 ft. (120–130 m) lower relative to present. Currently, there exist the Greenland Ice Sheet (GIS) and the Antarctic Ice Sheet, separated dynamically into the larger East Antarctic and smaller West Antarctic ice sheets by the Transantarctic Mountains. The GIS covers 1.74 million sq. km, holding 2.6 million cubic km of ice, 10 percent of the earth's total freshwater. Collectively, the Antarctic ice sheets cover 13.5 million sq. km, incorporating 25.4 million cubic km of ice. In addition to the current ice sheets, many more existed during the LGM, including the Laurentide (covering northern North America), Fennoscandian (Norway to Poland and Denmark), and the British Irish (most of the British Isles) ice sheets.

Ice sheets grow by addition of annual snow and refrozen meltwater layers. The low density of new snow (50–200 kg/m^3) increases with depth and compression; as snow refreezes, crystals become larger while air spaces between crystals decrease, with snow attaining a granular texture (firn). Eventually, a mass of solid intergrown ice crystals with discrete air bubbles (true glacial ice) develops. Ice sheets are valuable

ICE FORMATION

An ice sheet or glacier is a series of layers of snow and ice that have collected over many years. As snow falls, it collects atmospheric particles, such as dust particles, trace metals, chemical compounds, or radioactive material firn, which is a type of ice that is between snow and glacial ice and has the texture of granulated sugar. As the layers of snow accumulate, the firn is compressed resulting in the creation of ice crystals. At a depth of approximately 230–330 feet (70–100 m), the pressure becomes so great that the pockets of air and the firn transform into bubbly ice. Even deeper, the ice crystals fuse together with the air present to form pure ice.

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archives of past environmental conditions and can be sampled by coring (extracting a solid sample down through progressively deeper [older] layers from the ice sheet top toward its base). Notably, the discrete air bubbles in glacial ice represent samples of air at the time of snow and ice deposition, containing gases that influence global climate, such as carbon dioxide and methane. Ice cores can be studied to decipher past climate (including atmospheric composition) through time. The longest Greenland ice cores measure more than 9,000 ft. (3000 m), extending back 123,000 years, whereas Antarctic ice cores extend back 740,000 years at a maximum due to the low accumulation rates. Melting of the current ice sheets is of global concern due to its effect on global sea level. It is estimated that complete melting of the GIS would raise sea level globally by 22 ft. (7 m), while melting of the Antarctic ice sheets would raise it by 187 ft. (57 m).

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See also: Antarctic Ice Sheet; Ice Shelf; Ice Shelves of Antarctica

Further Reading

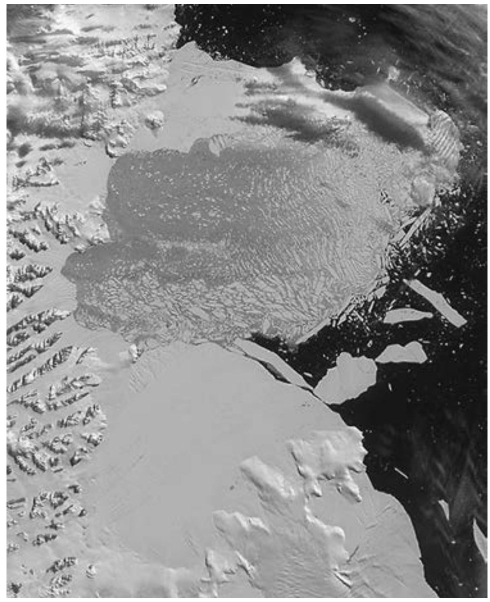
Greve, R., and H. Blatter. *Dynamics of Ice Sheets and Glaciers.* Dordrecht, the Netherlands: Springer, 2009.

Müller, J., and L. Koch, eds. *Ice Sheets: Dynamics, Formation and Environmental Concerns.* Hauppauge, NY: Nova Science, 2012.

Steig, E., D. Schneider, S. Rutherford, M. Mann, J. Comiso, and D. Shindell. “Warming of the Antarctic Ice-Sheet Surface since the 1957 International Geophysical Year.” *Nature* 457, no. 7228 (2009): 459–62.

Ice Shelf

An ice shelf is a persistent floating body of ice in the marine environment, thick enough to flow forward by internal deformation and frequently dynamically connected to a land-based ice sheet or glacier. Based on the dominant origin of ice within these features, ice shelves can be categorized as glacier ice shelves (composed of terrestrially derived glacial ice), sea ice shelves (grounded fast ice, i.e., sea ice attached to land and in contact with the seabed), and composite ice shelves (both glacier and sea ice). Ice shelves typically possess a low gradient and thicknesses over 650 ft. (200 m), though only 15 percent of this is above the waterline. The boundary between ice in contact with the land and that float off is referred to as the grounding line. Ice shelves are affected by tides, apparent in characteristic breaks or crevasses due to tidal flexing. Growth occurs through the addition of snow, glacial flow from the connected ice sheet or glacier, and underfreezing (often of seawater, forming marine ice) at the base. Mass is lost by break-off or calving into the ocean (producing icebergs) and surface and bottom melting due to increased air or seawater temperatures. Surface melting can produce extensive meltwater ponds.



View of the breakup of the northern section of the Larsen B ice shelf in this image from the Multi-angle Imaging SpectroRadiometer. The Larsen B ice shelf collapsed and broke away from the Antarctic Peninsula during February and March 2002. (NASA)

Ice shelves are restricted to polar regions, being most numerous in the Southern Hemisphere, fringing some 30 percent of the Antarctic coastline. The largest ice shelves in the world are the Ross Ice Shelf (182,626 square miles [473,000 sq. km], Ross Sea) and the Ronne-Filchner Ice Shelf (162,935 square miles [422,000 sq. km], Weddell Sea) in Antarctica. They extend hundreds of kilometers into the ocean from their grounding lines and calve massive tabular icebergs, tens to hundreds of kilometers in length. Such icebergs drift with currents and winds into warmer latitudes, melting en route. Other Antarctic ice shelves include the Amery, Riiser-Larsen, Fimbul, and Shackleton Ice Shelves. Though Northern Hemisphere ice shelves are rare compared with Antarctica, most are found in northern Greenland, and some exist on northern Ellesmere Island (Canada) and Franz Josef Land (Russia). The large extent of Antarctic ice shelves is partially due to the relatively deep water surrounding the Antarctic continent, and many (especially the larger ones) are fed by fast-flowing sections (ice streams) of the Antarctic Ice Sheet. In the Northern Hemisphere, ice shelves are relatively small and confined, that is, they are anchored by embayments, islands, and sides of fjords.

Ice shelves perform an important function in buttressing and stabilizing inland ice (glaciers and ice sheets), and their loss and breakup result in accelerated delivery of glacial ice (calving) into the ocean. They furthermore play an important role in global climate via albedo, reflecting back solar energy and insulating the underlying ocean. Melting and breakup of floating ice shelves contribute only marginally to global sea-level rise, the floating ice displacing seawater. The marginal sea-level contribution is primarily due to the differing densities of freshwater (i.e., glacial ice) versus seawater. It is estimated that melting of all ice shelves would raise sea level globally by about 1.5 inches (4 cm). Factors that contribute to maintaining an ice shelf include cool air (annual average below 32°F [0°C]) and sea-surface temperatures, high ice input from the adjoining glacier or ice sheet, small tidal ranges and tidal currents, constant sea level, deep water, and presence of coastal embayments and/or islands that can anchor and help stabilize the ice shelf.

Disintegration of ice shelves is of current concern because of the resulting acceleration and calving of previously buttressed land-based glaciers and ice sheets into the sea, thus contributing to rising global sea level. Ice shelf retreat typically occurs in two steps. Initially, slow recession of the ice shelf front due to climate warming occurs over a relatively long time period (years to decades). Once certain key instability thresholds are passed, collapse can be fast and often catastrophic. Such disintegration has included the recent and rapid retreat of large sectors of the Larsen Ice Shelf in the Weddell Sea (Antarctica), including disintegration of the Larsen-A and Prince Gustav Channel Ice Shelves. Both of these ice shelves, previously situated along the Antarctic Peninsula, rapidly deteriorated due to warming air temperatures during the 1980s and 1990s. Recent disintegration of ice shelves has also occurred in the Arctic. For example, most (90%) of the Ellesmere Ice Shelf (Arctic Canada) diminished within the twentieth century in a matter of 80 years, breaking into six separate remnant sections. After apparently stabilizing, the largest (154 square miles [400 sq. km]) of the remaining Ellesmere Ice Shelf pieces, the Ward Hunt Ice Shelf, has continued to fracture and break apart.

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See also: Ice Cap; Ice Domes: Argus, Charlie, and Fuji (Valkyrie); Ice Shelves of Antarctica

Further Reading

Fricker, H., R. Coleman, L. Padman, T. Scambos, J. Bohlander, and K. Brunt. "Mapping the Grounding Zone of the Amery Ice Shelf, East Antarctica Using InSAR, MODIS and ICESat." *Antarctic Science* 21, no. 5 (2009): 515–32.

Noerdlinger, P., and K. Brower. "The Melting of Floating Ice Raises the Ocean Level." *Geophysical Journal International* 170, no. 1 (2007): 145–50.

Scambos, T., H. Fricker, C. Liu, J. Bohlander, J. Fastook, A. Sargent, R. Massom, and A. Wu. "Ice Shelf Disintegration by Plate Bending and Hydro-Fracture: Satellite Observations and Model Results of the 2008 Wilkins Ice Shelf Break-Ups." *Earth and Planetary Science Letters* 280 (January 4, 2009): 51–60.

Vincent, W., J. Gibson, and M. Jeffries. "Ice-Shelf Collapse, Climate Change, and Habitat Loss in the Canadian High Arctic." *Polar Record* 37, no. 201 (2001): 133–42.

Ice Shelves of Antarctica

Ice shelves are found only in Antarctica, Canada, and Greenland. The Antarctica has most of the ice shelves. Of the 28,158 miles (45,317 km) of Antarctic coast, approximately 42 percent or 11,729 miles (18,877 km) are ice shelves with the remaining coast being 46 percent (13,031 miles [20,972 km]) ice and 12 percent (3,398 miles [5,468 km]) rock. By definition, an ice shelf is a persistent floating platform of ice in a marine environment commonly originating on land and by gravity drains an ice sheet or glacier. There are three types of ice shelves based on the ice source, which are glacier ice shelves, sea ice shelves, and composite ice shelves. A glacial ice shelf is made freshwater, while sea ice shelf is a mix of salt- and freshwater. Glacier ice shelves are composed of land-based glacial ice, sea ice shelves are from sea ice that is attached to land and connected to the seabed. Composite ice shelves are a combination of glacier and sea ice shelves.

There are a number of ice shelves in Antarctica of which 12 are major ones. Listed clockwise, the major ice shelves of Antarctic are the Ronne-Filchner, Riiser-Larsen, Fimbul, Amery, West, Shackleton, Ross, Getz, Abbott, George VI, Wilkins, and Larsen. There are 35 smaller ice shelves (listed clockwise): the Brunt, Quar, Ekstrom, Jelbart, Lazarus, Hannan, Zubchatyy, Wyers, Edward VIII, Publications, Moscow University, Voyeykov, Cook, Slava, Gillett, Nansen, Lady Newnes, McMurdo, Swinburne, Sulzberger, Nickerson, Dotson, Crosson, Cosgrove, Venable, Stange, Bach, Rameau, Verdi, Brahms, Britten, Wordie, Jones, Muller, and Prince Gustav. The total area of the ice shelves of Antarctica is 595,253 square miles (1,541,700 sq. km).

Ross Ice Shelf

The world's largest floating ice shelf is the Ross Ice Shelf (81° 30′S 175° W) covering an area of 182,000 square miles (473,000 sq. km). Captain John Ross (1777–1856) had first named the ice shelf "Victoria Barrier" in honor of Queen Victoria and then later the "Great Ice Barrier." The ice shelf was later named in his honor. The Ross Ice Shelf is horseshoe shaped and about 500 miles (800 km) across. From the open, the Ross Ice Shelf goes inland for more than 350 miles (600 km). The ice cliff face above the water surface ranges from 50 to 150 ft. (15–50 m) in height. The thickness of the Ross Ice Shelf ice ranges from 600 to 3,000 ft. (180–900 m). On the west side, the Ross Ice Shelf is bordered by Edward VII peninsula, Shirase, Siple, and Gould coasts neighboring Marie Byrd Land. On the eastern side of the Ross Ice Shelf are the Queen Maud Mountains of the Transantarctic Mountains, Shackleton and Hillary coasts, and Ross Island.

Several ice streams drain into the Ross shelf on the western side, such as the MacAyeal (80° S 143° W), Bindschadler (81° S 142° W), Whillans (83° 40′S 145° W), and Mercer (84° 50′S 145° W) ice streams. These ice streams were formerly known as the Ice Stream E, D, B, and A, respectively. On the eastern side, several major glaciers drain into the Ross Ice Shelf, such as the Leverett (85° 38′S 147° 35′W), Scott (85° 45′S 153° W), Beardmore (83° 45′S, 171° E), Nimrod (via the Shackleton Inlet) (82° 19′S 164° E), Byrd (80° 20′S 159° E), Mulock (79° S 160° E), and Skelton (78° 41′S, 161° 38′E) Glaciers.

There are two scientific bases on the southern part of Ross Island, which are the United States' McMurdo Station (77° 51′S 166° 40′E) and New Zealand's Scott Base (77° 51′S 166° 45′E). McMurdo Station is the largest community in

Antarctica. In 2007, the documentary *Encounters at the End of the World* directed by Werner Herzog highlighted different perspectives of people working at McMurdo Station. Scott Base is named after Captain Robert Falcon Scott (1868–1912), who led two British expeditions (the Discovery Expedition of 1901–1904 and Terra Nova Expedition of 1910–1913) to the Ross Sea region. Scott died on the Terra Nova Expedition.

Ronne-Filchner Ice Shelf

Ronne-Filchner Ice Shelf is the second largest in Antarctica (162,935 sq. miles [422,000 sq. km]) located at the head of the Weddell Sea. The thickness of the Ronne-Filchner Ice Shelf ice ranges from 500 to 650 ft. (150–200 m). Ronne-Filchner Ice Shelf is a combination of the Ronne and Filchner Ice Shelves. The Ronne Ice Shelf (78° 30′S 61° W) is larger of the two and located on the western side. The Filchner Ice Filchner (79° S 40° W) is on the eastern side. Located between the Ronne and the Filchner is Berkner Island (79° 30′S 47° 30′W). On the west side, the Ronne Ice Shelf is bordered by the Orville and Zumberge coasts and Ellsworth Land.

Three ice streams flowing into the Ronne Ice Shelves are the Rutford (79° S 81° W), Evans (76° S 78° W), and the Foundation (83° 15′S 60° W) ice streams. The Support Force Glacier (82° 45′S 46° 30′W) flows into the Ronne-Filchner Ice Shelf. The Recovery (81° 10′S 28° W) and Slessor (79° 50′S, 28° 30′W) Glaciers drain into the Filchner Ice Shelf. On the eastern side of the Filchner Ice shelf is Coats Land and the Argentine base Belgrano II (77° 52′S 34° 38′W) on the Luitpold Coast. Ronne Ice Shelf is named after the American explorer Edith Ronne (1919–2009), who was the first woman to work on Antarctica expedition. Three countries have claimed the Ronne Ice Shelf at different times: Britain in 1908, Chile in 1940, and Argentina in 1942. The Filchner Ice Shelf is named after German explorer Wilhelm Filchner (1877–1957). Two countries have claimed this ice shelf: Britain in 1908 and Argentina in 1942.

Riiser-Larsen Ice Shelf

The Riiser-Larsen Ice Shelf (72° 40′S, 16° W) is 250 miles (400 km) in length and covers an area of about 18,600 square miles (48,180 sq. km). The Riiser-Larsen Ice Shelf is located between Cape Norvegia (71° 20′S 12° 18′W) on the Princess Martha Coast of Queen Maud Land in the north and Lyddan Island (74° 25′S 20° 45′W) and Stancomb-Wills Glacier on the Princess Martha Coast of Queen Maud Land in the south. Lyddan Island and Stancomb-Wills Glacier are commonly considered the border between Brunt Ice Shelf and the Riiser-Larsen Ice Shelf. Sometimes the Brunt and Riiser-Larsen Ice Shelves are combined into one ice shelf. Early explorers to the ice shelf were William Speirs Bruce (1867–1921) in 1904, Ernest

Shackleton in 1915, and Captain Hjalmar Riiser-Larsen (1890–1965) in 1920s and 1930s. The Riiser-Larsen Ice Shelf was extensively photographed and described during the joint international expedition team from Norway, Sweden, and Britain in 1949–1952. This joint venture was called the "Norwegian–British–Swedish Antarctic Expedition." The United States also photographed the region during Operation Deep Freeze from 1967 to 1969.

Fimbul Ice Shelf

The Fimbul Ice Shelf (70° 30′S, 0° 10′W) is 120 miles (200 km) in length and covers an area of about 15,850 square miles (41,060 sq. km). The Fimbul Ice Shelf is located from 3° W to 3° E on the Princess Martha Coast and the Princess Astrid Coast of Queen Maud Land. From 1938 to 1939, the Third German Antarctic Expedition photographed the Fimbul Ice Shelf aerially. The joint international venture of the Norwegian–British–Swedish Antarctic Expedition photographed aerially, described, and mapped the region in 1949–1952 as did the Norwegian Expedition from 1958 to 1959. The Fimbul Ice Shelf was called "Fimbulisen" meaning "the Giant Ice." In 1939, after the Third German Expedition, they claimed the area roughly between 10° W and 20° E (approximately Ekstrom to Lazarev Ice Shelves) and 70° and 75° S as "New Swabia." The Norwegians disputed the German's claims and claimed the same area as "Dronning Maud Land."

The major feature of the Fimbul Ice Shelf is the Jutulstraumen Glacier (71° 35′S 0° 30′W). The Jutulstraumen drains into the Fimbul Ice Shelf and is the largest glacier between 15° E and 20° W. This glacier drains an area of around 48,000 square miles (125,000 sq. km). The Jutulstraumen Glacier is 120 miles (200 km) in length and 60 miles (100 km) in width. The glacier starts from the Kirwan Escarpment (west), and Sverdrup Mountains (east) flows through a geologic channel called the "Penck Trough" and passing by Borg Massif and Ahlmann Ridge (west). The Jutulstraumen Glacier was mapped by Norwegian scientists from aerial photos from the Norwegian–British–Swedish Antarctic Expedition (1949–1952) and Norwegian Expedition from 1958 to 1959. The name "Jutulstraumen" means the giant's stream in Norwegian. An interesting feature of the Jutulstraumen Glacier is its tongue or spit. The Jutulstraumen Glacier tongue advances through the center of the Fimbul Ice Shelf and is about 65 ft. (20 m) above the surrounding ice.

There are five research stations neighboring the Fimbul Ice Shelf area. These are the Neumeyer (German), SANAE IV (South Africa), Troll (Norway), Novolazarevskaya (Russia), and Maitri (India). The Neumayer is near Atka Iceport on the Ekstrom Ice shelf. The SANAE IV lies on the western edge of the Fimbul Ice Shelf. Troll Station is located 146 miles (235 km) off the coast on a nunatak named "Jutulsessen" in the Gjelsvik Mountains. Novolazarevskaya and Maitri Stations are about 3 miles (5 km) away from each other in the Schirmacher Oasis area.

Amery Ice Shelf

The Amery Ice Shelf (69° 45′S 71° E) is located roughly between the Lars Christensen Coast (69° S 69° E) and the Ingrid Christensen Coast (69° 30′S 77° E) and at the head of Prydz Bay (69° S 75° W). It is the largest ice Shelf in East Antarctica stretching about 125 miles (200 km) and covering an area of more than 24,000 square miles (62,620 sq. km). The thickness of the Amery Ice Shelf ice ranges from 1,300 to 2,600 ft. (400–800 m). Some estimates are as high as 9,800 ft. (3,000 m) thick in the center of the Amery Ice Shelf. This ice shelf is named after William B. Amery, a British representative to Australia from 1925 to 1928.

Three significant glaciers drain into the Amery Ice Shelf, which are the Mellor, Fisher, and Lambert. The Mellor and Fisher Glaciers are tributary glaciers to the Lambert Glacier. The Mellor Glacier (73° 30′S, 66° 30′E) flows between Mounts Newton and Maguire, where it combines with the Collins Glacier (73° 41′S 65° 55′E) and then at Patrick Point drains into the Lambert Glacier. The Fisher Glacier (73° 15′S 66° E) is the main western tributary flows between Mounts Menzies and Rubin before draining into the Lambert Glacier.

The Lambert Glacier (71° S 70° W) is the world's largest and longest glacier measuring 250 miles (400 km) in length and 60 miles (100 km) in width. The depth of the glacier is just more than 8,200 ft. (2,500 m) in some parts. The Lambert Glacier covers more than 386,000 square miles (1 million sq. km). The ice of the Lambert Glacier originates in the Polar Plateau in Mac Robertson Land. The ice drains from the Lambert Graben (70° S 70° W) toward the Amery Ice Shelf (69° 45′S 71° E). The Lambert Glacier accounts for approximately 12 percent of the East Antarctica ice volume drainage.

There are three scientific stations neighboring the Amery Ice Shelf area: Zhongshan (China), Progress II (Russia), and Law-Racoviță (Romanian) Stations. The Zhongshan (69° 22′S 76° 22′E), Progress II (69° 22′S 76° 23′E), and Law-Racoviță (69° 23′S 76° 22′E) Stations are located near Prydz Bay on Larsemann Hills. All these stations are in close proximity or roughly a mile apart.

West Ice Shelf

The West Ice Shelf (66° 40′S 85° E) is located between Barrier Bay (west) (67° 45′S 81° 15′E) and Posadowsky Bay (east) (66° 47′S 89° 27′E) of the Leopold and Astrid Coast. The West Ice Shelf stretches about 175 miles (280 km) covering an area of more than 6,300 square miles (16,370 sq. km). The east side of the West Ice Shelf is fed by a large unnamed glacier and tongue stretching about 60 miles (100 km) long and 30 miles (50 km) wide. It is between about a 20 miles (30 km) rift. West of this rift are the four ice rises of Leskov, Mikhaylov, Zavadovsky, and one that is unnamed (66° 30′S 85° 40′E). Further west is the Phillippi Glacier ice tongue stretching about 55 miles (90 km) in length. The West Ice Shelf was explored and detailed from 1901 to 1903 during the Gauss Expedition (also called the "First German Antarctica Expedition"). The Gauss Expedition was the first German South Polar expedition and was led by Dr. Erich Dagobert von Drygalski (1865–1949). In February 1901, the ship *Gauss* became frozen in pack ice, and ship and her crew were ice bound until February 8, 1903. Another discovery, besides the West Ice Shelf, was Kaiser Wilhelm II Land. Dr. Drygalski is credited as being the first person to operate a gas balloon in Antarctica.

Shackleton Ice Shelf

The Shackleton Ice Shelf (66° S 100° E) is located between the Queen Mary Coast (west) and Knox Coast (east). It faces the Indian Ocean and is between the marginal seas of Davis and Mawson. The Shackleton Ice Shelf covers an area of more than 13,000 square miles (33,820 sq. km) and stretches across 240 miles (380 km) of the Antarctic coastline. The ice shelf extends into the sea about 90 miles (145 km) in the western part and about 40 miles (64 km) in the eastern part. The ice shelf was discovered by the United States Exploring Expedition (1838–1842) (sometimes called the "Wilkes Expedition") under the direction of Charles Wilkes (1798–1877). In 1840, Wilkes mapped the ice shelf while on the expedition vessel USS *Vincennes.* The first person credited with exploring the ice shelf was Douglas Mawson (1882–1958) while leading the Australian Antarctica Expedition in 1911–1914. Mawson named the ice shelf after Ernest Shackleton (1874–1922). In 1946–1947, the United States Navy Antarctic Developments Program, more commonly known as Operation Highjump, delineated the area with aerial photographs. The First Soviet Antarctic Expedition from 1955 to 1957 made additional cartography that included the Scott Glacier portion of the Shackleton Ice Shelf.

Getz Ice Shelf

The Getz Ice Shelf (74° 15′S 125° W) is located on the Hobbs and Bakutis Coasts of Marie Byrd Land roughly between Hull Bay and Cape Herlacher. Getz covers an area almost 13,000 square miles (32,810 sq. km) and stretches for more than 300 miles (500 km) across the Antarctic coastline. The Getz Ice Shelf extends several miles into the sea and has a vertical face about 200 ft. (60 m). Several islands are embedded in or surrounded by the ice shelf, such as the Wright, Carney, Siple, Grant, and Shepard Islands. There is a bay and a gulf along the Getz Ice Shelf. Russell Bay is located between Carney Island and the northwest side of Siple Island off of the Getz Ice Shelf. Wrigley Gulf is on the opposite side of Siple Island and Russell Bay and in between Grant Island. In 1940, the United States Antarctica Program (USAP) is credited with discovering the area west of Siple Island. In 1946–1947, the United States Navy Antarctic Developments Program, more commonly known as Operation Highjump, delineated the area with aerial photographs.

The United States Geological Survey from 1962 to 1965 used the United States Naval Photos to make additional cartography of the Getz Ice Shelf.

Abbot Ice Shelf

The Abbot Ice Shelf (72° 45′S 96° W) is located on the Eights Coast (73° 30′S 96° W) of Ellsworth Land roughly between Cape Waite on King Peninsula and Phrogner Point on Fletcher Peninsula. The ice shelf covers an area almost 10,500 square miles (27,000 sq. km). It is 250 miles (400 km) in length and about 40 miles (60 km) in width. A major feature of the Abbot Ice Shelf is the ice-covered Thurston Island situated off the Eights Coast. Eights Coast and Thurston Island are in the ice-covered Peacock Sound. Thurston Island is the third largest island in Antarctica at more than 130 miles (215 km) in length and more than 50 miles (90 km) in width. In the Peacock Sound lies Sherman Island. Other notable islands are Dendtler, Dustin, Farwell, Johnson, and McNamara. The Abbot Ice Shelf was first spotted from flights off the United States Revenue Cutter Bear, in 1940. In 1946–1947, the United States Naval Program called Operation Highjump delineated the area with aerial photographs. The United States Geological Survey from 1962 to 1965 used the United States Naval Photos to make additional cartography of the Abbot Ice Shelf in 1966. The ice shelf is named after Rear Admiral James Lloyd "Doc" Abbot Jr. (1918–2012). Rear Admiral "Doc" was the commanding officer for the United States Naval Support Force in Antarctica from 1967 to 1969.

George VI Ice Shelf

The George VI Ice Shelf (71° 45′S 68° W) is located between Alexander I Island and Palmer Land. The George VI Ice Shelf fills in the George VI Sound with ice, making an ice bridge from Palmer Land to Alexander I Island. Outlet glaciers from the West Antarctic ice cap on Palmer Land fed the George VI Ice Shelf. The George VI Ice Shelf is bordered by the Ronne Entrance and roughly the Fleming glacier in Marguerite Bay (68° 30′S 68° 30′W). The Ronne Entrance (72° 30′S 74° W) is in between the George VI Sound (71° S 68° W) and the Bellingshausen Sea just southwest of Alexander I Island. The ice shelf covers an area about 9,200 square miles (23,880 sq. km). Alexander I Island is the largest Antarctic Island at about 240 miles (390 km) long and 50 miles (80 km) wide.

Wilkins Ice Shelf

On the Bellingshausen Sea side of Alexander I Island is the Wilkins Sound. The Wilkins Ice Shelf fills in the Wilkins Sound with ice. Within the Wilkins Sound is the ice-covered Charcot and Latady Islands. Charcot Island (69° 45′S 75° 15′W) is about 30 miles (48 km) long and around 25 miles (40 km) wide and lies approximately 55 miles (89 km) west from Alexander I Island. Latady (70° 45′S 74° 35′W) is west of Alexander I Island about 50 miles (80 km) south of Charcot Island. This island is about 40 miles (64 km) long and 11 miles (18 km) wide. The Wilkins Ice Shelf is approximately 90 miles (145 km) in length and 70 miles (110 km) in width. The Wilkins Ice Shelf was first noted during the First French Antarctica Expedition. The First French Antarctica Expedition was led by Jean-Baptiste Charcot (1867–1936), whom Charcot Island is named after. In 1940, the USAP is credited with delineating the Wilkins Ice Shelf and Sound. The USAP named the area the "Wilkins Sound" after Sir (George) Hubert Wilkins (1888–1958). Latady Island was unknown until 1960 when the Falkland Islands Dependencies Survey was investigating aerial photos taken during the Ronne Antarctic Research Expedition (1947–1948).

Larsen Ice Shelf

The Larsen Ice Shelf (67° 30′S 62° 30′W) is situated on the eastern side of the Antarctic Peninsula along the Oscar II, Foyn, Bowman, and Wilkins Coasts. The ice shelf faces the Weddell Sea. The ice shelf is located between Cape Longing (64° 33′S 58° 50′W) on Longing Island and Hearst Island (69° 25′S 62° 10′W) off Palmer Land. The Larsen Ice Shelf covers an area about 19,000 square miles (48,600 sq. km). The thickness of the Larsen Ice Shelf ice averages around 1,000 ft. (300 m). This ice shelf is named after Norwegian Captain Carl Anton Larsen (1860–1924), who piloted the whaling vessel *Jason* through this region in 1893.

The Larsen Ice Shelf is four ice shelves, labeled as Larsen-A, -B, -C, and -D. The Larsen-A part was located on the northeastern end and is the smallest section. Larsen-B portion is located in a group of 16 nunataks called the Seal Nunataks. The Larsen-C section is the largest. The Larsen-D section is the southernmost part and is thin running along the coast. Larsen-A merged with Larsen-B around 1995 and then merged with Larsen-B, which collapsed in 2002. It took 35 days for Larsen-B to disintegrate over 1,200 square miles (3,250 sq. km) sending numerous icebergs into the Weddell Sea. Larsen-C is presently thinning but considered stable. Larsen-D is largely intact.

Islands surrounded by the Larsen-C Ice Shelf include Francis and Tonkin Islands. There are also several peninsulas that extend into the Larsen-C section, such as Churchill, Cole, Jeorg, and Hollick Peninsulas. Several glaciers fed the Larsen Ice Shelf, such as Drygalski, Hektoria, Green, Jorum, Crane, Flask, and Leppard Glaciers. The disintegration of the Larsen Ice Shelf is of great interest to scientists and is under scientific investigation.

Andrew J. Hund

See also: Antarctic Ice Sheet; Ice Sheet; Ice Shelf

Further Reading

Greve, R., and H. Blatter. *Dynamics of Ice Sheets and Glaciers.* New York: Springer, 2009.

Ice Worms

Ice worms are annelids (segmented worms—including *Mesenchytraeus solifugus*, *M. harrimani*, *M. kuril*, *M. maculatus*, and *M. obscurus*) that survive exclusively on glacier ice. First described in 1887 by the geologist George Frederick Wright (1838–1921) on the Muir Glacier in southeastern Alaska, their range is limited to coastal glaciers between south-central Alaska and Oregon. Ice worms contain antifreeze proteins in their cells and subsist on pink snow algae, pollen, and spores. They have been fictionally celebrated in poems, songs, and festivals.

Ice worms are found in the coastal glaciers with hydrated ice and year-round temperatures near 32°F (0°C) in south-central and southeastern Alaska, the Pacific coast of Canada, and as far south as Oregon. Genetic testing shows that a St. Elias-area population gradually expanded northward to a group confined to Alaska (with one exception on Vancouver Island, British Columbia). A distinct southern group was likely founded by a dispersal event from a northern ancestor and covers British Columbia, Washington State, and Oregon. A distribution gap in Alaska is from Skagway to Petersburg, which restricts gene flow.

Ice worms have antifreeze proteins that prevent cellular water from freezing despite external temperatures. Their optimal habitat is around 32°F (0°C), and they can freeze at lower temperatures or disintegrate in temperatures above 50°F (10°C). Coastal summer glacier surface temperatures provide ideal habitat by remaining around 32°F (0°C). In winter, ice worms burrow deeper beneath the surface where insulating properties of snow and ice keep the temperature constant at freezing.

Ice worms have expansive mobility within the snow column and crystal boundaries of glacier ice, moving around to depths of 6.5 ft. (2 m). Worms appear smooth but have tiny external bristles called setae, which allow them to move through and along ice at rates of 3 m per hour. In summer, they generally stay near the surface of the glaciers, retreating in sunlight. At dusk, they rise to the surface, where more than hundreds in 1 sq. m have been observed.

Ice worms mainly eat pink snow algae (*Chlamydomonas nivalis*), as well as airborne pollen grains and fern spores. Winter behavior is poorly understood; they may hibernate or consume nutrient deposits trapped within glacial ice. Ice worms are eaten by small birds such as snow buntings and invertebrates. They range in length from 1 to 3 cm and are about 0.5 mm in diameter. Ice worms are mostly black or white, but can be white, red, blue, or even yellow.

The English poet Robert Service gave them widespread fame in the barroom poem titled "The Ballad of the Ice-Worm Cocktail," which familiarized the world with this improbable species. The poem was occasionally taken too literally in such phrases as ". . . ice-worms are peculiar to the Mountain of Blue Snow . . ." leading to the misinterpretation that they cause the bluish color of glacial ice. Ice worms are also mentioned in the ballad "When the Ice Worms Nest Again," an old Canadian song dating to Klondike gold rush in 1989, which Service used as inspiration for the synonymous poem written in "Twenty Bath-Tub Ballads" published in 1938.

The city of Cordova, Alaska, holds an annual Ice Worm Festival every year during the first full weekend of February when legend says that ice worms hibernating in the nearby Cordova Glacier start to emerge. The festival highlight is a 165-ft. (50-m) long ice worm leading a parade.

Elizabeth Bella

See also: Ice Sheet; Pink Snow

Further Reading

Dial, C., et al. "Historical Biogeography of the North American Glacier Ice Worm, *Mesenchytraeus solifugus* (*Annelida: Oligochaeta: Enchytraeidae*)." *Molecular Phylogenetics and Evolution* 63, no. 3 (2012): 577–84.

Eisen, G. "*Enchytraeidae* of the West Coast of North America." In *The Harriman Alaska Expedition, Alaska, XII, the Annelids.* Washington, DC: Smithsonian Institution, 1904.

Shain, D., T. Mason, A. Farrell, and L. Michalewicz. "Distribution and Behavior of Ice Worms (*Mesenchytraeus solifugus*) in South-Central Alaska." *Canadian Journal of Zoology* 79 (2004): 1813.

Tynen, M. "The Geographical Distribution of Ice Worms (O*ligochaeta: Enchytraeidae).*" *Canadian Journal of Zoology* 48 (1970): 1363–367.

Ihuma. *See* Inuit and Yup'ik Concepts of "Ihuma" and "Qanruyutet"

Ilira. *See* Inuit Concepts of "Naklik" and "Ilira"

Ilulissat Icefjord

A critically important cultural or physical space on the planet if deemed significant can be designated as a world heritage site under the United Nations Educational, Scientific, and Cultural Organization (UNESCO). To date, there have been 981 UNESCO world heritage sites, of which five are located in the Arctic. The Ilulissat Icefjord is one of five Arctic UNESCO World Heritage Sites.

The Ilulissat Icefjord (69° 7′N 49° 30′W) was declared as a UNESCO world heritage site in 2004. This heritage site includes the icefjord, the Jakobshavn Glacier

(Sermeq Kujalleq, in Greenlandic), and the surrounding area. The icefjord is 25 miles (40 km) in length. It was listed as a world heritage site because of its glaciological uniqueness and scenic beauty. The icefjord is located on the eastern end of the Jakobshavn Glacier of western Greenland. The Ilulissat Icefjord is one of the few drainage systems for the Greenland Ice Cap and one of the fastest glaciers in the Northern Hemisphere. The Ilulissat Icefjord unique glaciological characteristic is that every day, it calves between 66 and 115 ft. (20–35 m), which equates to about 20 million tons of ice being deposited into Baffin Bay every year. A total of 8.4 cubic miles (35 cubic km) of ice is calved annually or 10 percent of all of Greenland's ice.

Andrew J. Hund

See also: Laponian Area; Natural System of Wrangel Island Reserve; Putorana Plateau; Rock Art of Alta

Further Reading

Ilulissat Icefjord. UNESCO. http://whc.unesco.org/en/list/1149. Accessed January 13, 2014.

Imperial Trans-Antarctic Expedition (1914–1917)

In August 1914, the *Endurance* sailed from London with veteran polar explorer Sir Ernest Shackleton (1874–1922) and 27 men, on an expedition to cross Antarctica for the first time. The plan was to establish a base near Vahsel Bay on the Weddell Sea, from which Shackleton would lead five men 1,800 miles (2,900 km) across the continent, via the South Pole, using 69 dogs and two motor sledges. On the other side of the continent, the Ross Sea Party was tasked with laying supply depots to the base of the Beardmore Glacier, so the Transcontinental Party could resupply itself en route.

After stops in Buenos Aires and South Georgia, *Endurance* entered the Weddell Sea, and before reaching Vahsel Bay in February 1915, the vessel became trapped in the ice. The ship's furthest drift south was 76° 58′S, before being taken in a northwesterly direction by the pack. By October, the pressure on *Endurance*'s hull was so great that Shackleton ordered supplies and three lifeboats be put on the ice, and afterward the ship was abandoned.

Shackleton now had to concern himself with saving his men and, putting two of the lifeboats on sledges, began marching westward on October 30, toward one of three islands along the Antarctic Peninsula where he knew he would find a food depot or from where he could reach whaling outposts in Wilhelmina Bay. The sea ice was so rough that Shackleton gave up the march on November 1 and decided to make camp and await the breakup of the ice so the boats could be launched.

The place was named Ocean Camp. Over the coming weeks, various materials and supplies continued to be salvaged from the ship, until she sank on November 21.

The floe was drifting further away from the peninsula, so another march began two days before Christmas, to shorten the distance of the lifeboat journey. Conditions were still so bad that the march was abandoned after only a week, and what was called Patience Camp was set up. The third lifeboat was retrieved in February 1916, as all three boats would be required once the ice broke up; they were named for the expedition's main financial sponsors: *James Caird*, *Dudley Docker*, and *Stancomb Wills.* The intended destination was now either Clarence Island or Elephant Island.

On April 8, the floe Patience Camp was on suddenly split, and the men rushed to get in the boats. Shackleton headed for the nearest destination, and seven days later the party landed on Elephant Island, which was uninhabited and rarely visited by ships. Shackleton decided to go for help by taking six men and sailing the *James Caird* to the whaling station on South Georgia, an 800 nautical mile (920 miles [1,500 km]) voyage across some of the worst seas in the world.

The 16-day journey to South Georgia landed the men on the side of the island opposite the whaling station, so Shackleton and two men crossed mountains that had never before been traversed, reaching the station on May 21. The remaining three men were picked up, and Shackleton made three attempts to reach the rest of the party on Elephant Island, but each time was frustrated by the ice. The Chilean government lent Shackleton the steam tug *Yelcho* (commanded by Pilot 2nd Class Luis Pardo Villalón), and on August 30, 1916, the marooned men were rescued.

The Ross Sea Party experienced extreme difficulties in fulfilling its mission. Commanded by Æneas Mackintosh, it left Hobart, Tasmania, in the *Aurora* in December 1914 and arrived in McMurdo Sound on January 15, 1915.

Believing Shackleton might try to make a transcontinental crossing during the first season, Mackintosh prepared for a depot-laying journey on the Ross Ice Shelf. Due to the men and dogs not being acclimated to conditions, and the party as a whole lacking ice experience, 10 of the 18 dogs were lost, only one incomplete depot was laid, and the men were generally demoralized and frostbitten.

The sledging rations for the depots had been landed, but the majority of the party's fuel, food, clothing, and equipment were still on *Aurora*, as it was assumed the ship would spend the winter. On May 7, a gale tore the ship from her moorings, and she floated out to sea, becoming trapped in the ice until February 1916. She drifted hundreds of miles before escaping and making her way to New Zealand for repairs and a refit.

Determined to continue with its mission, the 10 marooned men salvaged supplies and equipment left from previous expeditions and began depot laying in September 1915. Through the months that followed, depots were laid at one-degree intervals across the Ross Ice Shelf to the base of the Beardmore Glacier. Scurvy struck the party during its return; Chaplain and the photographer Arnold Spencer-Smith died on the ice, but others reached the temporary shelter of Hut Point. Completed without sufficient clothing or support, the Ross Sea Party's achievements were unparalleled in Antarctic sledging.

On May 8, 1916, Mackintosh and Storekeeper and the dog handler Victor Hayward were lost in a blizzard when they attempted to walk across the unstable sea ice to Cape Evans. The governments of New Zealand, Australia, and Great Britain organized a relief expedition and sent *Aurora* south; Shackleton was on board, but only as a supernumerary officer and without authority. The seven survivors were not rescued until January 10, 1917.

Glenn M. Stein

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

Further Reading

Lansing, A. *Endurance: Shackleton's Incredible Adventure.* New York: McGraw-Hill Book Company, 1959.

McElrea, R., and D. Harrowfield. *Polar Castaways: The Ross Sea Party (1914–17) of Sir Ernest Shackleton.* London: McGill-Queen's University Press, 2004.

Rajala, E., ed. *The American on the* Endurance*: Ice, Seas, and Terra Firma, Adventures of William L. Bakewell.* Munising, MI: Dukes Hall Publishing, 2004.

Shackleton, Ernest. *South: The Story of Shackleton's Last Expedition 1914–17.* New York: The MacMillan Company, 1926.

Indigirka and Kolyma Rivers

Most major rivers flowing into the marginal Arctic Seas are found in Russia, with the exceptions being the Mackenzie River in Canada and the Colville River in Alaska (smaller compared with the Mackenzie River). The Mackenzie River flows into the Beaufort Sea. In the United States (Alaska), the Colville River flows into the Arctic Ocean. The Russian rivers flowing into the marginal seas and into the Arctic Ocean are the Khatanga, Lena, and Yana Rivers that flow into the Laptev Sea; the Indigirka and Kolyma Rivers that flow into the East Siberian Sea; and the Ob, Pechora, and Yenisey Rivers that flow into the Kara Sea. All these rivers flow generally northward. In general, rivers flow in a southerly direction, which is downhill; however, if the source of a river is at a higher elevation, the river will flow in a northerly direction but still downhill. The two major rivers that flow to the East Siberian Sea are the Indigirka and Kolyma Rivers.

Indigirka River

The Indigirka River is located in the Sakha Republic in Russia. The length of the Indigirka River is around 1,000 miles (1,600 km) and empties into East Siberian

Sea. The average water discharge of the Yana River is 63,919 ft^3/s (1,810 m^3/s). During the summer, the Indigirka is navigable, but freezes over in October, and the ice breaks up around June. The confluences of the Indigirka are the Khastakh and Taryn-Iuriakh Rivers. The course of the Indigirka is northwestern along Oimiakon Plateau, heading northward through the Cherskii Mountain Range, and then traversing the Chemalgin Mountain Range. The Indigirka is joined by a series of tributaries, which include the Badyarikha, Elgi, Kuydusun, Kyuente, Nera, Moma, Selennyakh, and Uyandina Rivers. On its course to the East Siberian Sea, the Indigirka breaks off into the Russko-Ustyinskaya Protoka on the western side, the Srednyaya Protoka about 60 miles (100 km) before the mouth of the East Siberian Sea. Further down the river, the Srednyaya Protoka splits again creating the Kolymskaya Protoka on its eastern side, resulting in the Srednyaya Protoka being in the middle. Just before reaching the East Siberian Sea, the Indigirka forms a delta that is 2,100 square miles (5,500 sq. km). The Indigirka Delta forms hundreds of channels and islands, such as Bolshoy Fedorovskiy, Krestovyy Island, Ploskiy Island, Usun-Ary, Uparovskiy Island, and Vkodnoy.

The Indigirka was first reached by Ivan Rebrov, around 1638. The first Russian human settlement was Zashiversk (67° 27′N 142° 37′E), in 1638. Zashiversk was abandoned in 1898. Other formerly inhabited now abandoned settlements are the Podshiversk and Uyandinskoye Zimov'ye. The first geological survey of the Indigirka basin was in 1892–1894 under the leadership of Eduard Gustav von Toll (1858–1902). Common game fish in the Indigirka include the Arctic Cisco, broad white fish, Muksun, vendace, and sheefish.

Kolyma River

The Kolyma River is located in northeastern Siberia and rises from several source streams in the Kolyma and Cherskogo Mountain Ranges. The length of the Kolyma is around 1,300 miles (2,100 km) and empties into East Siberian Sea. During summer, the Kolyma is navigable, but freezes over to depths of 10 ft. (3 m) in October, and the ice breaks up around June. The confluences of the Kolyma are the Ayan-Juriachas, Bioriolichas, and the Kulu rivers. The main tributaries are the Detrin, Buyunda, Balygychan, Sougoi, Korkod, Popovka, Yasachnaya, Zyryanka, Ozhogina, Sededema, Berezovka, and Omolon. The Kolyma Basin is around 250,000 square miles (647,000 sq. km) and covers portions of the Magadan Oblast and Sakha (Yakutia) Republic of the Russian Far East. The average water discharge of the Kolyma River is 134,195 ft^3/s (3,800 m^3/s).

The course of the Kolyma first flows out of the Kolyma and Cherskogo ranges through narrow deep canyons with numerous rapids then becomes wider and forms braided and meandering channels. Near the city of Zyryanka (65° 44′N 150° 54′E), the river spreads out across a wide floodplain. Roughly, near the edge of the Yukaghir Plateau, the Kolyma River runs along a steep right bank. About 45 miles

(75 km) before emptying into the East Siberian Sea, the Kolyma River splits into two main branches and forms several islands such as the Mikhalkino, Nazarovsky, Piat' Pal'tsev, Shtormovoy, and Sukhornyy.

The Kolyma was first reached by Dmitri Mikhailovich Zyryan (unknown–1646) and Semyon Ivanovich Dezhnyov (1605–1673), around 1644. The first geological survey of the Kolyma basin was in 1892–1894 under the leadership of Eduard Gustav von Toll (1858–1902). The Kolyma River area is most widely known as a Gulag, where it is estimated that over a million people perished at the Soviet labor camps from 1932 to 1954. Created by Soviet leader Iosif Vissarionovich Stalin, commonly known as Joseph Stalin (1878–1953), the large forced labor camps (Gulag) were built to extract gold from the upper Kolyma River goldfields. After 1954, Soviet Leader Nikita Khrushchev granted amnesty to the Kolyma Gulag prisoners. The camp was mostly transformed into a free labor camp. Upon becoming a free labor camp, many of the camps in the Kolyma Gulag complex were closed because of the lack of Soviet governmental resources and the outmigration of people.

In 2012, the National Academy of Sciences reported a 30,000-year-old fruit plant called *Silene stenophylla* found in permafrost in a squirrel burrow on the banks of the Kolyma had been revived. The Evenks, Evens (or Lamuts), the Chukchi, and the northern Yakuts use the Kolyma basin for subsistence activities. The Kolyma River region is home to the vanishing Yukaghir people. Common game fish are the broad white fish, beloribitsa, muksun, and sturgeon.

Andrew J. Hund

See also: Colville River; Khatanga, Lena, and Yana Rivers; Mackenzie River; Ob, Pechora, and Yenisey Rivers; Yukon River

Further Reading

Lantzeff, G., and R. Pierce. *Eastward to Empire: Exploration and Conquest on the Russian Open Frontier, to 1750.* Montreal: McGill-Queen's University Press, 1973.

Pearce, J., D. Esler, and A. Degtyarev. "Birds of the Indigirka River Delta, Russia: Historical and Biogeographic Comparisons." *Arctic* 51 (1998): 361–70.

International Geophysical Year (IGY)

The International Geophysical Year (IGY), the third in a succession of four international scientific efforts to investigate geosciences, took place between July 1, 1957, and December 31, 1958. The timing for the IGY was chosen because it coincided with a projected cycle of maximum solar activity. Scientific measurements around the globe resulted from this international consortium of scientific investigators.

The IGY effort really began in March 1950 when scientific entrepreneurs led by Sidney Chapman and Lloyd Berkner met to formulate strategies for the accomplishment of what became the IGY. In early 1952, these same scientists persuaded the International Council of Scientific Unions to establish a committee to oversee the effort. The Belgian Marcel Nicolet served as secretary general of the IGY oversight organization. Late in 1952, this body expanded the scope of the scientific research effort to include studies that would be conducted using rockets with instrument packages in the upper atmosphere. In October 1954, the council, at a meeting in Rome, Italy, adopted another resolution calling for the launch of artificial satellites during the IGY to help map the earth's surface, and both the Soviet Union and the United States accepted the challenge.

The IGY eventually involved 67 nations undertaking research across a broad spectrum of disciplines and regions. Eventually, more than 4,000 research stations, either already in operation or established as part of the IGY, participated in the cooperative endeavor. While efforts were concentrated in the polar regions, terrestrial stations along the equator and at several geographic lines north to south also yielded valuable scientific data. For example, scientists defined the mid-ocean ridges (developing the theories of plate tectonics and the nature of earth's crust that has defined modern geology), discovered the Van Allen radiation belts using data from Explorer 1 and Explorer 3, charted ocean depths and ocean currents, and measured a range of terrestrial phenomena from the magnetic field to upper atmospheric winds to the geophysical nature of the planet.

Two overwhelmingly significant events occurred as a result of the IGY. The first was the development of a means for multiple nations to engage in scientific activities on a continent under joint control. The establishment of this peaceful collaborative occupation of Antarctica is a subject of great significance. The IGY fostered the establishment of several bases on the Antarctic ice sheet, with British, French, Soviet, Japanese, and American researchers, among others, proliferated in Antarctica. The American base at McMurdo Sound base became a permanent fixture for American expeditions thereafter. Additionally, the original American Amundsen–Scott South Pole Station gained fame as the first permanent structure at the South Pole in January 1957, although it was demolished in December 2010 because its age and the harsh conditions at the pole had combined to make the original facilities unsustainable. It was replaced with newer structures that remained in operation thereafter.

Within a year of the conclusion of the IGY, the international community met in Washington, DC, to sign the Antarctic Treaty, which effectively internationalized Antarctica as a continent dedicated to peace and science. Article IV of the Antarctic Treaty suspended (or froze in the official pun of the conference) all sovereignty claims to the continent for its duration. To many people at the time, it appeared as if the idealism of science had triumphed over politics. The post-IGY

Antarctic Treaty System was responsible for three key positive developments over a 50-year period:

- It has preserved 10 percent of the earth for peaceful purposes.
- It has created the world's first nuclear-free zone.
- It instituted an unprecedented international scientific collaboration.

The results of the IGY convinced U.S. officials that internationalization would be the best course for Antarctic politics. In more than 60 meetings, the process of hammering out the Antarctic Treaty culminated in Washington, DC, between October 15 and December 1, 1959, setting in place a governing structure to continue international scientific efforts in Antarctica and prohibiting any claims of sovereignty on the continent.

The traditional narrative of the internationalization of Antarctica suggests that the IGY functioned as a deus ex machina coming out of nowhere to resolve the continent's vexing political problems through a wave a scientific idealism. In this interpretation, the cooperation and goodwill generated by the IGY acted as a force above politics, with the ability to overcome the petty squabbling that plagued the question of Antarctic sovereignty. IGY science fundamentally changed perceptions of the Antarctic environment and, at least in the short term, dispelled the myth that Antarctica could possess invaluable minerals. This reassessment coming as a result of the IGY concerning the economic worth of Antarctica changed political attitudes toward the continent. Having decided that they wanted internationalization, the international community then exploited scientific goodwill as a means to bring this about.

The second major event emerging from IGY was the space age, begun on October 4, 1957, when the Soviet Union launched Sputnik 1, the first artificial Earth satellite. Sputnik 1 twice passed within easy detection range of listening stations in the United States before anyone even knew of its existence. Then Moscow's official news agency, TASS, broke the story to the world. An IGY conference being held in Washington, DC, learned the details of the launch the next day from the Soviet Union's chief delegate, Anatoli A. Blagonravov. The conference congratulated the Soviets for their scientific accomplishment. What was not said, but clearly thought by many Americans in both the scientific and political communities, however, was that the Soviet Union had staged a tremendous propaganda coup for the communist system and that it could now legitimately claim leadership in a major technological field. The international image of the Soviet Union was greatly enhanced overnight. Even before the effects of Sputnik 1 had worn off, the Soviet Union struck again. On November 3, 1957, less than a month later, the Soviets launched Sputnik 2 carrying a dog, Laika. While the first satellite had weighed less than 200 pounds, this spacecraft weighed 1,120 pounds and stayed in orbit for almost 200 days.

The Sputnik crisis of the winter of 1957–1958 led directly to the decision in the United States to undertake a succession of actions aimed at catching up to the Soviet Union's space achievements. Among these are the following:

- A full-scale review of the civil and military space programs of the United States (scientific satellite efforts and ballistic missile development)
- Establishment of a presidential science adviser in the White House who had responsibility for overseeing the activities of the Federal government in science and technology
- Creation of the Advanced Research Projects Agency in the Department of Defense, and the consolidation of several space activities under centralized management
- Passage of the National Defense Education Act of 1958 to provide Federal funding for education in scientific and technical disciplines
- Establishment of the National Aeronautics and Space Administration (NASA) to manage civil space operations for the benefit of all mankind by means of the National Aeronautics and Space Act of 1958, with NASA becoming operational on October 1, 1958

Also as part of the IGY, the United States launched its first Earth satellite on January 31, 1958, known as Explorer 1. This satellite carried an experiment by James A. Van Allen, a physicist at the University of Iowa, which detected the existence of radiation zones encircling the Earth. Shaped by the Earth's magnetic field, what came to be called the "Van Allen Radiation Belts" partially dictates the electrical charges in the atmosphere and the solar radiation that reaches Earth. Explorer 3, launched on March 26, 1958, as part of the IGY, confirmed the observations of Explorer 1.

A long series of Explorer satellites, each with a different design and purpose, yielded valuable scientific information during succeeding years. Collectively, they explained much about the relationship of the Sun to the Earth, the interplanetary medium, and why certain physical features of Earth were present. Among other observations, these spacecraft mapped major respects of the Earth's magnetosphere. Extending outward in the direction of the Sun approximately 40,000 miles, as well as stretching out with a trail away from the Sun to approximately 370,000 miles, the magnetosphere is the area dominated by Earth's strong magnetic field. Measurements by these spacecraft calculated the size and intensity of this field, showing that it contains two belts of very energetic charged particles. At its upper limits, the magnetosphere encounters charged plasma particles thrown off by the Sun, known collectively as the Solar Wind, which create a boundary where the two come into contact. These electromagnetic fields interact and create shock waves, some of which are responsible for auroral phenomenon such as the aurora borealis or northern lights. This knowledge, growing out of the IGY, greatly enhanced understanding of the way in which the Sun exerted its influence on this planet.

In the end, the IGY must be judged as having been quite successful overall. Its two fundamental results, the maintenance of Antarctica as a place for science under joint oversight and the origins of the space age were lasting consequences that cannot be minimized. Scientific cooperation laid the basis for more than half a century of peaceful coexistence in two realms—space and the poles—that had been contentious beforehand.

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See also: International Polar Years (IPYs)

Further Reading

Belanger, D. *Deep Freeze: The United States, the International Geophysical Year, and the Origins of Antarctica's Age of Science.* Boulder: University Press of Colorado, 2006.

Berkman, P. *Science into Policy: Global Lessons from Antarctica.* San Diego: Academic Press, 2002.

Bulkeley, R. *The Sputniks Crisis and Early United States Space Policy: A Critique of the Historiography of Space.* Bloomington: Indiana University Press, 1991.

Launius, R., J. Fleming, and D. DeVorkin, eds. *Globalizing Polar Science: Reconsidering the International Polar and Geophysical Years.* New York: Palgrave Macmillan, 2010.

Launius, R., J. Logsdon, and R. Smith, eds. *Reconsidering Sputnik: Forty Years since the Soviet Satellite.* Amsterdam: Harwood Academic Publishers, 2000.

International Polar Years (IPYs)

The International Polar Years (IPYs) of 1882–1883, 1932–1933, and 2007–2008 are often described by scientists as exemplars of the universality of science, as indicative of the breadth of scientific knowledge that can be accomplished through transnational linkages and as an exemplar of positive interactions when actions are focused on the good of all humans on this planet rather than investigations of scientific phenomena governing this planet. The first IPY resulted from the rise of a scientific rationalism that tackled the systemization of knowledge about the planet. Several ambitious projects preceded it, including the Magnetic Crusade's cooperative endeavor to understand terrestrial magnetism, but the poles were omitted from much of that effort. That is, until advances in transportation, communication, and scientific instrumentation made possible broader cooperative efforts in more hostile environments.

Accordingly, the IPY of 1882–1883 resulted from the mind of Austrian naval officer and polar explorer Karl Weyprecht (1838–1881) aided by Georg von Neumayer (1826–1909), director of the German Hydrographical Office, and Heinrich

Wild (1833–1902), director of the Central Physical Observatory in St. Petersburg. He proposed the idea at the Academy of Sciences in Vienna in January 1875, arguing that expeditions to the poles sponsored by several nations as a coordinated effort could capture scientific data on many geosciences using the same instruments and protocols that could then be compared across a vast stretch of the Arctic. Weyprecht's initiative gained support, and he relentlessly championed a multinational cooperative year of scientific polar research using similar equipment, similar instruments, and similar data-gathering methods. In 1879, scientists convened the First International Polar Conference in Hamburg, Germany, to plan for this IPY, and a second followed in Berne in 1880.

At a third IPY conference in St. Petersburg in 1881, by which time Weyprecht had died and von Neumayer took the lead of a permanent International Polar Commission, set the dates for the First IPY as August 1, 1882, to August 31, 1883. Equally important, it set out a 39-point program for research and data gathering, as well as reporting on results.

Eventually, 12 countries (the Austro-Hungarian Empire, Canada, Denmark, Finland, France, Germany, Great Britain, the Netherlands, Norway, Russia, Sweden, and United States) placed 13 stations around the North Pole and two in Antarctica. These linked efforts to solve the mysteries of polar ecology, climate, atmosphere, glaciations, geology, flora and fauna, and human interactions were successful despite nationalism and empire at every turn. While domestic politics shaped these adventures in geosciences, they also fostered the cooperation, for it served well the needs of great powers to seem collaborative in such scientific pursuits, especially since every nation looked philanthropic when engaged in such endeavors.

Principal Research Expeditions of the First International Polar Year (1882–1883)

Austria—Jan Mayen Island
Denmark—Godthab, Western Greenland
Great Britain/Canada—Fort Rae at the Great Slave Lake
France—Orange Bay at the southern tip of Tierra del Fuego (Southern Hemisphere)
Finland—Sodankyla and Kultala (at Ivalojoki River)
Germany 1—Kingua-Fjord at Cumberland Sound, Baffin Island
Germany 2—Moltke-Hafen at Royal Bay, South Georgia (Southern Hemisphere)
Holland—Intended for Dickson Hafen but actually in Kara Sea near Waigach Island
Norway—Bossekop/Alten, Altenfjord
Russia 1—Karmakuly, Moller Bay, Nowaja Semlja
Russia 2—Sagasta at the Lena Delta
Sweden—Cap Thordsen in the Icefjord, Spitzbergen

USA 1—Point Barrow, Alaska (71°N)
USA 2—Lady-Franklin-Bay at Discovery Harbor, Ellesmere Isl. (81° 42°N)

Most of the IPY expeditions conducted their scientific measurements with accuracy and absent any serious difficulties. The success of the American expedition led by Lieutenant Henry P. Ray to the Alaskan Arctic Circle must be contrasted with the disaster and death that accompanied another American IPY expedition, Lieutenant Adolphus Greely's mission to Ellesmere Island. While Ray's expedition made everything look routine in vast and hostile terrain, 17 of 24 of Greely's men starved to death when a supply ship failed to reach them and those that survived had to resort to cannibalism. As another example, the Russian expedition to Ostrov Sagastyr' in the Lena Delta strained between December 1881 and August 1882 to reach their station traveling overland from St. Petersburg in often blizzard conditions. In all, some 700 men participated in the first IPY, serving at Arctic research stations between 1881 and 1884.

Once accomplished, the results transformed a Western world and set in train the major elements of the twentieth century's reliance on science and technology for its welfare. Its collection of data concerning meteorology, geomagnetism, auroral phenomena, ocean currents, tides, structure and motion of ice, atmospheric electricity, and anthropology remains a significant source of data for understanding historical climate variability and environmental change.

A second IPY in honor of the 50th anniversary of the first one emerged in 1927 out of an international conference of directors of national meteorological services held in Copenhagen, Denmark. The next year, the International Meteorological Committee made a formal proposal to undertake "magnetic, auroral and meteorological observations at a network of stations in the Arctic and Antarctic." This committee asserted that such an initiative "would materially advance present knowledge and understanding (of these phenomena) not only within polar regions but in general . . . This increased knowledge will be of practical application to problems connected with terrestrial magnetism, marine and aerial navigation, wireless telegraphy and weather forecasting." Eventually, 44 nations participated in the Second International Polar Year, collecting considerable data that are still being used to document historical trends in climate change and other scientific areas, especially the recently discovered Jet Stream.

As a part of the second IPY 40, permanent observation stations were established in the Arctic, and in Antarctica, the United States sponsored the second Richard E. Byrd Antarctic expedition, which established a winter-long meteorological station approximately 125 miles south of Little America Station on the Ross Ice Shelf. This was the first research station inland from Antarctica's coast. One notable result of the second IPY was the establishment of a world data center to manage scientific data under the auspices of the International Meteorological Organization.

Although it began as a Third International Polar Year, the broader International Geophysical Year (IGY) of 1957–1958 led to a strikingly successful effort especially in Antarctica to undertake collaborative scientific research. The IGY kick-started not only an ongoing, aggressive science collection program at the poles but also a space-based science program, both of which have been glamorous to most observers since they began. The genesis of the IGY took place at a dinner party in the home of James A. Van Allen in Bethesda, Maryland, in the summer of 1950. This event has taken on legendary status and serves a range of purposes from a very nearly mystical birth for the IGY to the reaffirming of the authority of science in modern life. Pressed by the American science entrepreneur Lloyd V. Berkner, the International Council of Scientific Unions (ICSU) in 1952 agreed to pursue a comprehensive series of global geophysical activities to span the period July 1957–December 1958.

The IGY was timed to coincide with the high point of the 11-year cycle of sunspot activity; this agenda expanded late in 1952 to include upper atmosphere studies. In October 1954, ICSU adopted at a meeting in Rome another resolution calling for the launch of artificial satellites during the IGY to help map the Earth's surface, and both the Soviet Union and the United States accepted the challenge. Launch of both Sputnik and Explorer orbital spacecraft were the direct result of that decision. Geophysical traverses across Antarctica yielded the first informed estimates of the total size of Antarctica's ice mass, and the Antarctic Treaty of 1960 established an international governing body for the continent dedicated to science that remains in place to the present. The scientific, institutional, and political legacies of the IGY have endured to the present.

Finally, the fourth IPY was conducted in 2007–2008 to focus both on the Arctic and on the Antarctic. It involved more than 200 projects, with thousands of scientists from more than 60 nations examining a wide range of physical, biological, and social science research topics. It emphasized six research themes as stated in "A Framework for the International Polar Year, 2007–2008":

Status: to determine the present environmental status of the polar regions;

Change: to quantify, and understand, past and present natural environmental and social change in the polar regions; and to improve projections of future change;

Global Linkages: to advance understanding on all scales of the links and interactions between polar regions and the rest of the globe, and of the processes controlling these;

New Frontiers: to investigate the frontiers of science in the polar regions;

Vantage Point: to use the unique vantage point of the polar regions to develop and enhance observatories from the interior of the Earth to the Sun and the cosmos beyond;

Human Dimension: to investigate the cultural, historical, and social processes that shapes the sustainability of circumpolar human societies, and to identify their unique contributions to global cultural diversity and citizenship.

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See also: International Geophysical Year (IGY)

Further Reading

Baker, F. "The First International Polar Year, 1882–1883." *Polar Record* 21, no. 132 (1982): 275–85.

Barr, W. *The Expeditions of the First International Polar Year, 1882–83.* Calgary, Canada: Arctic Institute of North America, 2008.

Launius, R., J. Fleming, and D. DeVorkin, eds. *Globalizing Polar Science: Reconsidering the International Polar and Geophysical Years.* New York: Palgrave Macmillan, 2010.

Inuit

The Inuit are an internationally recognized indigenous people in the Circumpolar Arctic, including aboriginal populations in Alaska, Canada, Greenland, and Chukotka (Russia). The word "Inuit" means "the people" (singular Inuk; person) and signifies a collective designation replacing the term "Eskimo," which received a negative and pejorative connotation as a result of the translation from an Algonquian language as "eaters of raw flesh/meat." Today, many linguists believe that the term originated from the Montagnais vocabulary meaning "snowshoe-netter." While the term "Inuit" is applied throughout Canada and Greenland, the term "Eskimo" is commonly used and officially accepted in Alaska (as Eskimo) and Russia (as Eskimosy). In international politics, the expression "Inuit" was promoted by the transnational nongovernmental organization Inuit Circumpolar Council (ICC, previously called Inuit Circumpolar Conference). The council campaigned for the rights of Inuit to self-determination and to their right to manage and use natural resources in their Arctic homeland (Inuit Nunaat/Inuit Nunangat). Due to the rich diversity of Inuit people, a plurality of self-articulations can be found, which can be seen in the usage of different ethnonyms signifying their own people: Iñupiat, Central Yup'ik, St. Lawrence Island Yup'ik, and Alutiiq (Sugpiaq) in Alaska; Inuit, Inuvialuit, and Inuinnait in Canada; Kalaallit, Inughuit (Thulefolk), and Iit in Greenland; Siberian Yup'ik in Chukotka.

People

Today, the sparsely populated territory inhabited by Inuit stretches from northeastern Chukotka (Russia) across the Bering Sea to Alaska to the north of Canada to East Greenland. There are 150,000–160,000 Inuit living in this vast geographical area, of which are approximately one-third living in Greenland, one-third in Canada, less than one-third in Alaska, and a small population of 1,600 people in Chukotka (Russia). The Inuit live in different national-states and represent, with the exception of Greenland and Northern Canada, a minority, though in a few local communities, they constitute the majority of the population. Historically, Inuit communities were not organized as social units such as clans or tribes. Before the colonial era, a variety of local groups lived in the Arctic, each with significant cultural differences. Local identity and membership were traditionally expressed by the use of place-names with the suffix -miut ("people of"). All Inuit groups experienced a colonial history and aspirations on the side of the dominant society trying to assimilate Inuit to national norms and values after colonial times.

Inuit are engaged in activities of subsistence harvesting like hunting and fishing to supply the household. Although nowadays a mix of different economic activities is often necessary to make a living, including wage income, revenues from hunting products, government services, and transfer payments. Inuit subsistence harvesting is a social, cultural, and economic activity. In many communities, a distribution system still exists, which ensures that prey animals are shared within extended families or the community. As a vital everyday activity, the act of sharing ties people together and establishes reciprocal social relationships. The hunting of marine mammals such as seals, whales, and walruses remains one of the most important hunting activities of Inuit hunters. However, fewer and fewer Inuit live as full-time hunters. Most parts of the Inuit population earn their primary income from commercial fishing, oil-related business, tourism, financial enterprise, or public administration. At present, the Inuit hunting complex is threatened by outside (exogenous) factors as environmental problems (transboundary pollution, climate change) or globalized activities of animal rights groups trying to stop sealing as well as whaling. Furthermore, inside (endogenous) factors as the rapid social and cultural transformation of the Arctic communities offer alternatives to Inuit hunters in the way that subsistence hunting is not a necessity of life anymore.

Inuit Language and Dialects

The Inuit language is part of the Eskimo-Aleut (Eskaleut) language family. This language family consists of two main branches (Aleut, Eskimo) and four subbranches (Aleut, Yup'ik, Sirenikski, Inuit-Inupiaq) with a total of seven languages: Aleut (Unangax), Yup'ik (Alutiiq, Central Alaskan Yup'ik, Naukanski Yup'ik, and Siberian Yup'ik), Sirenikski (Sirenikski), and Inuit-Inupiaq (Inuit). These seven languages can be further divided in groups, subgroups, dialects, and subdialects, for example, the Inuit language consists of 4 main groups of dialects with 16 regional subgroups of dialects: Alaskan Inupiaq, Western Canadian Inuktun, Eastern

Canadian Inuktitut, and Greenlandic Kalaallisut. Due to this language variation, it might likely be the case that interpersonal communication beyond these linguistic frontiers is not always manageable. All languages of the Eskimo-Aleut language family share—as being polysynthetic languages—the same linguistic structures: words are formed with extensions (affixes). Thus, by combining units of meaning, the creation of very long words is possible. The Eskimo-Aleut language family comprises several native languages and dialects, which are increasingly threatened by linguistic globalization. Therefore, smaller linguistic communities are continually exposed to the influence of a majority language—usually English—and therefore trends of unification emerge. All Eskimo-Aleut languages and dialects are recorded in UNESCO's Atlas of the World's Languages in Danger, whereas many of them are vulnerable, some of them are severely endangered (e.g., Central Siberian Yup'ik, Alaskan Inupiaq, Western Canadian Inuktitut) or critically endangered (e.g., Naukanski Yup'ik, Rigolet Inuktitut). By contrast, the language of the Inuit is very vital and popular in West Greenland (Kalaallisut) and in several areas of the eastern Canadian Arctic (Eastern Canadian Inuktitut) and is seen as being important for defining contemporary collective Inuit identity. In some regions, the Inuit language or dialect is recognized as official language (e.g., Kalaallisut in Greenland, Inuktitut and Inuinnaqtun in Nunavut). The written Inuit language is elaborated in Latin alphabet or syllabic writing.

History

Dating back up to 20,000 years, there is archaeological evidence that the origins of Inuit culture are in Siberia. Excavations indicate that a related hunting culture, the Paleo-Arctic Eskimo, had lived on both sides of Bering Strait 18,000 years ago. Arctic archaeologists analyzed several distinct cultural episodes, including those classified as Old Bering Sea, Okvik, Birnik, Punuk, and Thule in Siberia; Denbigh Flint complex, Choris, Norton, Ipiutak, Birnik, and Thule in Alaska; Pre-Dorset, Dorset, and Thule in Canada; and finally those classified as Independence I, Saqqaq, Independence II, Dorset, and Thule culture in Greenland. Taking similarities in the use of stone tools into account, archaeologists refer to the term "Arctic Small Tool Tradition" to describe a common Inuit culture among the earliest groups living in the Eastern and Western Arctic. These Arctic people are characterized as being nomadic or seminomadic and living from subsistence activities as, for instance, hunting, trapping, pastoralism, or fishing. Their existence was thus dependent on the availability of marine mammals like seals and whales and terrestrial mammals like caribou.

The different Inuit groups did not live isolated but were in close contact with external communities, for example, Erik the Red established a Norse settlement in Greenland in AD 984 or Martin Frobisher met Inuit on his voyage in 1576 in Canada.

Encounters between Inuit and European explorers, missionaries, and whalers increased in the sixteenth, seventeenth, and eighteenth centuries. In 1721, Hans Egede, a Moravian priest, founded a missionary station in Gothåb (today: Nuuk), thereby beginning Danish-Norwegian colonization of Greenland. In 1728 and later, on behalf of the Russian czar Peter the Great, the Dane Vitus Bering explored the northwest coast of North America. The Russian interest in establishing permanent colonies in Alaska arose from the valuable furs and sea otter pelts Bering brought back from his journeys. Almost all Inuit groups experienced interactions with explorers and commercial whalers and were involved in trading activities. The foreign traders, explorers, or administrative personnel established trading companies as, for example, in 1670, the Hudson's Bay Company in Canada, in 1774, the Royal Greenland Trading Company in Greenland, or in 1799, the Russian-American Company in Alaska. In this way, they used the knowledge and skills of hunters to get whale and seal products (tran oil, whalebone, furs, and skins) and offered them alcohol, tobacco, sugar, flour, tea, crackers, matches, firearms, or ammunition in exchange. The encounters with Europeans led to the emergence of new diseases and epidemics (tuberculosis, smallpox, mumps, measles, and influenza) and affected the population of some Inuit groups seriously. Furthermore, the colonization of Inuit homelands brought by the annexation of lands into the national states of Denmark, Russia (Soviet Union), the United States, and Canada led to great transformations and social change within Inuit communities. After World War II, Inuit were recognized as indigenous people within the human rights framework of the United Nations. However, Inuit in the Circumpolar North are still dependent on laws, institutions, governance structures, norms, and values, which are those of the dominant nation-states. To control their own affairs, Inuit seek to achieve political self-determination in the future.

Political Self-Determination

The dialogue and exchange between different Inuit groups in the Arctic was intensified during the 1970s and led to the organization of the Arctic Peoples Conference in Copenhagen (Denmark) in 1973 and the Inuit Circumpolar Conference in Barrow (Alaska) in 1977. The participants coming from Alaska, Canada, and Greenland realized that they all share the same problems as being postcolonial minorities, as well as the same cultural origins. As a new kind of modern indigenous internationalism, a pan-Eskimo—respective a pan-Inuit—movement commenced by establishing the Inuit Circumpolar Conference as the first permanent body for Inuit cooperation. In 1983, the first ICC president, the Greenlander Hans-Pavia Rosing, accomplished the official recognition of the ICC as a nongovernmental organization with consultative status by the United Nations Economic and Social Council. Since then, the ICC represents all Inuit living in the Arctic regions of Alaska, Canada, Greenland, and, since 1992, Chukotka (Russia), and promotes the rights of the Inuit as indigenous people within the human rights framework in different international fora and working groups. In addition, the ICC advocates a sustainable environmental management regime including traditional knowledge, the protection of the northern environment from global warming and extensive resource exploitation, and the right of the Inuit to reasonably use and exploit their natural resources and to emphasize the Inuit language and dialects. In 2006, the Inuit Circumpolar Conference was renamed as Inuit Circumpolar Council (ICC) in Utqiagvik, Alaska.

As Inuit live in different nation-states, the status of self-determination differs in dependence of the historical, cultural, administrative, and political contexts of the dominant society. Established in 1979 as home rule (Hjemmestyre) and modified in 2009 as self-rule (Selvstyre), the Greenlandic Inuit developed the most advanced form of self-government and will probably create the first independent Inuit state in the future. With the Nunavut Territory, another self-government was recognized in Canada in 1999. With the help of land claim agreements, the Inuit established other kinds of self-government or regional Native corporations with province-like powers (e.g., education, health care, municipal service), comanagement regimes to include traditional ecological knowledge as equal to scientific knowledge in the process of policy making, and formed their own organizations to articulate their interests in legal and political affairs (e.g., Alaska Eskimo Whaling Commission, Inuit Tapiriit Kanatami). To some of these organizations, a participant or observer status was permanently granted in international bodies, as the Arctic Council, the International Whaling Commission, or the United Nations Permanent Forum on Indigenous Issues. As officially recognized indigenous people, the Inuit were also successful in continuing whaling after the moratorium in 1986. Under the IWC category of "aboriginal subsistence whaling," today, Greenlanders are allowed to catch a fixed quota of minke whales, bowhead whales, fin whales, and humpback whales. Siberian Yup'ik are free to catch gray whales and bowhead whales, whereas the catch of bowhead whales is permitted to other Inuit groups as Iñupiat and Yup'ik in Alaska and Canada.

Frank Sowa

See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit and Yup'ik Concepts of "Ihuma" and "Qanruyutet"; Inuit Arctic Relocation; Inuit Concepts of "Naklik" and "Ilira"; Inuit Contribution to Polar Exploration; Inuit Language; Inuit Lawsuits over Climate Change; Inuit Qaujimajatuqangit; Inuit Worldviews and Religious Beliefs; Ket; Khanty; Koryak; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Csonka, Yvon. "Tchoukotka/Chukotka." Thematic issue of *Études/Inuit/Studies* 31, nos. 1–2 (2007): 7–37.

Lynge, Aqqaluk. *Inuit: The Story of the Inuit Circumpolar Conference.* Nuuk, Greenland: Atuakkiorfik, 1993.

Moseley, Christopher, ed. *Atlas of the World's Languages in Danger.* New York: UNESCO Publishing, 2010.

Stern, Pamela R. *Daily Life of the Inuit.* Santa Barbara, CA: ABC-CLIO, 2010.

Inuit and Yup'ik Concepts of "Ihuma" and "Qanruyutet"

A person who has "ihuma" and who follows the "qanruyutet"—rules for living—is considered mature. Having "ihuma" involves having knowledge and skills for controlling one's mind and emotions through thoughts, words, and acts of both compassionate nurturance and restraint to maintain peace in the family-community. "Ihuma" might be thought of as a mindful way of knowing (and living) that could be described as a well-developed understanding and balancing of the interdependent attitudes and feelings of "naklik" (affection, love, and concern) and "ilira"(respectful fear) because one has a deeply embodied reverence for promoting peace within self, others, and the larger extended family-community.

The idea and belief that each one is an interdependent part of the greater whole is key component for developing "ihuma" and sharing the "qanruyutet." In traditional subsistence-based cultures, this idea also extends to the belief that humans are spiritually interconnected with nature and/or the natural environment. The development and balancing of "ihuma" (Inuit word for mind) and "umyuaq" (Yup'ik word for mind) is essential for promoting peace and cooperation in the family-community. Disciplining our own thoughts, words, and actions for the greater well-being is a form of self-discipline through love of the greater whole. This idea also seems to be similar to the balancing of mind and emotions for practicing compassion and central to the concepts of cognitive, emotional, and compassionate empathy from the field of cognitive sociology and psychology.

The concept of compassion can be found in cultural and spiritual philosophies of all major world religions. The concept of promoting an ideal set of thoughts and behaviors that promise love, peace, and cooperation in family-community is the essence of "ihuma" and motivational force behind following and sharing the "qanruyutet." It seems the Yup'ik lived in much larger extended family-community societies in comparison with the Inuit and in response developed the "qanruyutet" as a set of instructions or rules for living to help develop knowledge and skills for compassionate nurturance and restraint to ensure maintenance of equanimity during difficult times.

The difference between the Inuit and the Yup'ik concepts of "ihuma" and "qanruyutet" remains that the Inuit emphasis is on "ihuma" as the governing force in adult life compared with the Yup'ik emphasis on "qanruyutet" as the governing force in adult life. The essential features of having an attitude of "ihuma" and living by the "qanruyutet" include embodied compassion and gratitude, speaking with love and practicing even-tempered restraint for the greater good, peace, and survival of the family-community. These features of "ihuma" and following the "qanruyutet" also serve as guiding principles for socialization in traditional, peaceful, polar, family-community subsistence societies.

The magnitude of social problems experienced in recent history (e.g., high suicide rates, rapid language loss, chronic poverty, and unemployment) led to an even greater wish to share the "qanruyutet." The concepts of "ihuma" and "qanruyutet" provide both a theoretical framework and a mechanism for protecting and building peaceful extended family-community subsistence societies necessary for both peace and survival. In traditional northern indigenous family-community societies, elders' understanding of the power of the human mind underlies what they consider appropriate responses to everyday life (i.e., how a person should think, feel, and act). The "qanruyutet" teach compassion and restraint because one's actions have a powerful effect on the mind of others. Acts of compassion will result in feelings of gratitude and good fortune. Acts of willfulness will result in hurt feelings and failure. We make choices, and they have consequences. The teaching and learning of "ihuma" and the sharing of "qanruyutet" have the potential to inspire the way we think, speak, and act.

Karen Knaus and Andrew J. Hund

See also: Inuit; Inuit Concepts of "Naklik" and "Ilira"

Further Reading

Briggs, J. *Never in Anger.* Cambridge, MA: Harvard University Press, 1970.

Fienup-Riordan, A. *Wise Words of the Yup'ik People: We Talk to You Because We Love You.* Lincoln: University of Nebraska Press, 2005.

Goleman, D. *Three Kinds of Empathy: Cognitive, Emotional, Compassionate.* 2007. http://www.danielgoleman.info/three-kinds-of-empathy-cognitive-emotional-compassionate/. Accessed January 10, 2014.

Inuit Arctic Relocation

During the Cold War, the Canadian government relocated 87 Inuit to the Arctic. The Inuit were relocated from the village of Inukjauk (58° 27′N 78° 06′W) in Northern Quebec and Pond Inlet (72° 41′N 77° 57′W) in what is now known at Nunavut, Canada, to Resolute Bay (74° 41′N 94° 52′W) on Cornwallis Island and Grise Fiord (76° 25′N 82° 53′W) on Ellesmere Island. The Inuit were transported to the Arctic by the Canadian Coast Guard on the *C. D. Howe* vessel. The relocation is a controversy because of the reasons for the relocation and the inhumane conditions faced by the relocated Inuit. Both the Inuit and the Canadian government acknowledge that the relocated Inuit lacked appropriate food, clothing, and supplies to endure the Arctic conditions upon arrival and for the first couple of years.

The Canadian government claims that the relocation of the Inuit was a humanitarian act. The Inuit selected for relocation were reported to be starving and receiving welfare benefits. In 1953, the Canadian government offered the seven or eight Inukjauk families and three families from Pond Inlet better living conditions and the ability to engage in the subsistence way of life if they moved to the Arctic region. The Pond Inlet group was to teach the Inukjauk Inuit the ways of living in the Arctic, including subsistence, survival, and Arctic skills. The Canadian government claimed that the families from Inukjauk volunteered for the relocation to return to the subsistence way of life and discontinue being on welfare. The Northern Quebec area around Inukjauk was viewed as overpopulated and lacking animals for adequate subsistence living.

The Inuit claim that the relocations were not voluntary but instead forced. The Inuit also claim that the Canadian government was not acting out of humanitarian motives, but was attempting to establish settlements in the Arctic Archipelago to establish Canadian dominion. Thus, the Inuit were human flagpoles to establish Canadian sovereignty over the Far North and stake claim to the disputed Arctic Archipelago. The Inuit were told on the *C. D. Howe* cutter that they were to be living in three separate locations. They were also reportedly told that they could return back to Inukjauk after two years, but this was not honored. The Inukjauk Inuit eventually learned the migration routes of the beluga whale and was able to adapt to and survive in the Arctic.

In the 1980s, the relocated Inukjauk Inuit and their descendants filed a complaint with the Canadian government. The Inuit alleged that the relocation was based not on humanitarian motives but solely to claim sovereignty over the Arctic Archipelago. In 1987, the Inuit claimants sought $10 million in compensation for the relocations. In response to public criticism, the Canadian government established a program to return the Inuit back to Inukjauk, in 1989. Around 40 Inuit chose to return, but many who grew up in the relocation communities chose to stay. In 1990, the aboriginal affairs committee of the Canadian House of Commons requested that the Canadian government apologize, financially compensate, and recognize the Inuit of Resolute Bay and Grise Fiord for their sacrifice to Canadian sovereignty. In response, the Canadian government authorized an investigation that resulted in the Hickling report. The Hickling report completely absolved the Canadian government of any wrongdoing. The report claimed that the Inuit had volunteered for the relocation because of the harsh living conditions in Inukjauk in the 1950s. In 1991, the Canadian Human Rights Commission issued a report that maintained that the relocation and settlement were for Arctic sovereignty. In 1994, the Royal Commission on Aboriginal Peoples had hearings on the matter. The Inuit claimed to have been forcibly relocated, while the Canadian government maintained the relocation was voluntary. The Canadian government did not apologize or acknowledge guilt but did establish a Reconciliation Agreement and created a $10 million trust fund for the Inukjauk Inuit and their families. In 2010, the Canadian government officially apologized to the Inuit for their inhumane treatment caused by the relocation.

Andrew J. Hund

See also: Eskimos; Inuit

Further Reading

Dussault, R., and G. Erasmus. *The High Arctic Relocation: A Report on the 1953–55 Relocation.* Ottawa: The Royal Commission on Aboriginal Peoples: Canadian Government Publishing, 1994.

Loukacheva, N. *The Arctic Promise: Legal and Political Autonomy of Greenland and Nunavut.* Toronto: University of Toronto Press, 2007.

Marcus, A. *Out in the Cold: The Legacy of Canada's Inuit Relocation Experiment in the High Arctic.* The International Work Group for Indigenous Affairs (IWGIA). 1992. http://www.iwgia.org/iwgia_files_publications_files/0155_71_Canada.pdf. Accessed January 10, 2014.

McGrath, M. *The Long Exile: A Tale of Inuit Betrayal and Survival in the High Arctic.* New York: Alfred A. Knopf, 2006.

Inuit Concepts of "Naklik" and "Ilira"

"Naklik" and "ilira" are balancing values for "ihuma." "Naklik" means a warm concern for the physical and emotional welfare of others, while "ilira" is a respectful fear of the other. Having "ihuma" involves having knowledge and skills for controlling one's mind and emotions through thoughts, words, and acts of both compassionate nurturance and restraint to maintain and restore peace in the family-community. "Ihuma" can be thought of as a mindful way of knowing (and living) by developing an understanding and balancing of the interdependent attitudes and feelings of "naklik" and "ilira" because one has a deep respect for promoting peace within self, others, and the larger extended family-community.

Some may like to think about "naklik" and "ilira" as "love" and "fear." Inuit children are taught to develop ambivalent feelings toward affection and fear as a strategy for promoting peace. The feeling of "ilira" is an undesirable feeling that prompts the countervailing desirable feeling of "naklik." People who have ihuma feel "naklik" and foster interpersonal gentleness by controlling anger and aggression because they understand that these are caused by "ilira." "Naklik" can be used for feelings of both protective concern and affection. "Naklik" is a feeling and reaction to the physical and/or emotional assistance needed by others. In particular, those who lack "ihuma" are to be naklik'd (e.g., a distressed child, an ill person, an orphan, a widow, a disabled person, and especially family members who are in need).

Jean Briggs (1929–) in her book, *Never in Anger*, described three types of feelings for affection that she observed in the Utku (Inuit): (1) desire to be with a loved person; (2) demonstrativeness: the desire to kiss, touch, or express tenderness verbally; and (3) protectiveness: the desire to take care of the physical and emotional needs of another. There are several words in the Inuit language for expressing affection. "Aqaq" is a term used to communicate tenderly with another by speech or by gesture. "Iva" is a term meaning to lie next to someone in bed, with connotations of affectionate touching. "Huqu" is a term that means to respond with nurturing behavior, especially to extended family members (ilammanigiit). "Unga" is a term meaning the desire to be with a loved person. Feelings of unga are particularly strong between family members. Feelings of unga have connotations of homesickness, wanting to be with someone as well as wanting to nurture and protect them.

As a child grows, he or she becomes a little less someone to be naklik'd, but the Inuit recognize that everyone including adults has a wish to be naklik'd. Someone to be taken care of is referred to as "naklingnaqtu." Some are embarrassed if they think they are naklik'd too much because it implies dependence and pity. Sometimes even if a person wishes to be naklik'd, they suppress this desire and choose to become the nurturing (nakliking) person, protecting others from the sadness that they would feel if he/she allowed them to feel "naklik" toward them. One of the qualities of a nakliking (nurturing and protective) person is kindness. A nakliking person is said to *hatuqnaq*—inspire gratitude.

An understanding of "naklik" promotes one to think, speak, and act with loving and respectful concern for others, thus inspiring gratitude and "naklik" feelings and behavior in others. Understanding "naklik" is not possible without understanding the balancing principle and feelings of "ilira." Understanding "ilira" is based on an understanding of feelings of fear including the fear of being treated unkindly, disapproval, and not being protected by others. The anxiety experienced by feelings of "ilira" may cause people to act in different ways: (1) conform to what they think others wish; (2) avoidance; or (3) attempting to destroy the source of the uncomfortable feeling (e.g., a person they perceive to be unkind or disapproving). The antidote or balancing principle for "ilira" is "naklik."

A person who possesses ihuma should feel "naklik" in the face of a fearful person or situation because nakliking makes people feel safe and comfortable, and these feelings promote peace and cooperation, especially in the family-community. "Ilira" is uncomfortable. The cure for helping a person overcome feelings of ilira is to be proactively considerate of them through kind, nurturing, and protective behavior (nakliking them). By being kind to a person who fears you, they will no longer fear you, and peace will be restored. Understanding the interdependent nature of the principles of "ilira" and "naklik" is the key to having "ihuma" and being a social agent for peace in extended family-community.

Karen Knaus and Andrew J. Hund

See also: Inuit; Inuit and Yup'ik Concepts of "Ihuma" and "Qanruyutet"

Further Reading

Briggs, J. *Never in Anger.* Cambridge, MA: Harvard University Press, 1970.

Hinde, R., and J. Groebel. *Cooperation and Prosocial Behaviour.* Cambridge: Cambridge University Press, 1991.

Inuit Contribution to Polar Exploration

"[I]t is one of the least explicable things in the history of Arctic exploration that Eskimo methods of travel were not sooner and more generally adopted" (Stefansson 1908: 211). By the time of the first-contact European explorers, the Inuit of North America and Greenland had developed the expertise for Arctic exploration that was far in advance of those venturing north. This cold-living culture encompassed clothing, hunting, and traveling techniques, diet, and shelter, and a broader intellectual framework that, in more subtle ways, assisted accommodation to an environment perceived as harsh and dangerous by outsiders but not by the Inuit themselves.

So long as exploration could be conducted primarily from ships, there was obviously less to be learned from the Inuit, though early expeditions did seek to acquire interpreters—sometimes by force—to help them discover what they could from the inhabitants. Maps were particularly useful, not infrequently demonstrating an expert knowledge of regions far beyond the local area. Once, however, exploration required travel away from ships—over ice, land, or water—explorers needed to copy Inuit techniques, though very few did. Some transference of knowledge did occur in West Greenland, where Danish missionaries and traders lived among the Inuit. It also took place to a more limited extent when expeditions wintered close to Inuit communities (e.g., those of Edward Parry in 1821–1823 and John Ross in 1829–1833) or recruited Inuit dog drivers (e.g., those of Elisha Kent Kane and Isaac Hayes). Charles Francis Hall in 1860 was any one of the first explorers to learn and adopt Inuit knowledge, techniques, and lifestyle which prepared him for efficient Arctic travel; yet, it is generally held that is was not until Robert Peary did any explorer acquire mastery of Inuit methods.

One of the most effective of the early travelers was the Hudson's Bay Company (HBC) surgeon and fur trader John Rae, whose explorations in the 1840s and 1850s anticipated the lightweight, self-sufficient practices later advocated by Vilhjalmur Stefansson. Like other HBC employees—Samuel Hearne, Peter Dease, and Thomas Simpson, for example—Rae's methods were initially derived from the Indians, although he did go beyond them to construct igloos and was the first to ice the runners of his sledge to reduce friction.

Fridtjof Nansen used the opportunity of his enforced stay in West Greenland in 1888–1889 to learn how to kayak but not how to handle dogs. This skill he acquired the hard way, through repeated error, while practicing for his polar journey from *Fram.* Peary chose a relatively southerly winter quarters in northwest Greenland in 1891 so as to be close to areas populated by the Inuit. It was there that he acquired both Inuit clothes and knowledge of how to wear them, allowing the cold air to circulate at times to avoid becoming overheated. Following Inuit practice, he was able to dispense with tents (by sleeping in igloos) and sleeping bags (unnecessary in igloos).

Such improvements resulted in a considerable savings in weight, particularly in the later stages of a journey as the tents and sleeping bags accumulated moisture, becoming heavier and heavier as well as more and more uncomfortable. Although Peary learned much from the Inuit, the learning was not all one way, especially where he had access to better materials. Thus, instead of piecing his sledges together from whalebone and driftwood, Peary's sledges were constructed from timber brought north from the United States. These materials enabled him to build larger sledges that still retained the traditional shape and lashings employed by the Inuit. Peary also introduced the use of iron under the runners. Roald Amundsen learned much from the Inuit when he spent 23 months on King William Island in the Canadian Arctic during his first transit of the Northwest Passage. He too learned to wear furs, and several members of his expedition became expert dog drivers, including Helmer Hanssen, who was later to make good use of his skills during Amundsen's journey to the South Pole.

Knud Rasmussen's account of equipment and materials taken with him on his first Thule Expedition gives a good idea of what an Inuit hunting party might carry on an extended journey. "We took with us . . . harpoons, spears, bladders, lines and implements of all kinds, both those used in hunting on the ice and those for kayak work. . . . In addition, we had a number of strong seal-hide lines, 15–20 fathoms long; these were intended partly as extra traces in reserve, and partly as lashings etc. in case of need. We had also skins of bladder-nose seal, reindeer, musk ox and bear to lie on. . . . [F]inally, we had with us a big and very strong reindeer horn, from which Eskimo bows could be made" (Rasmussen et al., 1915: 290). Rasmussen's description of methods adopted during his first and later expeditions is the nearest we have to a manual of Inuit traveling techniques.

Stefansson recommended that all expeditions make a point of cultivating good relations with the Inuit, for whom they should take care to bring appropriate gifts. For those already used to contact with outsiders, they should bring tea, tobacco, and flour. For those not yet contacted, needles and files were more suitable. They should also match their activities to those of the Inuit, who had long experience of which areas were best visited at different times of the year. Thus, the best time to explore the interior was when the Inuit hunted caribou inland. Fishing season was the time to undertake boat journeys. Knowledge of how to build an igloo was mandatory. It was quite unnecessary to freeze to death in the Arctic, when one-and-a-half-hour's labor could erect a warm shelter.

Gino Watkins and the members of his British Arctic Air Route Expedition of 1930–1931 learned about polar travel from the East Greenlanders. One of those with him, John Rymill, later attributed the success of his British Graham Land Expedition of 1934–1937 to its adoption of Inuit practices, particularly with regard to dogs. Through Edward Bingham, these practices were later passed to the Falkland Islands Dependencies Survey and through it to the British Antarctic Survey and to other expeditions and agencies operating in Antarctica. Thus, much of Antarctica as well as North America and Greenland was explored using methods evolved by the Inuit over generations. As far as North America and Greenland are concerned, Inuit also participated in many, if not most, expeditions. Knud Rasmussen, one of the greatest of all explorers, was partly of Inuit descent.

William James Mills

See also: Amundsen, Roald Engebrecht Gravning (1872–1928); British Arctic Expedition (1875–1876); Canadian Arctic Expedition (1913–1918); Dogs in the Arctic; First German North Polar Expedition (1868); Inuit; Rasmussen, Knud (1879–1933)

Further Reading

Brody, H. *Living Arctic: Hunters of the Canadian North.* London: Faber and Faber, 1987.

Rasmussen, K., P. Freuchen, C. Ostenfeld, and O. Bøggild. "Report on the First Thule Expedition, 1912." *Meddelelser om Gronland* 51 (1915): 283–425.

Stefansson, V. "Suitability of Eskimo Methods of Winter Travel in Scientific Exploration." *Bulletin of the American Geographical Society of New York* 40 (1908): 210–13.

Inuit Language

The Inuit language is spoken by the population living on the vast area expanding from Bering Strait to eastern Greenland all along the northern coast of Canada and the Arctic Archipelago, largely north of the tree line. Together with the Yup'ik languages (spoken in southwestern Alaska and in the easternmost part of Siberia) and the Sirenikski language (easternmost part of Siberia, now extinct), it constitutes the Eskimo branch of the Eskaleut linguistic family. In the early twenty-first century, about 101,000 people speak the Inuit language, that is, 89 percent of all Eskaleut speakers.

The Inuit language itself comprises 16 dialects distributed among the following four groups: Inupiaq (four dialects in northern and northwestern Alaska: Bering

Strait, Qawariaq, Malimiutun, North Slope), Western Canadian Inuktun (three dialects in the Inuvialuit region of the Northwest Territories and the Qitirmiut region of Nunavut: Siglitun or Inuvialuktun, Inuinnaqtun, Nattilingmiutitut), Eastern Canadian Inuktitut (six dialects in the Kivalliq and Baffin regions of Nunavut, Nunavik, and Labrador: Kivalliq, Aivilik, North Baffin, South Baffin, Nunavik, Labrador), and Kalaallisut (three dialects in Greenland: North Greenland or Avanersuarmiutut, West Greenland or Kitaamiutut, East Greenland or Tunumiisut). Despite this huge geographical dispersion, most specialists agree that these speech varieties constitute dialects of a single language, and not 16 languages. They have shown the unity of the Inuit lexicon since 90 percent of the basic vocabulary is identical from Alaska to Greenland. This is why it is also often spoken of as *the Inuit continuum.*

Presently, about 75 percent of the Inuit people speak an Inuit dialect throughout the continuum, all dialects; however, they do not share the same demographic vitality. Broadly speaking, it must be underlined that the eastern dialects (in Greenland, Nunavik, and large part of Nunavut) are much more spoken and used than their western counterparts, as shown by the following data (including only Inuit living in one of the various Inuit lands):

As the main exception in the eastern Canadian Arctic, in 2006, only 22 percent of the 2,200 Labrador Inuit spoke the aboriginal language as mother tongue. Historical, political, and socioeconomical reasons (including, in particular, the types and duration of contacts with Europeans and North Americans, schooling system, ideological pressure) explain these large regional discrepancies.

Even in Nunavut and Nunavik where the vast majority of Inuit have Inuktitut as their mother tongue, it is not the Inuit language but English that constitutes today the lingua franca, like everywhere else in the Canadian Arctic. This is even the case in the Baffin Island region, where the Inuit language has retained its supremacy as compared with the two other regions of Nunavut (Kivalliq and Qitirmiut), not to talk about most parts of Alaska, as well as the westernmost regions of Arctic Canada and Labrador, where the Inuit dialects are generally no more or hardly transmitted to children.

Table 1 Inuit language (Data from Dorais, 2010).

Dialect Groups	Number of Speakers	Proportion of Speakers
Alaskan Inupiaq	2,145	14
Western Canadian Inuktun	3,135	44
Eastern Canadian Inuktitut	28,255	89
Greenlandic Kalaallisut	48,855	97

Consequently, all the Inuit territories, including those where the aboriginal language is today widely spoken and used in everyday life, like Greenland, Baffin Island, and Nunavik, constitute multilingual societies in which many people can choose between two tongues at least, Inuit language and English in Alaska and Canada (plus French in Nunavik), Inuit language and Danish in Greenland, to express themselves depending on the circumstances (at home, at school, at work, on the land, in church, in dealings with the administration, etc.) and on the interlocutor's (parents, grandparents, children, siblings, friends, colleagues, members of authorities, etc.) identity. Many Inuit communities are quite clearly similar in dialect (diglossic).

Writing Systems and Literacy

Two types of writing systems (orthography) are used to write the Inuit dialects: the Roman or Latin alphabet, exclusively, is used in Alaska, the Inuvialuit region, Nunavut's Inuinnaqtun speaking communities, Labrador, and Greenland. In Nunavut's Baffin and Kivalliq regions as well as in Nunavik, a syllabic system, known as Inuit syllabics, is highly dominant although the Latin alphabet is often used in parallel.

Literacy has been introduced to the Inuit by Christian missionaries, as early as the eighteenth century firstly in Greenland then in Labrador, much later in the nineteenth century in Alaska, and most of Arctic Canada. In 1742, the Act of Faith was published in Greenlandic, the first text ever published in the Inuit language, in Roman orthography somewhat adapted to transcribe specific phonemes. Early in the nineteenth century, most west Greenland and Labrador Inuit were then able to read and write their language. Over decades, an important literary tradition has emerged and developed in Greenlandic, with, in particular, numerous poets and novelists.

From 1876, Reverend Edmund Peck, an English Anglican missionary, promoted the use of a syllabic system among Inuit from Nunavik and south Baffin Island, a writing system previously invented by Reverend James Evans to write the Ojibwa and Cree languages, then further adapted to Inuktitut by two other missionaries, John Horden and Edwin Watkins. This system was easy to learn and became rapidly popular and known by most Inuit in the Eastern Arctic, except Labrador. In the western Canadian Arctic, as well as in Alaska, people had been exposed to the Roman alphabet as from the end of the nineteenth century, so that the syllabics never spread in these lands. In Canada, the Inuit Cultural Institute (ICI) adopted, in 1976, a standardized dual writing system comprising the Roman alphabet and the Inuit syllabary, which became the official system. Although not yet fully accepted and used in all regions, the ICI standard is now well established in, for example, official documents, school materials, newspapers, and books.

Language's Use in Schools

Kalaallisut became the sole official language of Greenland in June 2009. In practice, Danish is still widely used in the administration and public sphere. Kalaallisut is officially the main school language; children can however follow a Greenlandic or a Danish curriculum in which the other language is taught as a second language. Inuktitut and Inuinnaqtun are official languages of Nunavut, together with English and French. With respect to the education system, from kindergarten and up to grade three, children in Baffin and Kivalliq schools are instructed in Inuktitut; afterward there is switch to a fully English-instructed education where Inuktitut is only a subject and, from time to time, a teaching medium for matters with Inuit content. In the western Canadian Arctic, teaching is carried out in English, and Inuktun is taught only as a second language in some schools. In Nunavik, Inuktitut is the sole teaching language until grade two, after which children follow either the English or French curriculum. Some courses (e.g., culture, religion) continue to be taught in Inuktitut. In Alaska, the state legislature voted in 1972 to provide bilingual education programs in any state-operated school with at least 15 pupils, then reduced to 8 whose native language was other than English. But in the many locations where children no longer speak the aboriginal language, English is used from kindergarten on, and only basics of the local indigenous tongue are taught to children as a second language.

The Structure of the Inuit Language

The Inuit language, like the other Eskaleut languages, is polysynthetic by structure. It means that words, except for conjunctions and interjections, are formed by adding one or several lexical and grammatical affixes (or morphemes or yet postbases) to a lexical base (or radical). This language has also some agglutinative features since each element of the final word keeps a specific and distinguishable meaning. The affixes will develop and make precise the meaning of the initial base, which can be nominal or verbal. In the successive synthesis of morphemes on the word-base, the location of each element is essential to the generation of the final meaning, each of them including semantically the set that proceeds. It comes out that the Inuit language possesses a high degree of motivation, meaning that the resulting word often presents itself as a descriptive definition. Examples of word construction in Inuktitut:

igluliuqpunga "I build a house" (from *iglu* "house", -*liuq*- "build", -*punga* "first singular person of the indicative mode)
igluliulauqpunga "I have built a house" (-*lauq*- "expression of the past")
igluliulaaqpunga "I will build a house" (-*laaq*- "expression of the future").

Guy Bordin

See also: Inuit; Inuit and Yup'ik Concepts of "Ihuma" and "Qanruyutet"; Inuit Concepts of "Naklik" and "Ilira"; Inuit Qaujimajatuqangit

Further Reading

Dorais, Louis-Jacques. *The Language of the Inuit.* Montreal and Kingston, NY: McGill-Queen's University Press, 2010.

Fortescue, Michael, Steven Jacobson, and Lawrence Kaplan. *Comparative Eskimo Dictionary, with Aleut Cognates.* Fairbanks: University of Alaska, Alaska Native Language Center, 1994.

Harper, Kenn. "The Early Development of Inuktitut Syllabic Orthography." *Études/Inuit/Studies* 9, no. 1 (1985).

Inuit Lawsuits over Climate Change

There have been two climate change legal actions filed by and on behalf of the Inuit. In 2004, the Inuit Circumpolar Conference (ICC) filed a petition with the United Nations Inter-American Commission on Human Rights (IACHR) titled, "Petition to the Inter-American Commission on Human Rights Seeking Relief from Violations Resulting from Global Warming caused by Acts and Omissions of the United States." The petition outlined the effects climate change has had on the Inuit and their lands and demanded that the United States reduce greenhouse gas emissions to rectify the continued destruction to the Inuit livelihood. The IACHR chose not to hear or rule on the merits of the ICC petition and did not provide a reason for doing so.

In 2008, the Native American Rights Fund, the Center on Race, Poverty, and the Environment, and six other law firms filed a lawsuit on behalf of the Native Village of Kivalina in U.S. District Court in San Francisco. The lawsuit alleges that 14 power companies, nine oil companies, and one coal company had conducted a misinformation campaign that deceived the public about the science of global warming. The lawsuit sought $400 million in restitution. Lawyers for plaintiffs argued that the defendant actions resulted in an increase in climate change, which caused flooding and destruction to Kivalina. In September 2009, the court case (*Native Village of Kivalina v. ExxonMobil Corp., et al.*) was dismissed on the grounds that it needed to be resolved by the U.S. Congress and the president and not by the court system. In November 2009, an appeal was filed with the Ninth Circuit Court of Appeals. In July 2010, the Washington Legal Foundation filed a legal brief that sought to reject the appeal on the grounds that the suit lacked standing. In September 2012, the panel of appeals judges did not vote in favor of reinstating this case.

Andrew J. Hund

See also: Inuit; Inuit Arctic Relocation; Inuit Qaujimajatuqangit

Further Reading

Bryner, G. "The Rapid Evolution of Climate Change Law." *Utah Bar Journal* 20, no. 2 (2007): 22.

Inuit Circumpolar Conference, Petition to the Inter American Commission on Human Rights Seeking Relief from Violation Resulting from Global Warming Caused by Acts and Omissions of the United States. http://www.inuitcircumpolar.com/files/uploads/icc-files/FINALPetitionICC.pdf. Accessed January 10, 2014.

Inuit Qaujimajatuqangit

In 1999, the Canadian territory of Nunavut (meaning "our land" in Inuktitut) was officially created as a result of a land claim settlement between the federal government and the Inuit population of the central and eastern Canadian Arctic. At the time of its formation, Nunavut was understood to be an "Inuit homeland" that was to be governed through novel policies and practices specifically designed to incorporate the culture and history of the territory's overwhelmingly Inuit constituency. The question of how to represent Inuit traditions in the modern world was foremost on the agenda in 1998 when representatives from the Nunavut Social Development Council met in the municipality of Igloolik to discuss the integration of traditional knowledge and governance in the soon-to-be-inaugurated territory. It was decided that the term "traditional knowledge" was inadequate to represent the holistic nature of Inuit knowledge, envisioned as being equally rooted in traditional lifestyle and contemporary strategies for adapting to the modern world. The term "Inuit Qaujimajatuqangit" was chosen as a replacement to traditional knowledge.

The concept of Inuit Qaujimajatuqangit or simply called "IQ" serves as a bridge between old and new life ways in the Canadian Arctic. While the Inuktitut term literally translates as "that which has long been known to the Inuit people," it is a modern concept designed to enhance Inuit participation and representation in government, as well as social and cultural policies, programs, and services within Nunavut. The term "IQ" is seen as encompassing the relationship between thought, action, and belief, linking the knowledge and values that have allowed Inuit people to survive for centuries in the Canadian Arctic to both present Inuit society and their future aspirations for cultural independence and fortitude. Inuit have described IQ as a form of living technology or a tool that can be used to more successfully adapt to a rapidly globalizing world while still maintaining a foundation of traditional culture and values. While IQ technically refers to the cultural knowledge applied on a daily basis in the lives of Inuit individuals, it is rarely considered at the personal level and typically appears in conversations relating to Nunavut politics and pan-Inuit identity. IQ has become a key concept behind the quest to ensure that the structural and political operation of Nunavut represents Inuit interests. Each department of government is responsible for developing and implementing IQ-related policies, though some have been more active in this regard than others. The Department of Culture and Heritage (formerly Culture, Language, Elders and Youth) has made the most notable contributions to exploring what IQ entails and how it can seek practical application. Other departments have been criticized for overzealously relating IQ to areas such as customer service and business management, which have little association to traditional Inuit culture. A common practice in various government departments is to hold regular IQ days, which allow staff to forgo office work and engage in cultural activities such as fishing, sewing, or out-of-town excursions.

The translation of IQ into policy and politics has required that the term go beyond a sense of cultural instinct and be articulated into a formal set of rules and values amenable to practical application. The government of Nunavut has devised and issued a list of core IQ principles, or values, for this purpose. This list outlines eight broad principles, such as environmental stewardship and working together for a common cause, which are said to guide traditional Inuit living. This list of principles has been contested by some Inuit people for its removal of values from the broader cultural context that gives them their meaning. A task force set up to oversee the implementation of IQ in government practice has sought to broader understanding of the concept as a series of relationships relating individuals to the land, their family, their inner spirit, and community. Despite this, the concept of IQ remains a conscious topic of debate in Nunavut. While it has potential to bring generations of Inuit together to counteract the erosion of cultural traditions, it also has the potential to codify traditional knowledge and values in a way that undermines the intricacy and diversity inherent in Inuit worldview. Attempts to define and record IQ knowledge remain an ongoing priority within the territory.

Brendan Griebel

see also: Eskimos; Inuit; Inuit Arctic Relocation

Further Reading

Kassam, K. "Thunder on the Tundra: Inuit Qaujimajatuqangit of the Bathurst Caribou, by Natasha Thorpe, Naikak Hakongak, Sandra Eyegetok, and the Kitikmeot Elders." *Arctic* 55 (2002): 395.

Oosten, J., F. Laugrand, and M. Aupilaarjuk. *Inuit Qaujimajatuqangit Shamanism and Reintegrating Wrongdoers into the Community.* Inuit Perspectives on the 20th Century. Vol. 4. Iqaluit, Canada: Nunavut Arctic College, Language and Culture Program, 2002.

Inuit Worldviews and Religious Beliefs

Prior to their permanent contacts with Westerners (*Qallunaat*), Inuit groups formed animist societies where shamans (*angakkuit*) played a major role in many aspects of daily life. Depending on the region, conversion to Christianity happened at different periods, between the middle of the eighteenth century (western Greenland) and the early twentieth century (some parts of present Nunavut). This entry will focus on the situation of Inuit from eastern Canadian Arctic, that is, Nunavik (Arctic Quebec), Nunavut, and Labrador.

Inuit Animism and Shamanism

Until their conversion to Christianity, Inuit beliefs rested on animistic ontology according to which every natural entity, whether living or inanimate—human beings, animals, plants, rocks, landscape elements, natural phenomena, and so forth—possesses a spiritual essence called *inua.* This is a major concept in Inuit beliefs of the past. Entities could interact through their *inua*, that is, literally through their person or owner. This word is indeed built on the root *inu-* "person" and the possessive (third person singular) *-a*, hence it denotes a relational feature. For instance, a tale from north Baffin Island tells the love story between a woman and the *inua* of a lake (*tasiup inua*, "of the lake, its 'owner'") that took the shape of a penis. There existed also a number of owners of particular importance, originally human beings who got transformed because of evil deeds: *Takannaaluk* (also known under other names), the "sea woman," is the *inua* of the sea; *Taqqiq*, the "moon man," is that of the moon; and *Sila*, a former giant, is the *inua* of the sky and weather.

Shamans, assisted by their helping spirits (*tuurngait*), were the intercessors between the various realms, those of the living beings, of the dead, of the nonhuman entities, able to cross the boundary between the visible and the invisible. They were in charge of keeping the harmony between those worlds and bringing it back when it had been broken from lack of respect for ritual injunctions and restrictions, which were numerous. Sickness, starvation, or prolonged bad weather, for instance, were thought as resulting from such breaking of rules, as no event was believed as occurring just by chance. It was then the task of the shamans to act to restore the lost equilibrium by making use of their great powers. In case of famine, shamans would travel down to the sea woman, guardian of the sea mammals, and intervene with her so that she would free the sea animals that she retained in her hair. Although some of them could also behave evilly, like putting curses on other people, shamans were key characters of past Inuit life.

Conversion to Christianity

Within a gradual process, the Inuit of Labrador have been the first ones in Canada to get into permanent contact with missionaries. The Moravian Brethren settled down in 1771 in Nain where they started their activities, and in a few decades, all Inuit of the region were converted. In other Canadian Inuit regions, it is not before the last decades of the nineteenth century that the Anglican and Roman Catholic Churches started to be active. After years of actions first in Nunavik, the Anglican

Church Missionary Society (Reverend Peck) opened its first mission in 1894 in south Baffin Island in Uumanarjuaq (Blacklead Island). But it was not before 1901 that the first conversions took place. For its part, the Roman Catholic Church (Father Turquetil) established its first mission in 1912, in Igluuligarjuk (Chesterfield Inlet) in Kivalliq. In the early years of the twentieth century, many books of the New Testament and hymns were translated into Inuktitut in syllabic orthography and rapidly spread over. In many places, Inuit converted to the Christian faith in the absence of missionaries, under the leadership of Inuit proselytes, sometimes after collective conversion where ritual prescriptions were transgressed.

The expansion of Christianity in the eastern Canadian Arctic was also a field of rivalry between Anglicans and Roman Catholics. For instance, in 1929, arriving on the same ship, Fathers Prime Girard and Étienne Bazin as well as the Reverends John H. Turner and Harold Duncan founded the Roman Catholic and Anglican missions respectively, in Mittimatalik (Pond Inlet). Very quickly, there grew to be marked differences in terms of prosperity: the Catholics had planned to set up a mission in 1927, but a shipwreck forced them to postpone their project until 1929. Anglicans benefitted from this setback and acquired a definitive advantage: in 1928, Bishop Anderson spent the summer in Mittimatalik and baptized about 35 people, and asked the baptized already familiar with the Bible of the Anglicans not to ever follow the Catholics. Very soon after their arrival, therefore, the two reverends found themselves in a favorable environment and attracted the vast majority of the Inuit to their church. On the whole, communities on Baffin Island have always been largely Anglican, with the exception of Iglulik, where both churches were and still are equally important. Opposite to the Baffin situation, and also to that in Nunavik where Anglicanism is the predominant religion, the Kivalliq is largely a Roman Catholic area, except for the communities of Qamanittuaq (Baker Lake) and Naujaat (Repulse Bay).

Contemporary Inuit Christianity is above all marked by the rise of Evangelical and Pentecostal movements. After their gradual emergence during the last decades of the twentieth century, they experience presently a strong attraction of faithful. They also significantly influence the beliefs and rituals of the historical churches, the Anglican one in particular. It is worth to mention that although these movements strongly reject the shamanic past that they associated to a pagan era, their practices tend to evoke these old traditions, in particular public confession, repentance, introduction of Inuit drums in their celebrations—while earlier missionaries, especially the Anglicans, had forbidden their use—and the focus on healing and solidarity between people and generations with deep attention to elders. Some people, Inuit and observers alike, see in that a particular manner to reconnect Inuit Christian present time with pre-Christian history, what is however not acknowledged by all.

Guy Bordin

See also: Eskimos; Inuit

Further Reading

Boas, F. *The Central Eskimo.* Lincoln: University of Nebraska Press, 1964 [1888].

Laugrand, F., and J. Oosten. *Inuit Shamanism and Christianity.* Montreal and Kingston, NY: McGill-Queen's University Press, 2010.

Oosten, J., and F. Laugrand, eds. *The Transition to Christianity.* Iqaluit, Canada: Nunavut Arctic College, 1999.

Invasive Species. *See* Climate Change and Invasive Species in the Arctic

Ionosphere, Polar

The ionosphere is part of the upper atmosphere. Solar radiation in the far ultraviolet (FUV) and extreme ultraviolet (EUV) wavelength region has sufficient energy to ionize the molecules and atoms of the air. On the dayside of the Earth, the upper atmosphere is thus constantly ionized. This means that an electron gets stripped off a neutral particle (atoms and molecules), leaving a free electron and an ion. These have opposite electric charges, and usually they would recombine again to a neutral particle in a very short time. Because the atmospheric density decreases as altitude increases, collisions between the molecules, atoms, and free electrons become less frequent. Some of these ions can therefore survive long enough that the ionosphere lasts through the night, especially at higher altitude.

The polar regions are special areas of the ionosphere. First, the day–night cycle of solar illumination has a strong seasonal dependence. In the winter, it can be almost continuously dark, while in the summer, the sun radiates the atmosphere continuously. Second, the close connection to the near-space environment due to the nearly vertical magnetic field provides an additional ionization source with the aurora. At these high latitudes, the ionosphere is highly variable due to the changing conditions in the solar wind, while at lower latitudes, the variation of the ionosphere is mostly dominated by the rotation of the Earth. As the neutral atmospheric density decreases with altitude, the physical process that dominates the ionosphere also changes. At lower altitudes, we have an atmosphere consisting of molecular nitrogen and oxygen, like the air we breathe, while higher up, the lighter atomic oxygen becomes the main constituent.

Collisions between particles depend on the density and, thus, also change with altitude. Therefore, the separation of the ionosphere into several altitude regimes (layers) makes sense. The naming of these layers has historical reasons: the region of highest electric conductivity around 60–90 miles (100–150 km) is called the E-region (E for electricity). The regions above and below just got the next letters of the alphabet: the F-region is higher up, about 120–600 miles (200–1000 km), the D-region is below, about 45–55 miles (70–80 km). As long as the solar FUV and

EUV illuminate the atmosphere, it creates an E- and an F-region. The E-region decays quickly after sunset because of the many collisions, and because the chemistry here is based on molecules of N_2 and O_2. Higher up, collisions become rare, and the chemistry changes to atomic oxygen. This allows the F-region to survive during the night. Aurora is brightest in the E-region and causes a lot of ionization there. Very bright aurora creates secondary X-rays within the E-region, which penetrate a little deeper into the atmosphere and cause ionization in the D-region.

Some space weather events (e.g., solar energetic proton events) have high-energy particles that make it into the D-region and cause extra ionization at that altitude. Aurora also causes ionization in the F-region, depending on the energy of the auroral particles. Because the ionosphere conducts electricity, it can also reflect radio waves. This depends on the frequency of the radio wave. Lower-frequency waves have a long wavelength (e.g., shortwave radio) and get reflected in either the E- or the F-region, while extremely short-wavelength waves (e.g., GPS signals) go through the ionosphere. The reflection of radio waves allows shortwave radio to reach between continents, around the curvature of the Earth. Sometimes,

SOLAR ENERGETIC PROTONS (SEP)

The polar caps of the ionosphere are the areas poleward of the auroral oval in the Northern and Southern Hemispheres. These areas have a nearly vertical magnetic field. The auroral oval marks the approximate boundary in the magnetic field, where field lines either connect to the solar wind or lead back to the other hemisphere. Because of the magnetic field, the polar cap is closely connected to the solar wind. When particularly violent events on the sun inject high-energy protons into the solar wind, these energetic protons can be guided by Earth's magnetic field directly into the polar ionosphere. These protons have enough momentum and energy to penetrate deep into the atmosphere and cause significant ionization in the D-region. Unlike auroral particles, which come down in a sheetlike geometry and affect the ionosphere in localized areas, the energetic protons from a SEP event blanket the entire polar cap. The enhanced ionization in the D-region during these events causes shortwave radio communication to fail in the polar region. The high atmospheric density in the D-region causes a lot of collisions between charged and neutral particles. The charged particles want to move with the frequency of the radio wave, but quickly lose their energy in collisions. The result is strong absorption of HF radio waves. SEPs are space weather events that affect airplane communication for flights that cross the polar region.

Dirk Lummerzheim

the D-region is strong enough to interact with shortwave radio. Since the density at that altitude is much higher than that in the E- or F-region, there are more collisions between the charged particles. This can cause absorption of radio waves and lead to dropouts for long-distance radio communication. Although high-frequency radio waves can pass through the ionosphere, they sometimes get distorted or change the direction of travel slightly. This can affect the accuracy of GPS signals.

There are several methods to make observations of processes in the ionosphere. One expensive possibility is to launch a rocket and make local observations right inside the ionosphere. The electric properties of the ionosphere make it possible to use radio waves, either by transmission to or from a satellite (e.g., GPS) or by reflection in the ionosphere. There are also natural phenomena, like the aurora, that create radio waves. Using a wavelength that is absorbed by the ionosphere, it is possible to deposit energy in a defined location in the ionosphere and have a controlled radio wave experiment. And finally, because the processes that create the ions, either solar radiation or particle precipitation, leave the ions with excess energy, there is a plethora of chemical reactions going on. Some of these cause light emission. Although this light (airglow) is not bright enough to be seen by eye, sensitive optical instruments can observe these emissions and much can be learned from the spectrum and brightness.

Dirk Lummerzheim

See also: Aurora Australis; Aurora Borealis; Auroral Substorm; Geospace; Space Weather

Further Reading

Elkins, T., and C. Rush. A Statistical Predictive Model of the Polar Ionosphere, An Empirical Model of the Polar Ionosphere, T. J. Elkins, Tech. Rep. #AFCRL-TR-73-0331, AD766240, Air Force Cambridge Research Laboratory, Bedford, Mass., 1973: 1–100.

Riddolls, R. *A Canadian Perspective on High-Frequency Over-the-Horizon Radar.* Ottawa: Defense Research and Development Canada, 2006.

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Antarctica and the Arctic Circle

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Antarctica and the Arctic Circle

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Japanese Antarctic Expedition (1910–1912)

The third and least known Antarctic expedition during the Heroic Era of Antarctic Exploration was the Japanese Antarctic Expedition (1910–1912). This expedition was privately funded and also known as the Shirase expedition, after Lieutenant Nobu Shirase, Japanese Imperial Navy. Although it did not have any chance of reaching the Southern Pole, it laid the foundations for later Japanese research efforts in Antarctica and is therefore held in high esteem in the country, with a dedicated museum in Akita Prefecture. The Japanese explorers were forced to spend the winter of 1911 in Australia, and their memory, in particular Shirase's gift of a sword to Professor Edgeworth David (1858–1934), has become a symbol of friendship and reconciliation between these two countries.

The 27-member expedition, none of whom had any polar experience, and its 29 dogs, departed on November 29, 1910, from Tokyo Bay on board the *Kainan-maru* (the *Southern Pioneer*), a 100-ft. long schooner displacing 204 tons and equipped with an 18-HP engine (just one-third the size of Scott's *Terra Nova*). They reached Wellington (New Zealand) on February 8, 1911, and three days later set sail for the Antarctic. Original plans to land in Antarctica in March 1911 (to explore for seven months and dash to the pole) failed due to unfavorable ice conditions, and they avoided being trapped in the ice thanks to the skillful seamanship of Captain Naokichi Nomura. They were forced to spend the winter in the Parsley Bay Reserve, on the shores of Sydney Harbour, which they had reached on May 1, 1911, setting out once more on November 19, 1911. While staying in Sydney, Captain Nomura and the expedition's secretary returned to Japan to raise more funds, coming back after five months and bringing provisions and other equipment.

On their second attempt, they reached Antarctica, and a team of six (including two Ainu dog handlers) led by Shirase climbed the Ross Ice Shelf and under very harsh conditions, using dogs and sledges, set off on a dash for the South Pole. Eight days and 160 miles (257 km) later, they reached 80° 5′S, where the weather and a lack of provisions forced them to turn back, leaving a copper receptacle with a record of their efforts. Meanwhile, the *Kainan-maru* sailed further east than any previous vessel, making the first ever landing in King Edward VII Land, a feat that Scott and Shackleton had unsuccessfully attempted, with a party exploring the lower slopes of the Alexandra Range. Although this was far cry from the original intention to reach the pole, the expedition could nevertheless be considered a reasonable success, in particular if we take into account that it was the first such Japanese endeavor. Furthermore, Shirase managed to bring back home all of his crew, without any casualties. On the minus side, the scientific output was limited. The expedition returned to Japan on June 20, 1912, reaching Yokohama, where a multitude welcomed them. An account of the expedition was published in 1913 under the title "Nankyokuki," which was first translated into English in 2011.

The total cost of the expedition was 125,000 Yen. Only 72,000 were raised from the public and 20,000 from the sale of the *Kainan-maru*, and Shirase had to take the balance, spending the rest of his life trying to pay off this debt. He died in 1946, poor and forgotten.

The expedition was met with mistrust on reaching Sydney. Although relations with the local population were generally good, rumors of espionage soon arose, reflecting long-held suspicions of Asians and the impact of Japan's victories over China (1895) and Russia (1905). Professor Edgeworth David (a famous Antarctic explorer himself, and a member of the first expedition to reach the magnetic south pole) intervened to quell them and provided Shirase with useful information. As a token of gratitude, on returning to Sydney from Antarctica in 1912, Shirase gave him a seventeenth-century samurai sword, currently exhibited at the Australian Museum in Sydney. Beyond its artistic value and historical significance, the sword and more generally the expedition's Australian connection have become a symbol of friendship and postwar reconciliation between the two nations.

LIEUTENANT NOBU SHIRASE (1861–1946)

Lieutenant Nobu Shirase was born in 1861 in Konoura, a village in northwestern Honshu (Japan's biggest island); his father was a Buddhist monk. In 1879, he entered a school for Buddhist priests at Sensoji Temple in Asakusa (Tokyo Prefecture), but since childhood, he had been fascinated with the tales of adventure and exploration, so he quit and entered the army's noncommissioned officers' academy. He got a taste of subarctic exploration in 1883, when he joined a naval expedition to Chishima Island (north of Hokkaido, Japan's northernmost main island). Originally intending to be the first to reach the North Pole, Peary's success turned Shirase's attention to Antarctica, and he started raising funds. The Antarctic Expedition Supporters' Association was set up, with the former Japanese Prime Minister Shigenobu Okuma as president. Although the government voted a 30,000-yen subsidy, this was never actually delivered, and the Japanese Antarctic Expedition (1910–1912) had to rely on donations.

Alex Calvo

The expedition took place at a time when Japan was a junior partner in the world liberal order, working hard to be accepted by the Western powers. One of the reasons for public support for the expedition was the desire to be accepted as an equal by the leading Western powers of that time, something which demanded, among others, proof of first-class scientific activities and the willingness and ability to explore and settle other lands.

Echoes of the expedition in today's Japan can be found in the Shirase Antarctic Expedition Memorial Museum, in 15–3 Aza-iwagata, Kurokawa, Nikaho, Akita Prefecture. It consists of a cone-shaped hall surrounded by a ring, both of reinforced concrete, and is designed to both educate and inspire.

In addition, one of Japan's three icebreakers, and the only one to be managed by the Maritime Self-Defence Forces, is named after Lieutenant Shirase. Furthermore, the west end of the Ross Ice Shelf is known as the Shirase Coast. In 2010, a commemorative program was launched, on the occasion of the 100th anniversary of the expedition, comprising a number of events and the issuing of a 500-yen coin, a 100-yen coin, and different stamps. The possible territorial claims by Japan on Antarctica based on the expedition were formally renounced with the signing of the 1951 San Francisco Peace Treaty.

Alex Calvo

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

Further Reading

Shirase Antarctic Expedition Supporter's Association. *The Japanese South Polar Expedition of 1910–12: A Record of Antarctica. Translated from the Japanese by Lara Dagnell and Hilary Shibata*. Norwich: Erskine Press, 2011.

Wells, P. "Nobu Shirase: The First Japanese Antarctic Explorer." http://www.if-9.de/cmc/cmc_25.htm. Accessed February 11, 2013.

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K

Karakat

A so-called karakat was invented in early 1970s in the city of Severodvinsk (Arkhangelsk region) by a couple of friends, passionate ice-fishermen, aiming to make their travels on the ice safer and faster. The original karakat is based on a motorbike, slightly modified by attaching four inner tubes taken from truck wheels. To prevent overinflation of tubes during pumping, they are bound with straps around the entire circumference. Besides maintaining the inner volume, these straps serve as grousers, that is, prevent wheels from slipping on the snow and ice. Importantly, the pressure of the completed vehicle on the surface does not exceed 0.05 kg per sq. cm. Karakat can travel at an average speed of 12–30 mph (25–50 km/h) and move on the loose snow and off-road landscape, as well as swim. Thus, in case of accident, for example, falling into an ice hole, the vehicle does not sink.

The advantages of this kind of vehicles were as follows:

- Excellent cross-country ability
- High bearing (load) capacity
- Relatively lightweight

The idea of karakat spread quickly across the Russian North, including West and East Siberia. The karakat is still actively used in almost every northern settlement, due to long distances with few roads, resulting in its widespread popularity. Karakats are designed and made of nearly the same reused details of old cars. The open construction of the vehicle allows a great variety of adjustments, according to, first and foremost, environmental conditions of use and, second, to a creator/owner's personality. Thus, despite nearly the same set of available parts, every vehicle is born with its own face, remarkably similar to its creator/owner. For example, the original light construction could not protect its driver from cold and wind, which are the main factors influencing human existence in tundra and taiga areas. It is well known fact that increasing the speed by 1 km per hour leads to decreasing the perceived temperature by 1.5 degrees. This issue forced local inventors to improve the original design by adding the cockpit. First attempt has resulted in a small all-terrain vehicle (in Russian, *snegobolotokhod*, i.e., vehicle for snowy and swampy terrains) called "Nara," based on a Soviet micro car (informally known among people as *invalidka*, i.e., "disabled car").

Another modification of *karakat*, produced in a workshop by Vladimir Rulevich, Arkhangelsk, was so-called Arktika. It had a cockpit made of a fuel tank of a Soviet fighter aircraft MiG-23. The carrying capacity of this machine was equal to its own weight.

A rather recent stage of amateur improvements has led to the creation of an all-wheel-drive vehicle on low-pressure tires with a cabin from a famous Russian car "Lada." One of the main advantages of such a construction is that the driver of this car can easily repair it on his own (i.e., a standard Lada's engine is quite simple and intuitively understandable; also some elements can be replaced with handmade substitutes), while being protected from cold and wind by a heated cabin. This point is critical for users from remote northern regions with extreme weather conditions.

Svetlana Usenyuk

See also: Dogs of the Arctic; Lost Patrol

Further Reading

Miller, D. *Car Cultures.* Oxford: Berg, 2001.

Kara Sea

The Kara Sea is a marginal sea of the Arctic Ocean and is located between the Barents (west) and Laptev (east) Seas. The western sea border is the Kara Strait and the Novaya Zemlya Archipelago (74° N 56° E). The eastern sea border is the Vilkitsky Strait and the Severnaya Zemlya Archipelago (79° 30′N 97° 45′E). The Kara Sea's northern border is the Arctic Cape (81° 13′N 95° 15′E) of Komsomolets Island of the Severnaya Zemlya Islands to the east. The western northern border is Cape Kohlsaat (81° 14′N 65° 10′E) on the eastern side of the Graham Bell Island. The total area of the Kara Sea is about 340,000 square miles (880,000 sq. km). It is about 900 miles (1,450 km) long and 600 miles (970 km) wide. The average depth is about 360 ft. (110 m). The Kara Sea is frozen for nine months of the year.

The Nordenskjold Archipelago is the largest group of islands in the Kara Sea. Within the Nordenskjold Archipelago, the western group of Islands are the Tsivolko Islands (76° 44′N 94° 38′E), the south central are Vilkitsky Islands (76° 25′N 95° 15′E), the middle central are the Pakhtusov Islands (76° 37′N 95° 53′E), the north central are the Litke Islands (76° 49′N 96° 36′E) and Russky Island (77° 3′N 96° 9′E), and the westernmost are the Vostyochnyye Islands (76° 56′N 97° 48′E). There are also a number of islands located in the open waters of the Kara Sea, such as the Arctic Institute Islands (75° 32′N 82° 5′E), Izvesti Tsik Islands (75° 58′N, 82° 21′E), Kerova Islands (77° 36′N 91° 55′E), Uyedineniya Island (77° 29′N 82° 30′E), Vize Island (79° 18′N 76° 32′E), and Voronina Islands (78° 14′N 93° 41′E). Other notable

Iceberg on the Kara Sea. (Shutterstock.com)

islands are Bely Island (73° 15′N 70° 50′E), the Kammennyy Islands (74° 7′N 82° 48′E), Oleni Island (72° 25′N 77° 36′E), and Taymyr Island (76° 12′N 96° 7′E).

Kara Sea's name is derived from the Kara River that flows into the Kara Sea. The three major rivers flowing into the Kara Sea are the Ob, Pechora, and Yenisey Rivers. Other rivers flowing into the Kara Sea are the Pyasina and Taimyra. The major ports are the Dikson (73° 30′N 80° 31′E), the northernmost Russia port, and Novy Port (67° 41′N 72° 53′E) located on the mouth of the Ob River. These ports are frozen in most of the year and generally open only for about two months.

There is radioactive contamination in the Kara Sea. Nuclear waste was dumped on the western and eastern sides of Novaya Zemlya, from 1960 to 1991, in the Barents Sea and Kara Sea, respectively. A significant amount of this high-level radioactive waste was dumped into the shallow fjords of the Kara Sea near the Novaya Zemlya Archipelago. The waste is dumped at a depth of about 33 ft. (10 m) to 440 ft. (135 m). Low-level radioactive liquid waste has also been dumped in the open Barents and Kara Seas. In September 1982, the decommissioned K-27 submarine was sunk off the shore of the Novaya Zemlya Archipelago in the Kara Sea (72° 31′N 55° 30′E). Scientific assessments by the International Atomic Energy Agency claimed that the radioactive contamination per individual of the Kara and Barents Seas ranges from 1 to 20 microsieverts annually.

Andrew J. Hund

See also: Arctic Basin; Arctic Ocean; Barents Sea; Laptev Sea

Further Reading

Mount, M., M. Sheaffer, and D. Abbott. "Kara Sea Radionuclide Inventory from Naval Reactor Disposal." *Journal of Environmental Radioactivity* 25 (1994): 1–19.

Ket

Etymologically, the word *Ket* means "man". Its plural form is *deng*, which denotes men or people. They are Siberian people, and distinguish themselves by their language, which is spoken only by Ket population in the Siberian region. The Ket language is similar to the Na-Dené languages of North America that comes under the Dené-Yeniseian language family. Matthias Castrén, Vasiliy Ivanovich Anuchin, Kai Donner, Hans Findeisen, and Yevgeniya Alekseyevna Alekseyenko are the ethnographers who have closely studied the life and culture of the Kets deng. In Siberia, they are thought to be the descendants of the ancient most nomadic people who have lived across the central-southern part of Siberia. During the Imperial Russian time, Ket were known as the *Ostyaks.* It was rather a collective name without any distinction from other indigenous people in the Arctic Siberian region. Since they found their habitat in the middle and lower basins of the Yenisei River in the Krasnoyarsk Krai district of Russia, they, later on, found a general name "Yenisey ostyaks." In the modern age, the Kets situated themselves along the eastern middle side of Yenisei River and, later, got assimilated politically into Russia in the seventeenth and nineteenth centuries. Some Ket population is also spread along the Kas, Sym, and Dubches Rivers in Siberia. They prefer them calling *jugun.* Keeping pace with the modern-day development, they are seldom nomadic today and live in small villages along the river banks. Interestingly, their population is not increasing since 1923, which is a serious concern as far as the culture is concerned. The data of the 2002 census have shown their population in Russia to be only 1494.

Traditionally, the Ket's livelihood was based on subsistence activities, and they engaged in hunting, fishing, and reindeer husbandry. They were supposed to be associated, culturally and ethnically, with the Yenisey taiga, which had adopted some of the cultural ways of the original Ket-speaking tribes of south Siberia. Kets are also associated with ancient Dingling and Tashtyk people. It is the linguistic link that has brought them closer to the northern Athabaskan indigenous people.

Although the Ket were at times resistant to being incorporated into Russia, by the seventeenth century, they had assimilated, and their traditional lifestyle and worldview faded. During the twentieth century, the Kets collectivized under the Soviet Union. With the implementation of the Soviet government's policy of defining the indigenous population, they were officially declared "Kets" in 1930. Under Soviet Union system, the Kets adopted the Soviet cultural system, and cultural traits were weakened. The Ket culture had the clues of Shamanism till 1930s, which had shown the use of skeleton, bones of the helper animal, and so on. The shamanism of the Kets had certain common traits with the Turkish and Mongol people. They performed the shamanism for curing the diseases and sometimes talking with the spirits.

Ravindra Pratap Singh

See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit; Khanty; Koryak; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Alekseyenko, E. "Categories of Ket Shamans." In Diószegi, Vilmos, and Hoppál, Mihály, eds. *Shamanism in Siberia.* Budapest, Hungary: Akadémiai Kiadó, 1978.

Khanty

The Khanty are the tribal people from Siberia whose origin goes back around 8,000–11,000 years ago in the Priuralic area inhabited by the proto-Uralic tribal people in the Siberian wilderness. The name "Khanty" comes from Komi-Zyrian language, and the word "Khanty" appears for the first time in Russian records as "Yugra," in the eleventh century, with their contact with Russian hunters and merchants. It is conjectured that they were brought to record for the first time by Alfred the Great, the English king in the nineteenth century, who discovered Fenland (wetland) to the east of the White Sea in western Siberia. Traditionally, in Russia, they were known as "Ostyak." They are associated with Finno-Ugric language–based people. Out of the 26 major indigenous tribal groups in Russia, the Khanty people are the most widespread and culturally rich. They associate with many other prime groups like the Nenets, Mansi, and the modern Finns and Hungarians. They believe in the special powers of the forefathers and think that their lineages have been created by the divine ancestors. The ancestors are given greater importance in their social lives, and it is their popular belief that the ancestors have created the system of rivers and nature upon which the majority of the Khanty live. They suppose themselves of one clan, and their families reside in the traditional family hunting territories. They believe in many family spirits who are said to be the offspring of the clan's founding divine ancestors. They have the belief that the topographic and biologic creation significantly affected by the spirits of their forefathers. Khanty have close similarities with the Native Americans. Khanty habitat has a subarctic topography with boreal forest and bog at an elevation of about 80–330 ft. (25–100 m) above sea level. They live in the basin of the

Ob'-Irtysh River system, which is the third largest in the world, and flows to the north. Basically, Khanty are rural people who love to stay in villages—scattered in extended family settlements and encampments. Their economy is based on Taiga hunting, caribou hunting, fishing, and trapping, and gathering berries and selling reindeer and furs.

Khanty culture comprises three distinct Khanty groups, which are the Northern, Southern and Eastern Khanty. These groups can easily be recognized by locating the traces and trajectories in dialect and subsistence patterns along with material culture. As far as their religious belief is concerned, traditionally they were pagan, who associated themselves very close to nature, but many of them have become Orthodox Christians now, which is uniquely shown in practicing shamans and reincarnation mixed with traditional beliefs. In the seventeenth and nineteenth centuries, many forces worked for bringing Christianity in the Khanty habitat, but the Khanty lifestyle did not undergo any real changes. From the latter half of the nineteenth century, they started accepting state laws.

Khanty live their life to the full, and as a part of their culture, they have many occasions for celebration. On the successful hunting of a bear, they perform the Bear Celebration, which may prolong up to five to six days with a repertoire of more than 300 songs and performances in many forms. Interestingly, the celebration prolongs in case the prey is a male animal. Nukh Kiltatty Ar (the Awakening Song), Ily Vukhalty Ar (the Coming Down from the Sky Song), Il Veltatty Ar (the Lullaby), and the Crow cult are the other festive aspects of the Khanty people. Russian intervention in the Khanty habitat in the sixteenth century for furs, gold, and other valuables has started the series of change in their lives, but they remain successful in protecting their traditional customs and ways of life reflected in language history along with accepting certain artifacts of the acquired culture and lifestyle.

Khanty people have realized sweet–sour relationship with Russia. Under the Soviet rule, Khanty people were given autonomy in the form of an *okrug* or an autonomous district, which proved seminal in collectivizing them. With the fall of Stalin, the collectivizing process was relaxed. They faced problems and found their culture endangered by national intervention. During the 1980s, sustainable efforts have started to protect their common territory from industrial expansion for protecting their culture, language, and heritage. Today the Khanty are seminomadic herding people. The strands of the so-called modern civilization and economic imperialism have set their dislocation. Russian indigenous organizations are helping them for making their life sustainable and better. The Khanty population, today, in Siberia records approximately 22,500.

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See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit; Ket; Koryak; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Abondolo, D. "Khanty." In Daniel Abondolo, ed. *The Uralic Languages.* London: Routledge, 1998.

Khatanga, Lena, and Yana Rivers

Most major rivers flowing into the marginal Arctic Seas are found in Russia, with the one exception being the Mackenzie River in Canada and the Colville River in Alaska (smaller compared with the Mackenzie River). The Mackenzie River flows into the Beaufort Sea. In the United States (Alaska), the Colville River flows into the Arctic Ocean. The Russian rivers flowing into the marginal seas and into the Arctic Ocean include the Khatanga, Lena, and Yana Rivers that flow into the Laptev Sea; the Indigirka and Kolyma Rivers that flow into the East Siberian Sea; and the Ob, Pechora, and Yenisey Rivers that flow into the Kara Sea. All these rivers flow generally northward. In general, rivers flow in a southerly direction which is downhill; however, if the source of a river is at a higher elevation, the river will flow in a northerly direction but still downhill. The three major rivers that flow to the Laptev Sea are the Khatanga, Lena, and Yana Rivers.

Khatanga River

The Khatanga River is located in the Krasnoyarsk Krai in Russia (north-central Siberia). The length of the Khatanga River is around 140 miles (227 km). It flows southeast and north to the Khatanga Gulf of the Laptev Sea, forming an estuary. The confluences of the Khatanga River are the Kotuy River to the north and Kheta River to the south. The major tributaries are the Bludnaya, Malaya Balakhnya, Nizhnyaya, Novaya, and Popigay Rivers. During the summer, the Khatanga is navigable, but freezes over in late September to early October until it thaws in June (called "breakup"). The watershed of the Khatanga is approximately 140,000 square miles (364,000 sq. km) and includes more than 100,000 lakes. The average water discharge of the Khatanga is 117,244 cubic feet per sec (ft^3/s) (3,320 cubic meters per second [m^3/s]). The Khatanga was first noted by Russian fur traders, around 1611. The first human settlement on Khatanga River was the town of Khatanga (71° 58′N 102° 28′E) with a population of around 3,400. Common game fish in the Khatanga are white fish (Baikal omul, *Coregonus albula*, and muksun) and salmon (silver and Siberian).

Lena River

The Lena River is the largest river in the Laptev Sea basin and the second largest river in Russia. The Lena starts out as a tiny spring in the Baikal Mountains, grows into a massive river, and then becomes a delta before emptying into the Laptev Sea.

The journey of the Lena is 2,700 miles (4,400 km) long making it the 11th longest river in the world. The entire Lena watershed is completely within the Russian territory. The course of the Lena starts in the Baikal Mountains and flows northeast. The Kirenga, Vitim, and Olyokma Rivers join the Lena on its travel to the Laptev Sea. At the town of Yakutsk (62° 2′N 129° 44′E), the population is around 270,000; the Lena flows north across the lowlands. Then, the Lena is joined by its second-longest tributary, the Aldan River. The Lena travels northwest and is joined by its largest tributary, the Vilyuy River, and then heads north. Before emptying into the Laptev Sea, the Lena River forms a 12,350-square-mile (32,000-sq.-km) delta that is traversed by seven major branches of the river. The three main outlets are the Trofimov (accounting for almost three-fourths of the water flow) and the Olenek and Bykov. The average water discharge of the Lena is 600,349 ft^3/s (17,000 m^3/s).

LENA DELTA WILDLIFE RESERVE

Established in 1985, the Lena Delta Wildlife Reserve (Ust'-Lenskii Nature Reserve) is the largest scientific nature reserve in Russia with a total land area of 23,552 square miles (61,000 sq. km). The Lena Delta is one of the earth's largest deltas encompassing about 12,000 square miles (30,000 sq. km). The delta is bordered to the southwest by the Chekanovskogo mountain range and the Kharaulakh mountain range to the southeast. The delta has thousands of lakes, channels, and islands. The main outlet is the Trofimov, which accounts for 70 percent of water flow to the Laptev Sea. The Lena Delta Wildlife Reserve average winter temperature is about –32.8° F (–36° C), while summer temperatures average around 37° F (2.8° C). Yearly, precipitation is around 6.7 inches (17 cm) in the northern part of the delta and 7.8 inches (20 cm) annually in the southern part.

For around seven months a year, the delta is frozen. In May, the delta is transformed into a wetland and becomes an important breeding ground and nursery for wildlife. The amount of precipitation contributes to a diverse flora population of more than 400 vascular plant species, more than 150 aquatic plant types, more than 200 lichen species, and more than 100 mosses. Year-round residents of the delta are Arctic fox, snowy owls, polar bear, tundra hare, ptarmigan (rock and willow), and tundra vole. In the summer, the delta teems with wildlife, such as 30 mammal species (lemmings (collared and Siberian), reindeer, wolves, bighorn sheep, musk oxen, and so on). There are more than 100 bird species, such as loons (red-throated and black-throated), swan (Bevick's), gulls (Ross and Sabine), Eiders (King and

Steller), and various waterfall (Northern pintail and long-tailed duck). Marine mammals have been known to swim and feed in the larger channels, such as beluga whales and seals (bearded and ringed). Fish species number more than 30 and include Arctic char, Arctic lamprey, burbot, common roach, grayling, sheefish, and Siberian salmon.

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The Lena Delta is the largest protected area in the Russian Federation called the "Lena Delta Wildlife Reserve." The Lena Delta forms thousands of lakes, channels, and islands. For around seven months a year, the delta is frozen. In May, the delta is transformed into a wetland. The first Russians to reach the Lena River were in the 1620s. It is not certain who was the first explorer to travel the Lena River: it could be Demid Pyanda in 1623, Bazhen Kokoulin in 1626, Martemyan Vasilyev in 1627–1628, or Vasily Bugor in 1628. The first human settlement Yakutsk was founded in 1623. In 1633, the Lena delta was explored.

Yana River

The Yana River is located between the Lena River (west) and the Indigirka (east) in the Sakha Republic (Yakutia) in Russia. Its length is around 540 miles (872 km) and flows into the Yana Bay of the Laptev Sea, forming a delta. The confluences of the Yana are the Dulgalakh and Sartang Rivers. The major tributaries are the Abyrabyt, Adycha, Bytantay, and Oldzho Rivers, most of which originate high in the Verkhoyansk Mountains. The Yana freezes over in late September to early October then thaws in late May and becomes is navigable. The average water discharge of the Yana River is 34,396 ft^3/s (974 m^3/s).

Before emptying into the Laptev Sea, the Yana River forms a 3,938-square-mile (10,200-sq.-km) wetland. East of the mouth of the Yana is Yarok Island, which is dotted with small lakes and swamps. Yarok Island is 23 miles (38 km) long and 16 miles (26 km) wide. During the winter, the Yana Bay freezes over, resulting in the Yarok Island merging with the mainland.

Continuous permafrost exists under the Yana basin, which is almost 92,000 square miles (238,000 sq. km). The Yana basin has about 40,000 lakes. The Yana basin in the upper region of the Yana River is the pole of cold, which is the place with the lowest recorded air temperatures in the Northern Hemisphere. The average January temperature is −50°F (−58°C).

The Yana River was first noted by Russian explorers Ilya Perfilyev and Ivan Ivanovich Rebrov (unknown to 1666) around 1633. Based on artifact finds, the Yana River region dates back to 30,000 years ago, making it the oldest human habitation location in the Arctic. The first geological survey of the Yana basin was in 1892–1894 under the leadership of Eduard Gustav von Toll (1858–1902).

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See also: Colville River; Indigirka and Kolyma Rivers; Mackenzie River; Ob, Pechora, and Yenisey Rivers; Yukon River

Further Reading

Armstrong, Terence. *Russian Settlement in the North.* Cambridge: Cambridge University Press, 2010.

Lantzeff, G., and R. Pierce. *Eastward to Empire: Exploration and Conquest on the Russian Open Frontier, to 1750.* Montreal: McGill-Queen's University Press, 1973.

King Penguin

The king penguin is the second largest penguin, with the emperor penguin being the biggest. It is distributed throughout northern parts of Antarctic. Two subspecies exist with wider morphometrical and geographic differences: *Aptenodytes patagonicus patagonicus* and *A. p. halli.*

King penguins and chicks. (National Oceanic and Atmospheric Administration)

This colorful penguin feeds less on krill than the other penguin species. It preys primarily on smaller fish (lantern fish) and squids. None of the penguin species can fly. On land, king penguins walk or slide for longer sections. But penguins can swim very well, and king penguins were found to dive about 330 ft. (100 m) deep, with a record depth of almost 1,000 ft. (300 m) (the depth probably relates mostly to the location of food sources). The study of diving depth recorders developed early on using this species (1970s by G. Kooyman). Such details matter because they help to define part of the ecological niche for this species and which environment is now generally stressed and changing due to human and other impacts.

This species is found breeding on islands throughout the subantarctic, as

King penguins. (Shutterstock.com)

well as on Falkland and Tierra del Fuego. Some large breeding hot spots are found, such as Crozet Island, Prince Edward Islands, Kerguelen Islands, South Georgia Islands, and Macquarie Island with huge breeding colonies (e.g., 100,000 breeding pairs). The nesting habitat is located just at a relatively narrow band on the coast. The breeding period of this species takes up to 16 months, starting in September. Early and late breeders are encountered. The breeding cycle of king penguins is unusually long for birds, and thus colony locations are found to be occupied throughout the entire year. Many of these sites have an archeological track record.

Birds start breeding from the age of three years onward and usually have successful nesting attempts every second or third year. These birds are classified as being serially monogamous, and genetic studies offer much information, for instance, regarding mating behavior and kinship. Penguins forage approximately 30 miles (50 km) around their colony site and have nesting shifts. The egg is balanced on the feet and in a pouch. Once chicks have left the nest, they form crèches (many chicks guarded by an auntie). The timing of breeding, fledging, departure, and molting appears to be optimized and adjusted for the seasonal ocean conditions of Antarctica.

Apart from breeding, nonbreeders form a large and very relevant part of the penguin population. They are equally or more significant for the population than just the breeders; they are found in a much wider ocean habitat with large movements.

While the exact behavior details are not so well known yet for penguins, it can be assumed that higher-order complexities are at work, for example, individual recognition, social networks, pelagic adjustments, and individualism (some of these traits are presumably very sophisticated and shared with species like in the primate and marine mammal world).

Penguins are preyed on by many species such as leopard seals, orcas, and skuas and sheathbills (e.g., for eggs and chicks). However, they can reach a relatively high life expectancy. In the wild, king penguins can live from 15 to 20 years and up to 30 years in captivity. It should be noted that general marking of penguins, such as the use of flipper bands and geo-recorders, can affect birds' behavior and foraging abilities and thus could produce flawed estimates.

Penguins are a charismatic species and are widely used as flagship species and icons in movies, as well as synonyms and symbols of the wild and polar regions. They were also introduced to northern Norway in the 1940s but without apparent success. Several zoos keep king penguins on display, and good museums usually hold a bagged specimen.

Penguin species provide us with relevant information when it comes to evolutionary questions, as well as climate sentinels, and as indicator species in remote oceans and for fisheries. Penguins are currently facing historic declines, and more than 10 of the 18 penguin species are already of serious conservation concern. Antarctica is not pristine anymore. It is not free of an intense international and commercial fisheries effort and of overfishing; trophic cascades occur all the way down to the smaller food chain (which then affect penguins and their prey). While the current king penguin populations appear to be stable and are reported to increase (up to 3.5 million breeding pairs), their habitats and ecosystems underlay major stressors and already cause major concern on a global level. Penguin conservation is therefore a major topic for many managers and policy makers (oil spills are virtually impossible to resolve in such remote and extreme waters where penguins occur). This topic matters even more for the Antarctic Treaty. This international legislation basically handles the Antarctic continent as a protected global national park for the wider public good and peace of mankind. However, it widely fails to effectively address marine, even coastal and atmospheric issues yet. For over a century, Antarctica has already experienced a huge history of overuse (e.g., marine mammals harvested to commercial extinction, abuse of the atmosphere), and more is currently ongoing, for example, tourism and fishing (see alone for Patagonian toothfish and whale and plankton harvest done by Norway and Japan supported by investment banking and strategic interest). Man-made climate change will also remain to be among the major force of destruction. Further, mining is on the horizon, and the international pressure and global demand for resources are increasing, too.

According to the Antarctic Treaty of 1950s, all scientific data with their metadata are to be fully shared with the public and researchers for the wider good. However, this has rarely happened yet, and certainly not for king penguin and similar species and management. This basically creates violations of the Antarctic Treaty concept and scientific conduct, for example, in the International Polar Years, with the National Science Foundation, National Academies, and the International Council of Science: data repositories remain widely empty or underused, and no efficient enforcement, policing, or penalties really exists to change it. Most nations, projects, and investigators remain guilty here by having widely ignored those subjects to share and to deliver meaningful and documented research raw data to the public for decades, for example, Alfred Wegener Institute, Convention for the Conservation of Antarctic Marine Living Resources, Tagging of Pacific Predators, Movebank, most NGOs, and many research cruises and their vessels (either data are missing or are not freely available without passwords, contracts, etc.). The SCAR-MARBIN (Marine Biodiversity Information Network), the Ocean Biogeographic Information System, and the Global Biodiversity Information Facility have set a good Antarctic example by sharing king penguin data publicly. The data can be modeled and utilized for better management of king penguins and their ecosystem.

Falk Huettmann

See also: Adélie Penguin; Chinstrap Penguin; Emperor Penguin; Gentoo Penguin; Macaroni Penguin; Rockhopper Penguin

Further Reading

De Broyer, C., P. Koubbi, B. Danis, B. David, S. Grant, H. Griffiths, J. Gutt, et al. "Biogeographic Atlas of the Southern Ocean. SCAR and ANTABIF." June 2013. http://conference.antarctica.gov.au/program/posters/posters/the-caml-scar-marbin-biogeographic-atlas-of-the-southern-ocean. Accessed January 10, 2014.

Williams, T. *The Penguins.* Oxford: Oxford University Press, 1995.

King Sejong Antarctic Station

The King Sejong Antarctic Station is a research station for Korea Antarctic Research Program of South Korea. It is in King George Island of the South Shetland Islands (62° 2′S 58° 21′W) about 75 miles (120 km) off the coast of Antarctica in the Southern Ocean. The King Sejong station consists of 11 facility buildings including a main operating office, a research building, an accommodation for researchers and workers, a warehouse for devices and machines, a developing center, observatories, and a gymnasium that about 35 people can stay and work together. The King George Island is the largest of the South Shetland Islands and the staging area to the Antarctica. Because of its relatively mild weather condition, there are 12 research stations from Argentina, Russia, Chile, Uruguay, Brazil, Poland, United States, Germany, Czech Republic, Peru, China, and South Korea.

The station is named after Sejong the Great in Chosun Dynasty, the last dynasty of Korea. He was the fourth king of the Chosun Dynasty, who led Korea into a golden age in terms of agriculture, economy, geography, music, science, military technology, and literacy. Among his contributions, the invention of the Korean alphabets called "Hangul" in 1446 is considered to be the best till today. Also, he developed effective farming methods with advancements in technologies such as water clocks, armillary spheres, sundials, and the world's first rain gauge called "Chukwoogi."

South Korea began exploring Antarctica by investigating krill in the Antarctic Ocean in 1978 and 1979. In November 1986, South Korea became the 33rd member who signed on Antarctic Treaty. In the following year, Korea Polar Research Institute was established in Antarctica as a part of Korea Ocean Research and Development Institute. Then, the King Sejong station was completed in February 17, 1988, and the first Korean Antarctic Research Team composed of summer and winter teams was sent to the station till 1989. The research teams studied submarine topography, benthos, stratum prospecting, marine organisms, lipid and rock samples, and distribution of animals and plants. The research outcomes and capability were internationally well acclaimed. As a result, South Korea was accepted to Antarctic Treaty Consultative Party in October 1989, which enables South Korea to do dynamic research on Antarctica, and obtained a full membership of Scientific Committee Antarctic Research in July 1990, which manages all scientific research activities in Antarctica. Since then, the station has been dedicated to study environmental monitoring, geodesy/mapping, geomagnetic observations (since 1989), glaciology—sea ice zone (since 1998), ionospheric or auroral observations (since 1989), lower/upper atmospheric science, meteorological observations, oceanography, offshore marine biology, onshore geology/geophysics, seismology, stratospheric ozone monitoring (since 1998), terrestrial biology, tide measurement, and so on. In the station, usually 15 researchers from government bodies, research centers, and universities constantly stay and work on various projects.

In February 2014, South Korea opened its second Antarctic research station called the "Jang Bogo Antarctic Research Station," which is named after an eighth-century maritime ruler of Korea. It is an inland Antarctic research station in Terra Nova Bay in the Antarctica. With the completion of the research station South Korea is the ninth country to have more than two research stations in Antarctica.

Sehjeong Kim

See also: Antarctic Programs and Research Stations/Bases

Further Reading

King Sejong Antarctic Station. http://eng.kopri.re.kr/home_e/contents/e_3110000/view.cms. Accessed January 10, 2014.

Klënova, Mariya Vasilevna (1898–1976)

Mariya Vasilevna Klënova was a marine geologist and mineralogist and one of the first women to play a leading professional role in polar science. She joined her first Arctic cruise on the now legendary research vessel *Persey* in 1925, while still a postgraduate at the University of Moscow. During the next six years, she served as the geologist on *Persey* for 10 cruises, one of which she directed herself in 1929. In 1932, she began working on the *Knipovich* in the Barents Sea and other Arctic waters; in 1933, she directed the cruise. Well before any women took part in oceanographic cruises elsewhere, therefore, Klënova had directed two of them. From the 1930s onward, she contributed both data and methodology for more than 150 seafloor maps of the Barents, White, Caspian, and other seas, thereby playing a major role in the establishment of marine geology as a separate academic discipline.

During the Great Patriotic War, Klënova was employed by the Soviet Navy as a mapmaker and lecturer. Between 1948 and 1975, she published several books and monographs on marine geology. In 1955, however, she returned to the field as a member of the first Soviet Antarctic Expedition, in preparation for the International Geophysical Year. Working from the icebreaker *Ob'*, Klënova became the first woman to work as a professional scientist in Antarctica. (Three more female scientists took part in the second Antarctic cruise of the *Ob'*, from 1956 to 1957.) Klënova continued to take part in research cruises, including a visit to the Soviet Arctic drift station *North Pole 4*, until 1972.

Robert Ion Pierson (Rip) Bulkeley

See also: Amundsen, Roald Engebrecht Gravning (1872–1928); Barents Sea; Lazarev, Mikhail Petrovich (1788–1851)

Further Reading

Klenova, M. V. *Geology of the Sea* (in Russian). Akad. Nauk. Moscow: Uchpedgiz, 1948.

"Mariya Klenova." http://english.turkcebilgi.com/Mariya+Klenova. Accessed January 13, 2014.

Kolyma River. *See* Indigirka and Kolyma Rivers

Koryak

The Koryak are one of the indigenous ethnic groups of Kamchatka (Kamchatskiy Kray) in the Russian Far East. Most of the 8,000 Koryak live in Northern Kamchatka. The different Koryak dialects and languages are classified as Paleo-Siberian languages; the closest related language is Chukchi. The ethnonym "Koryak" encompasses various groups that may differ significantly in language, dialect, and traditional lifestyle.

Traditionally, the Koryak are divided into several different ethnic subgroups, which were defined by the characteristic subsistence activity and also by peculiarities in their dialect/language and material culture. For the people's ethnic identity, the understanding of this classification exists until today; however, very few people still pursue the economic activity this division is based on. These former reindeer herders and nomads have lost their animals and as a result have become sedentary. Nevertheless, they refer to themselves as reindeer Koryak: *Chavchuven.*

Chavchuvens were mainly nomads who had herds with up to 10,000 reindeer. Those who lived in several local groups in settlements along the shore or rivers are called the "maritime" or "sedentary Koryak" (*Nymylans*). The *Nymylans* harvested salmon and sea mammals. The division of economic activity was, however, not rigid: maritime reindeer might own reindeer, too, and some reindeer Koryak went fishing in summer or lost their reindeer and became sedentary. Gathering berries, roots, and other plant parts played an important role for all groups.

The different groups of sedentary Koryak have all distinct dialects. One of them shows so many differences from others that it has been recognized as an own language a few years ago: Alyutor. Today, only very few young people in Northern Kamchatka understand or are able to speak their native language. The main language is Russian. Nevertheless, there is a considerable group of young people who engage in actively living and preserving their culture.

During Soviet times, it was quite common that people were forcedly resettled several times in their lives. In the early years of the Soviet Union, reindeer herders were expropriated, and the herds became state owned. Instead of a family living with their animals, workers spend shifts out in tundra looking after the animals. Children were sent to boarding schools where they were oftentimes forbidden to speak their native language. This situation lead to a rift between the generations: the children couldn't understand their grandparents anymore. The parents, in turn, had little possibilities to teach their children their culture and traditional way of life. This way, language skill and traditions got lost as well as the knowledge about how to live in and off the land.

The perestroika was an important event for all ethnic groups of the former Soviet Union: it was accompanied by a rising of national movements and indigenous revitalization within the disintegrating Soviet Union. The hopes for a self-determined and prosperous future in the Koryak Autonomous Okrug were starkly disappointed, as in many other regions. This struggle was overshadowed by an economic crisis and new power structures that gained strength in the young Russian Federation. The Koryak Autonomous ceased to exist in 2007 when it was merged into the Kamchatskiy Kray.

Because of skyrocketing transportation costs and economic hardship in rural areas, traditional and modern subsistence practices still play a major role in the lives of oftentimes highly remote places in Kamchatka. In public, Koryak culture is displayed by traditional dance ensembles, some of which are famous far beyond Kamchatka. Another event displaying Kamchatkan indigenous and Koryak culture is the annual sled dog race Beringia.

Lisa Strecker

See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit; Ket; Khanty; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Jochelson, W. *The Koryak.* New York: AMS Press, 1975.

King, A. "Koryak Autonomous Okrug." In Josh Newell, ed. *The Russian Far East: A Reference Guide for Conservation and Development.* McKinleyville, CA: Daniel and Daniel, 204, pp. 313–18.

King, A. *Living with Koryak Traditions: Playing with Culture in Siberia.* Lincoln: University of Nebraska Press, 2011.

Kosterkin, Tubyaku (1921–1989)

Tubyaku Kosterkin (1921–1989) is considered to be the last great Nganasan shaman. Tubyaku lived on the tundra of the Arctic and spent his time hunting, fishing, reindeer herding, and being a shaman. Under the Union of Soviet Socialist Republic or the Soviet Union, shamanism was forbidden and illegal. In the late 1940s, the Soviet government sought to eliminate shamanism in Taimyr, and Tubyaku was incarcerated for practicing shamanism. Tubyaku was released in the 1950s and continued to practice shamanism.

Family Background

Tubyaku's father, Dyukhade Kosterkin, was a well-known shaman after Russian ethnologist Andrei Popov published the book titled *Tavgitsy* in 1936. This book highlighted the Nganasan culture and Nganasan shamanism. Dyukhade gained significant notoriety for his knowledge of shamanism among the Nganasan, especially the seven-day clean tent rite of passage for shamans, which is important to modern researchers and scholars. However, Dyukhade Kosterkin was not the first shaman in the Kosterkin family tree. According to oral history, shamans ran in the Kosterkin family for many generations. There are two stories as to the origin of the shamanistic gifts within the Kosterkin linage. The first is about Neiming and her white skinned blue-eyed son Lambie "the eagle," and the alternative story is about a wolf-tailed shaman, which has at least two different oral histories as noted by Popov and Gracheva.

The first history is the story of Neiming. The first shaman was noted to have been an ancient shaman who survived a great epidemic with his children. The son of this shaman begot a son, who begot a daughter named "Neiming." Neiming produced a son who had white skin and blue eyes. She named this white child "Lambie," which means eagle. Neiming claimed his father was an "eagle god." The family moved away from the village and lived in isolation. Lambie became a powerful shaman and was said to be able to become invisible. Some scholars argue that Neiming was who the family got the shamanistic gift, while others hold it was her grandfather.

Tubyaku Kosterkin's brother and sister were also shamans. Demnime Kosterkin (1926–1980), Tubyaku's brother, Boriss Kosterkin, was a shaman. Dyukhade's (Tubyaku's sister) daughter was named Nobupti'e and was reported to be a powerful shaman with a helping spirit named "Barusi." Barusi was characterized as a one-eyed, one-armed, and one-legged evil spirit. Few villagers sought Nobupti'e's aid because her guide was considered a malevolent or evil. Villagers told Gracheva that Nobupti'e had a child with Barusi.

Tubyaku History

Prior to Tubyaku birth, all sons of Dyukhade had died during either pregnancy or infancy. Dyukhade had three wives, and when the first wife was again pregnant, Dyukhade predicted that she would produce a boy who would open the way for the subsequent boys to be born. This boy was Tubyaku. From his birth, Tubyaku was considered special and was born with a mole on his back that resembled a button. After Tubyaku's birth, Dyukhade's prediction came true, and Dyukhade's wives born him several additional sons.

At the age of seven or eight, Tubyaku had a dream in which a girl led him to a faceless woman. The faceless woman gave Tubyaku his first helping spirit, a female reindeer. This was Tubyaku's journey into shamanism. His dominant helping spirit was an eight-legged bull reindeer named "Hotarie." Hotarie was also known as the Water-Stag, the Water-Eagle, the Nail of the Earth, and the Private Enterpriser. Tubyaku accumulated several helping spirits after he went through the clean tent rites. During these clean tent rites, Tubyaku acquired helping spirits such as an iron horse called "Mikulushka" (provided by the Westerly God), an iron reindeer (provided by the 10th God), a hornless reindeer (provided by the Frosty God), a water-girl (provided by the Mistress of Water), seven sun girls (provided by the Mistress of Sun), and seven women with dogs (provided by Smallpox God). Mikulushka was symbolic of the Soviet power. In addition to the helping spirits, Tubyaku also had Hositala spirits or special informers. These were Seimybtymy (a spirit with no eyes but saw everything), Koubtumu (a spirit without ears but could hear everything), and Nganabtumu (a spirit that had no mouth but talked to Tubyaku everything). Tubyaku also had many helping animal spirits, such as a polar bear, mouse, female wolf with seven cubs, a dog with seven tails, an ermine, and a brown bear to name only a few. Tubyaku could summon, through either song or melody, his different helping spirits to help in his time of need or help others. To summon the helping spirits, the most shaman of Siberia had headgear with a fringe, special ties for blindfolding to block out the light. Séances took place in the dark or lowlight places.

In the later part of his life, Tubyaku no longer used his informers, or helping and animal spirits. He no longer had a drum or a shaman costume with the headdress cover for journeys into the spirit world. The only helping spirits he kept with him were Hotarie and Mikulushka. In 1989, researchers Helimski, Sheikin, Dobzhanskaya, Ojamaa, and Lintrop visited Tubyaku in his village (e.g., Ust-Avam). They recorded two short shaman séances with the help of his daughter Nadezhda Kosterkina. The séances were translated into text by E. Helimski and published in *Taimyrskij etnolingvisticheskij sbornik* (Moscow 1994).

Andrew J. Hund

See also: Evenks; Nganasan

Further Reading

Forsyth, J. *A History of the Peoples of Siberia: Russia's North Asian Colony 1581–1990*. Cambridge; New York: Cambridge University Press, 1992.

Gracheva, G. *Shamany unganasan. Problemy istorii obshchestvennogo soznania aborigenov Sibiri.* Leningrad, 1981, pp. 69–89.

Popov, A. *The Nganasan: The Material Culture of the Tavgi Samoyeds.* Bloomington, *Indiana*. Indiana University Publications, 1962.

Kotzebue, Otto von (1787–1846)

Otto von Kotzebue was a Russian explorer who, in two separate expeditions, circumnavigated the globe and explored the Pacific. Otto von Kotzebue, born on December 30, 1787, in Revel (now Tallin) in Estonia, was the son of August von Kotzebue, a very successful German playwright at the time. Otto was educated at St. Petersburg school of cadets. In 1803, he was serving as a cadet on the *Nadezhda*, which was commanded by Commodore Adam Johann Ritter von Krusenstern (1770–1846), who was the first Russian to lead a voyage circumnavigating the globe. Kotzebue's voyage with Krusenstern in the Baltics lasted three years wherein he impressed Krusenstern with his astronomical observational and trigonometry skills; both needed to be a good navigator.

One of the goals of eighteenth-century explorers was to try to find a water passage in the subarctic that was navigable across the North American continent. If found, this route would make the journey from Europe to the Pacific much shorter and less dangerous than going around the tip of South America. This route became known as the Northwest Passage. Explorers such as James Cook and George Vancouver searched for such a passage but did not find one. Russian nobleman and statesman Nikolai Petrovich Rumianstev (also spelled Romanzov) was determined to find the passage. He financed an expedition to search for it and ascertain if Siberia and America were joined or separate. Impressed with von Kotzebue's enthusiasm, qualifications, and knowledge upon meeting him together with a recommendation from Commodore Krusenster, Rumianstev commissioned Kotzebue, now a lieutenant in the Russian Navy, to lead the expedition. Hailed as the voyage of discovery, the route would cross the little known South Seas twice in opposite directions and navigate up the little known coast of North America north of the Bering Straits.

Count Rumianstev christened the Russian Navy brig (a two-masted vessel square-rigged on both masts) *Runik* or *Ryurik.* The small 180-ton ship with a crew of 20 was designed for the voyage of discovery as it could sail nearer to shore and examine it more accurately than possible on a larger vessel. It was equipped with astronomical and physical instruments and an extensive map collection. She carried surgical instruments, medicines, spices, clothing, a safety boat, and a stock of food stored in a new invention, tinned meat, vegetables, soup, and milk. This new way of storing fresh food in smaller space was hailed as the greatest use to navigators. The ship also carried a physician, two naturalists who collected plant samples where they landed, and the famous painter, Ludovic Choris, who drew South Sea islanders and North American Indians during voyage, leaving a wealth of information about the social life of those he drew in detail.

On July 30, 1815, the *Runik* set sail from Kronshtadt, a port on the small island of Kotlin in the Gulf of Finland and commercial harbor of St. Petersburg until the 1880s. *Runik* sailed to Copenhagen and onto Plymouth to prepare for the long voyage. She then sailed to the Canary Islands, Cape Verde Islands, and onto the coast of Brazil, around Cape Horn to Talcahuano Chile where it reprovisioned. From there out, he sailed into the Pacific stopping at Easter Island and then onto Petropavlovsk on the Kamchatka Peninsula. From there, he entered Bering Strait, charted much of the coast of Alaska, and discovered Kotzebue Sound, what he thought at first might be the Northwest Passage. Kotzebue notes in his book that:

> I certainly hope that this sound may lead to important discoveries next year, and through a north-east passage, many not with certainty be depended upon, yet I believe I shall be able to penetrate much further to east, as the land has very deep indentures.

He wrote that government should emulate what the Hudson's Bay Company had done in the East by establishing several settlements on the coast of the Bering Straits to the North.

Kotzebue sailed back to San Francisco Bay, onto Sandwich Islands (Hawaii), then to the Marshall Islands, where he discovered small chain of atoll islands. The ship headed for Kamchatka and Alaska again, but they were forced to Unalaska in the Aleutians after suffering damage from a severe storm. Kotzebue fell ill and was forced to head home and abandon his search for the Northwest Passage. On his return trip, he stopped in the Sandwich Islands and Ratak, Guam, and Manila, where the ship was repaired again, then onward to Cape Town, Portsmouth, Reval, Kronshtadt, and arrived in St. Petersburg on August 3, 1818. Although he failed to find the Northwest Passage, the voyage was noted as important to advances made in natural history, natural philosophy, and navigation. He did discover some islands in the Marshall's previously unknown in Europe and did explore the country beyond the Bering Strait. In 1821, he published a three-volume account of the expedition. These make for fascinating reading as there are detailed ethnographic accounts about the native people he encountered, flora, fauna, and geography.

Czar Alexander I then appointed Captain Kotzebue of the Imperial Navy to set sail on the *Predpriate* with a crew of 144 to undertake a further scientific expedition, take cargo to Kamchatka, and sail to America to protect the Russian American Company from foreign smugglers. Kotzebue set sail from Kronshtadt on July 28, 1823, headed for some months in the Pacific before heading to New Archangel (now known as Sitka) in Alaska to preside over the affairs of the Russian American Company between March and August 1825. He returned to Kronshtadt three years later on July 10, 1826. During this voyage, he discovered new islands in the Society and Marshall groups and added to Russian's knowledge of the Pacific. Little is known about Kotzebue's later life. He passed on February 15, 1846, in Revel.

Leslie McCartney

See also: Bering, Vitus Jonassen (1681–1741); Bransfield, Edward (1785–1852); Cook, James (1728–1779); Cook, James, Voyages of

Further Reading

Von Chamisso, Adelbert. *A Voyage around the World with the Romanzov Exploring Expedition in the Years 1815–1818 in the Brig* Runk, *Captain Otto von Kotzebue.* Translated and edited by Henry Kratz. Honolulu: University of Hawaii Press, 1986.

Von Kotzebue, Otto. *A Voyage of Discovery into the South Sea and Beering's Straits.* Amsterdam: N. Israel, 1967.

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Lake Vostok

Lake Vostok (77° 30′S 106° E) is the largest subglacial lake in Antarctica. For the first time, the hypothesis about a possible existence of lakes beneath the thick continental ice sheets was suggested in the second part of the nineteenth century by the Russian geographer Peter Kropotkin (1842–1921). In the mid-1960s, the known Russian glaciologist Igor Zotikov has theoretically calculated the necessary pressure values at the bottom glacial surface at which the ice melting conditions are created. Water thus formed, being uncompressible, can accumulate in bedrock hollows under the glacial body producing freshwater lakes. In the summer season 1959–1960, during seismic ice thickness measurements in the Soviet Vostok station area, the Russian geographer Andrey Petrovich Kapitsa (1931–2011) found a pronounced uniform layer several hundred meters thick under the bottom ice sheet surface, which was interpreted at that time as loose sedimentary rocks.

In the 1970–1980s, the British and Soviet geophysicists arranged a series of inland research aircraft flights with the aim of determining the ice sheet thickness by methods of radio-echo sounding. On some short flight track lines including the Vostok station area, the reflected radio-echo signal typical of bedrock was sharply changing its pattern, corresponding to reflection from the water surface. However, at that time, that fact was in no way connected with the presence of subglacial lakes.

In the early 1990s, an analysis of high-precision altimetry measurements of the underlying surface of central East Antarctica from ERS-1 satellite showed the presence of an enormous relatively flat plain to the north of Vostok station. A comparison of the collected ground-based seismic, airborne radar, satellite, and altimeter data in different years allowed the international team of scientists from Russia, Great Britain, and the United States to make a presentation at the open conference of the Scientific Committee on Antarctic Research held in Rome in the summer of 1994 about the existence of a large subglacial lake in the area of the Soviet Antarctic Vostok station. In 1995, same authors published their first article about this unique natural phenomenon in the British scientific Journal *Nature*. They proposed to call the lake by the name of the Russian Vostok station beneath which it is located. Most investigators believe this lake to be formed due to melting processes at the glacier foot; however, Zotikov suggested a hypothesis about the origin of this lake in the epoch preceding glaciation of Antarctica (i.e., more than 30–40 mya).

No additional evidence about the lake was available to the scientific community by that time, so from the summer season of 1995–1996, the Russian Antarctic Expedition began regular annual geophysical (seismic, ground radio-echo sounding) studies of Lake Vostok. The aim was to determine the spatial distribution of the ice sheet thickness, water layer and sedimentary rocks over the entire lake area, and its coastline configuration. This work was finished at the beginning of 2008. At present, more than 300 subglacial lakes were discovered in Antarctica using methods of airborne radio-echo sounding and satellite altimetry; the Lake Vostok however is the largest and most studied of all similar lakes.

In 1969, Soviet specialists began deep ice drilling at Vostok station aiming to perform paleoclimatic reconstructions based on the ice core data. In 1990, drilling of the fifth by count deep borehole was started. In January 1998, when its depth reached a mark of more than 10,000 ft. (3,623 m), drilling was stopped by the demand of Antarctic community, as according to seismic and radio-echo sounding measurements, the ice thickness under the borehole was 3750±20 m. The scientific community was concerned about a possible adverse impact of the drilling fluid consisting of a mixture of kerosene and Freon on relict lake waters at the moment of drill penetration into it. At the same time, the penetration to the lake through this ice borehole was the shortest and relatively cheap way of lake water sampling. The isotopic analysis of the ice core drilled showed that from the depth of more than 11,500 ft. (3,535 m), ice of atmospheric origin was replaced by ice formed of frozen water. Using methods of molecular biology in this lake ice, three DNA molecules of thermophilic bacteria inhabiting water with a temperature of more than +60°C were isolated. This fact has indirectly showed a possibility of existence of geothermal fluxes at the bottom of Lake Vostok. The ecologically clean technology of penetration to Lake Vostok through this deep borehole was developed in Russia and presented in 2001 to the Antarctic community at the ATCM XXIV in St. Petersburg. In 2010, at ATCM XXXIII in Uruguay, having fulfilled all procedures and requirements of the Protocol on Environmental Protection to the Antarctic Treaty, Russia has developed and presented the final Comprehensive Environmental Evaluation of its Project for penetration to the water column of Lake Vostok. On February 5, 2012, at a depth of more than 12,300 ft. (3,769 m), the lake was unsealed, and water from its surface layer being denser than the drilling fluid went up the borehole. In the next Antarctic season 2012–2013, this fresh frozen water in the form of an ice core was drilled out and recovered to the surface for analysis.

In 2010, the technology and unique tools were developed in Russia for hydro-*biochemical* sounding of the water column and water sampling through the aforementioned deep ice borehole at Vostok station.

Valery Lukin

See also: Antarctic Programs and Research Stations/Bases

Further Reading

Oswald, G., and G. Robin. "Lakes beneath the Antarctic Ice Sheet." *Nature* 245, no. 5423 (1973): 251–54.

Siegert, M., J. Ellis-Evans, M. Tranter, C. Mayer, J. Petit, A. Salamatin, and J. Priscu. "Physical, Chemical and Biological Processes in Lake Vostok and Other Antarctic Subglacial Lakes." *Nature* 414, no. 6864 (2001): 603–9.

Talalay, P. "Twenty Years of Drilling the Deepest Hole in Ice." *Scientific Drilling* 11 (March 11, 2011): 41–45.

Zotikov, Igor. *The Antarctic Subglacial Lake Vostok: Glaciology, Biology and Planetology.* London: Springer Praxis Books/Geophysical Sciences, 2006.

Lambert Glacier

The Lambert Glacier (71° S 70° W) is located in East Antarctica and is the world's largest and longest glacier. The glacier is 250 miles (400 km) in length and 60 miles (100 km) in width. The depth of the glacier is just more than 8,200 ft. (2,500 m) in some parts. The Lambert Glacier covers more than 386,000 square miles (1 million sq. km). The ice of the Lambert Glacier originates in the Polar Plateau in Mac Robertson Land. The ice flows from the Lambert Graben (70° S 70° W) toward the Amery Ice Shelf (69° 45′S 71° E), where it hangs out over the Prydz Bay. Prydz Bay (69° S 75° W) is located in between Lars Christensen Coast (69° S 69° W) and Ingrid Christensen Coast (69° 30′S 77° W).

The glacier was first described and named "Baker Three Glacier" by John H. Roscoe in 1952. Roscoe was an American geographer and took aerial photos of the glacier while part of the U.S. Navy Antarctic Developments Program in 1946–1947 or more commonly known as Operation Highjump. Baker Three Glacier was the code name for the navy aircraft used for the photo missions over Antarctica during Operation Highjump. The navy conducted three flights along the coastal area near Baker Three Glacier. In 1956, the finding and description of the Baker Three Glacier was published in the Geographic Names of Antarctica Gazetteer No. 14. The name was subsequently changed by the Antarctic Names Committee of Australia in 1957 after the Australian National Antarctic Research Expeditions in 1956 conducted a mapping of the glacier. The new name became the glacier's present-day name of the Lambert Glacier. It is named after the director of the National Mapping in Australian Department of National Development, Bruce P. Lambert.

The Lambert Glacier accounts for approximately 12 percent of the East Antarctica ice volume drainage. Scientists as a result study Lambert Glacier to understand the ice mass balance changes to East Antarctica. One such study is the Antarctic Mapping Mission. The Antarctic Mapping Mission used radar from satellites to measure the rate of movement of the glacier toward the Amery Ice Shelf. In 2000, scientists took two satellite images 24 days apart with the Canadian Space

Agency's RADARSAT-1 satellite. The RADARSAT-1 satellite is capable of detecting geographic and surface features of the glacier. The scientists analyzed the two different images with a scientific technique called "radar interferometry." In their analysis, the scientists were examining surface feature changes, which enabled them to calculate how far the surface features had moved over the 24-day period. The rate of movement was then extrapolated to estimate a yearly rate of movement or velocity. The results showed that the Lambert Glacier annual rate of movement was around 1,200–2,600 ft. (400–800 m). They also found that in some areas, the glacier moved faster, such as the glacier section over the Amery Ice Shelf. The annual rate of movement for this part was around 3,300–4,000 ft. (1,000–1,200 m). These results demonstrated that the Lambert Glacier was advancing faster as it enters Prydz Bay, which means the upper section of the glacier becoming thinner. Further study is needed to determine the rate of melting occurring on the world's largest and longest glacier.

Andrew J. Hund

See also: Antarctic Ice Sheet; Ice Shelves of Antarctica

Further Reading

Allison, I. "The Mass Budget of the Lambert Glacier Drainage Basin, Antarctica." *Journal of Glaciology* 22, no. 87 (1979): 223–35.

Kiernan, R. *Ice Sheet Surface Velocities along the Lambert Glacier Basin Traverse Route.* Canberra, Australia: Antarctic Cooperative Research Centre and Australian Antarctic Division, Research Report No. 23, 2001.

Lapland Longspur

The Lapland longspur (*Calcarius lapponicus*) is a small migratory songbird. It breeds in the Arctic regions of Canada and Alaska, and is the only longspur to breed in the Arctic regions of Eurasia, where it is known as the Lapland bunting. The species is highly migratory. As with the other five members of the Calcariidae family (longspurs and snow buntings), the Lapland longspur is small but sturdy, varying in length from 6 to 6.5 inches but weighing over an ounce. It has short legs, typical of species that breed in the High Arctic. The stout yellow bill is designed for eating seeds, and the longspur spends most of its time on the ground, feeding on grasses and plants. The name "longspur" derives from the long claw on its hind toe, the utility of which has yet to be fully determined by ornithologists. Unlike sparrows and most other buntings, longspurs walk on the ground instead of hopping.

In breeding plumage, a male Lapland longspur has a black cap, face, and bib, set off by a white eye-stripe that broadens as it extends back to a chestnut nape. The back is heavily streaked with both light and dark tones, and the underparts are

Lapland longspur walking in the snow. (Shutterstock.com)

white. A variable amount of chestnut appears in the wing panels. Females, nonbreeding males, and young birds are of a more nondescript brown coloration, although in most plumages, chestnut tones can be seen in the nape and wing panels, and a strong brown ear patch is bordered by black.

The Lapland longspur has long wings designed for long-distance migration, with a wingspan of up to 11 inches. Birds winter in a wide zone, from the colder regions of northern Europe, the Russian steppes, and the central United States to more temperate climates, such as the southern United States and northern Mexico. Wintering flocks are often small but can be huge, occasionally numbering in the millions. In North America, wintering Laplands will join with other longspur species, most notably the chestnut collared, although occasionally all four species can be seen in the same flock.

On their breeding grounds, where the sun barely sets during the summer, Lapland longspurs often sing all-day long. They nest in wet areas of tundra near the tree line, although they are strictly ground nesters. Although primarily seedeaters the rest of the year, during breeding, they supplement their diet heavily with insects. Typically, between two and four eggs are laid, although it is not uncommon for clutch sizes to be up to half a dozen. Mortality rates among young are high, with predators including skuas and Arctic fox. White outer tail feathers are thought to distract predators who focus their attack on these feathers instead of the body.

Despite modifications to the High Arctic due to climate change and urbanization in their wintering areas, the Lapland longspur is not at all threatened, categorized as a species of least concern.

Andrew J. Howe

See also: Arctic Loon; Arctic Seabirds; Arctic Skua; Arctic Tern; Common Raven; Gyrfalcon; Red-Throated Loon; Snow Bunting; Snow Goose; Snowy Owl; Sooty Albatross; Wandering Albatross

Further Reading

Hussell, D., and R. Montgomerie. "Lapland Longspur (*Calcarius lapponicus*)." In A. Poole and F. Gill, eds. *The Birds of North America.* No. 656. Philadelphia: The Birds of North America, Inc., 2002.

Laponian Area

A critically important cultural or physical space on the planet, if deemed significant, can be designated as a world heritage site under the United Nations Educational, Scientific, and Cultural Organization (UNESCO). To date, there have been 981 UNESCO world heritage sites, of which five are located in the Arctic. The Laponian area is one of five Arctic UNESCO world heritage sites. The Laponian area (67° 19′N 17° 34′E) is a wildlife and mountainous region located in Sampi (northern Sweden). It was declared a UNESCO world heritage site in 1996. It was listed because it is a prestigious unmodified nature area. Ninety-five percent of the Laponian area is a collection of national parks and reserves. The Swedish National Parks within the Laponian area are Muddus (66° 54′N 20° 10′E), Padjelanta (67° 22′N 16° 48′E), Serak (67° 17′N 17° 42′E), and Stora Sjöfallet (67° 29′N 18° 21′E). The National parks and the UNESCO listing intention were to allow the Sami to continue their ancestral and migratory reindeer husbandry ways of life. It has a total pastoral area about 3,600 square miles (9,400 sq. km).

Andrew J. Hund

See also: Ilulissat Icefjord; Natural System of Wrangel Island Reserve; Putorana Plateau; Rock Art of Alta

Further Reading

"Laponian Area." UNESCO. http://whc.unesco.org/en/list/774. Accessed January 12, 2014.

"Laponian Area." World Heritage Site. http://www.worldheritagesite.org/sites/laponianarea.html. Accessed January 12, 2014.

Laptev Sea

The Laptev Sea (76° 16′N 125° 38′E), with a surface area of 339,000 square miles (878,005 sq. km) and a catchment area ranging from 30,000 to 938,228 square miles (78,000–2,430,000 sq. km), is located on the northeastern coast of Siberia in Russia. It forms a shallow inland basin with an average depth of 11,106 ft. (578 m). Its borders begin at the Arctic Cape at the northeastern tip of the Komsomolets Island, extending southward to the coastline of the Taymyr Peninsula and the Kara Sea to the west of the mainland. To the east, the sea is bound by the New Siberian Islands and the East Siberian Sea. The number of zooplankton found in the Laptev Sea is low around 400 species, and there are around 40 fish species. However, along the coastline of the Eastern Siberian and Laptev Seas lies a stretch of the most productive coastal subarctic tundras in northeastern Russia. The climate of this region is noted for its oceanic and continental processes, supporting numerous species of breeding birds migrating along the Nearctic and Palearctic flyways. Between 40 and 60 bird species breed on the river deltas, including endangered populations of Steller's and spectacled eiders. The Yana River Delta, like the Kolyma, Indigirka, and Khromskaya Deltas, is protected within existing reserves and the Kytalyk reserve. The Khatanga River transects the Anabar River and Bay to the west; other important freshwater rivers include the Olenyok River and Bay, the Omoloy River, and the Lena River and its delta. The Lena is the second largest river in Russia after the Yenisei.

The Laptev Sea was named after Khariton and Dmitry Laptev in 1935, brothers who mapped the Siberian Sea (as it was known) during the mid-1730s. It is one of five marginal seas located along the coastal circumference of the Arctic Ocean. The other seas contiguous with the Arctic Ocean are the Barents, the Chukchi, the Beaufort, the Wendell, and the Kara Sea. Marginal seas are distinguished from the oceans by their proximity to land; on maps, they frequently appear as landmass indentations. Their depth is generally shallower than the oceans that interact with them. Like oceans, marginal seas have layered water distribution patterns and support varied degrees of biodiversity. Because of their proximity to land, they are more susceptible to human impacts. Together with the Arctic Ocean, the five Arctic seas are a part of a larger topography known as the Arctic Ocean Estuary. This definition reflects agreement within the scientific community that estuarine exchanges best characterize the freshwater and saltwater hydrography that occurs when the Atlantic and Pacific Oceans interact with the waters within the Arctic Circle. This broader concept is essential to better understand the complex relationships that govern sea-ice formation, climate impacts on local ecosystems, and the mechanics governing the sequestering and release of water, methane, and carbon.

Circumnavigating the Arctic domain, freshwater inputs into the panarctic drainage basin vary considerably by region and by latitude, precipitation regimes, and watershed topology. The Laptev Sea's runoff cycle runs from April to June, while farther to the west, the cycle begins in March. Current research models on Arctic and subarctic estuaries include the Siberian River Runoff project, a German–Russian program in the Laptev Sea, and the Canadian Arctic Shelf Exchange Study/Arctic River-Delta Experiment.

Nearly 24 percent of the lands in the Northern Hemisphere serve as a permafrost carbon reservoir. These frozen lands exert a strong influence on the patterns of water flow through the Arctic landscape, affecting the formation of river channel networks and their geomorphology. The majority of the world's permafrost is found in Siberia and Far Eastern Russia, northern Mongolia, northeastern China, and Tibet. The subsea permafrost acts as a lid locking in vast methane reserves trapped within the East Siberian Arctic Shelf (ESAS). The ESAS includes the Laptev, East Siberian, and Russian waters of the Chukchi Seas and flows over an area 2.1×10^6 km^2, an area three times the size of the terrestrial Siberian wetlands. It is a shallow seaward extension of the Siberian tundra that flooded during the Holocene 7,000–15,000 years ago; it is defined by frozen sediments interlayered with flooded peatlands holding reservoirs of carbon and seabed deposits of methane (CH_4). It is estimated that the annual average temperature of ESAS bottom seawater (29° to 34°F [−1.8° to 1°C]) is 53.6° to 62.6°F (12° to 17°C) warmer than the annual average surface temperature of the on-land permafrost. Thawing subsea permafrost allows for greater permeability allowing gases, particularly methane, to be released into the Arctic atmosphere. This release and its effect on global climate change are of great concern to climatologists.

Rising atmospheric temperatures also have a profound influence on the formation of sea ice, a process for which the Laptev Sea is nicknamed the Arctic "ice factory." The Laptev Sea is a primary source of Arctic sea-ice production, and the Lena River is a main freshwater source with a mean annual discharge of 525 km, representing roughly 20 percent of the total. The depth of the sea varies from 16 to 65 ft. (5–20 m) in the southern ranges to more than 6,500 ft. (2,000 m). The shallow coast of the Lena Delta harbors a depth of only 6–9 ft. (2–3 m). The shallower waters of the coast, under the influence of river runoff, will warm as much as 10 degrees with salinities lower than 10 practical salinity units (psu). During the winter months, the southern and southeastern waters of the sea are covered with level fast ice with a depth of approximately 6 ft. (2 m); beyond the fringes are open polynyas, which produce stretches of new ice.

The polar processes that regulate the formation of sea ice play a significant role in the regulation of global temperature. Those processes include ocean circulation, rainfall patterns, ocean biology, and atmospheric phenomena. Studies based on SMOS Satellite imagery of the Laptev Sea conducted under the auspices of the

Alfred Wegener Institute for Polar and Marine Research document larger areas of thin ice that will melt in the coming early summer months. Other studies of the annual variation in the mass of the world's glaciers, excepting Greenland and the Antarctic, confirm that while they represent only approximately 4 percent of the total glacier area, they may have contributed to as much as 30 percent of the rise in sea level during the twentieth century as a result of rapid ice reduction due to global warming. In the November 23, 2012, edition of the *Barents Observer*, it was noted that the number of vessels using the Northern Sea Route (NSR) for cargo transport between Europe and Asia increased 10-fold in the past two years, rising from 4 in 2010 to 34 in 2011 and 46 for the 2012 season. This represents a 53 percent increase in tonnage from 2011, rising from 820,789 tons to 1,261,545 tons in 2012. Primary cargoes are petroleum products, iron ore, and coal.

As the Arctic sea ice retreats, the northern coast of the Russian arctic offers a cost-efficient option as a shipping route for European and Asian markets. Further, the remarkable natural resources of the region, including large reserves of oil and gas, have stimulated interest in regional markets for a variety of goods. The International Northern Sea Route Programme was a six-year program established in June 1993 to increase the knowledge of the icebound sea routes of the Russian arctic. The development of the NSR is a priority that requires important innovations in Russian maritime commercial infrastructure including government oversight, supporting transport services, intermodal connections, weather satellites, and bases for coast guard and navy support service teams.

Victoria M. Breting-Garcia

See also: Arctic Basin; Arctic Ocean; Greenland Sea; Kara Sea; Khatanga, Lena, and Yana Rivers; Northwest Passage Claims and Disputes

Further Reading

Bennett, M. "Russia Pushes Forward on Northern Sea Route." Commentary, Alaska Dispatch, publication of *Eye on the Arctic*, 2012.

Eicken, H., I. Dmitrenko, K. Tyshko, A. Darovskikh, W. Dierking, U. Blahak, J. Groves, and H. Kassens. "Zonation of the Laptev Sea Landfast Ice Cover and Its Importance in a Frozen Estuary." *Global and Planetary Change* 48 (2005): 55–83.

Holmes, R., et al. "Seasonal and Annual Fluxes of Nutrients and Organic Matter from Large Rivers to the Arctic Ocean and Surrounding Seas." *Estuaries and Coasts* 35 (2012): 369–82.

Lazarev, Mikhail Petrovich (1788–1851)

Mikhail Petrovich Lazarev (1788–1851) was an officer of the Imperial Russian Navy and served as a lieutenant in command of the support ship HIMS *Mirnyi* on the Russian Antarctic Expedition of 1819–1821, which was commanded overall by Junior Captain Bellingshausen.

Lazarev was born in 1788 as the second son of the governor of Vladimir, Pëtr Gavrilovich Lazarev, himself a former naval officer. Lazarev first saw the sea in 1800, when he and his two brothers entered the Naval Cadet Corps. In 1803, he was one of about 30 cadets selected for training as volunteers with the Royal Navy, in which he served for almost five years. He was promoted midshipman in 1805 and lieutenant after returning to Russia in 1808. Between 1813 and 1816, Lieutenant Lazarev was detached for service with the state-sponsored Russian-American Company, during which he commanded the *Suvorov* for a voyage in support of settlers in Russian America (Alaska) and completed the first of his three circumnavigations.

In early 1819, several months before Bellingshausen was selected to lead the expedition, Lazarev was appointed captain of the naval transport HIMS *Ladoga* and

WHO DISCOVERED ANTARCTICA?

Some authors have claimed that the Russian Antarctic Expedition were the first people to discover Antarctica. But such statements are often blurred by failure to define what is meant by Antarctica: the whole of the continent including its offshore islands, or just the mainland? If the former, then Smith is a better candidate for priority than Bellingshausen. If the latter, the Bransfield expedition sighted the tip of the Antarctic Peninsula on January 30, 1820, and the only evidence for prior Russian sighting of something like a coastal ice barrier or ice tongue comes from a private letter written by Lieutenant Lazarev shortly after returning to Russia, and probably after handing in his journal to Captain Bellingshausen in the usual way. That letter happens to contain several minor exaggerations and factual errors. Bellingshausen himself never recorded anything of the sort before February 17, 1820, 18 days after Bransfield. Added to this, there is some evidence that unnamed American sealers had sighted at least the South Shetlands and possibly also the peninsula in the early years of the nineteenth century, well before the arrival of either: Smith, Bransfield, or Bellingshausen. And there is another well-known but poorly documented story that land was first sighted in the area as early as 1599. The Finnish Swedish polar explorer Otto Nordenskjöld, for one, believed that on balance William Smith was the most convincing first discoverer of Antarctica. But in view of the other nameless mariners who almost certainly preceded Smith, even his achievement was not perhaps the most important event in the history of the continent.

Robert Ion Pierson (Rip) Bulkeley

tasked to oversee the extensive modifications needed to convert her into the sloop-of-war HIMS *Mirnyi.* (Simultaneous but less radical alterations to HIMS *Vostok* were supervised by another officer.) *Mirnyi* then joined the First Squadron, or Russian Antarctic Expedition, and set sail from the naval base of Kronstadt, outside St. Petersburg, on July 15, 1819, with 73 people on board.

Bellingshausen's standing orders, issued as the expedition departed Rio de Janeiro in November 1819, were that *Mirnyi* should normally take station several kilometers to one side of *Vostok*, closing to 3,000 ft. (900 m) behind her in bad weather. However, *Mirnyi* was a much slower ship than her companion. (Lazarev privately considered, however, that she was better suited for their mission than *Vostok.*) Since the weather in high latitudes was often poor and *Mirnyi* was often bringing up the rear, she had generally less chance of making important sightings than *Vostok.* An exception may have occurred in December 1819, as the expedition approached the area where they discovered the Traversay Islands, at the northern end of the South Sandwich Islands. However, the description of this event in Bellingshausen's book, published in 1831, is somewhat confused, perhaps because of clumsy editing, and there is nothing corresponding to it in his official reports. In January 1821, the two ships sighted Peter I Island almost simultaneously. Another important event on *Mirnyi* was a head-on collision with a large ice floe, which took place at 2:00 A.M. on January 21, 1820. The shock threw the watch below out of their hammocks. *Mirnyi* remained just about seaworthy, but needed a major repair to her bows at Sydney in April.

Lazarev was warmly and repeatedly praised in Bellingshausen's reports for the brilliant seamanship that enabled him to remain in company with *Vostok* while exploring the ice fields in highly unfavorable weather conditions and with a slower ship. One seaman, Fëdor Istomin, died on *Mirnyi*, of typhoid, on February 21, 1820.

Robert Ion Pierson (Rip) Bulkeley

See also: Amundsen, Roald Engebrecht Gravning (1872–1928); Klënova, Mariya Vasilevna (1898–1976)

Further Reading

Firsov, M. *Pervootkryvatel golubogo kontinenta* ("Discoverer of the Blue Continent"). Moscow: Vladimir, 1963.

Lazarev, A. *Plavanie Vokrug Sveta na Shliupe Ladoga (Around the World Voyage on the Ship "Ladoga" in 1822–1824).* St. Petersburg, 1832.

Zubov, N. "Mikhail Petrovich Lazarev." In *Ote-chestvennye fiziko-geografy i puteshestvenniki* ("National Physical Geographers and Travelers"). Ministerstva prosveshcheni͡ia, Moscow, 1959: 193–97.

Lemmings

Lemmings (*Lemmus lemmus*) are small rodents (subfamily: Arvicolidae) usually found in Arctic regions and characterized by their short legs, tail, and ears. Some lemming species are distributed in boreal regions (i.e., bog and wood lemmings), yet the present entry will address those found in the Arctic (hereafter Arctic lemmings), namely, brown lemmings (*Lemmus* species) and collared lemmings (*Dicrostonyx* species). Arctic lemmings are found throughout the tundra in North America and Eurasia, where they feed on sedges, grasses, forbs, and mosses. They can overwinter for as long as nine months of the year in nests and tunnels built under the snow. Arctic lemmings have sparked interest of laymen, naturalists, and scientists. This may be due to their well-known population fluctuations that can reach considerable amplitudes and to their key role in Arctic food webs.

Arctic lemmings play a pivotal role in tundra food webs due to their recurrent mass occurrence that induces profound impacts on Arctic terrestrial predators and on tundra vegetation. Mass occurrences of Arctic lemmings are usually cyclic, with a regularity of three to five years. Yet, the amplitude and duration of these cycles vary from site to site. During peak years, high abundance of Arctic lemmings sustains high reproductive success in resident predators such as Arctic foxes and stoats, and attracts nomadic predators such as snowy owls that will reproduce in areas of high lemming densities. Arctic lemmings can considerably affect tundra vegetation. This is especially true during peak years when their grazing impact can even be detected through satellite imagery.

Lemming. (Shutterstock.com)

There is growing evidence pointing to climate warming phasing out lemming cycles. Snow conditions can largely influence winter reproduction of lemmings, an important determinant of cycles' amplitude and duration. Warmer winter climate in the tundra is associated with an increased frequency of rain-on-snow events, which can encapsulate the vegetation in ice, hampering foraging activities and hence reproduction. Current research projects conducted throughout the Arctic are now aiming to better understand the links between changes in snow conditions associated with climate warming and dynamics of lemming populations, and the cascading impacts of these changing lemming cycles on tundra food webs.

In addition to their importance in ecological research, lemmings are well known to the lay public for the myths that characterized them. Perhaps the best known of those myths is that lemmings commit suicide. This myth may have roots in the dispersal behavior of the Norwegian lemming (*Lemmus lemmus*). The latter can undergo long-distance dispersal during years of high abundance, and underway, concentrations of lemmings may build up along river or lakeshores. Although lemmings can swim, they may also drown if waves become too high. Density and dispersal therefore drive their survival, not suicide.

Marie-Andrée Giroux

See also: Arctic Fox; Arctic Ground Squirrel; Arctic Hare; Arctic Seabirds; Arctic Wolf; Caribou; Dogs in the Arctic; Musk Oxen; Polar Bear; Wolverine

Further Reading

Stenseth, Nils Chr., and Ims, Rolf Anker, eds. *The Biology of Lemmings.* London: Academic Press, 1993.

Lena Massacre of 1912

The Lena Massacre occurred in April 1912 resulting in at least 150 to 270 deaths and 100 to 250 people wounded. It is sometimes referred to as the Lena Execution or the Lena Goldfield Massacre. The location of the massacre was at the Lena Gold Mining company about 30 miles northeast of Bodaybo, Russia. The gold mining company was owned by the Joint Stock Company and was very profitable for the Russian and British shareholders.

The goldfield workers worked under harsh conditions to increase the profits of the shareholders. For example, they worked up to 16 hours a day, commonly had their pay reduced by fines, and were given food vouchers to shop at the company store. Accidents were very common, and it is estimated that an average of 7 out of 10 workers experienced an accident. The workers put up with the harsh working conditions until a shipment of rotten meat arrived at the store. The rotten meat (some reports claimed it was meat made from horse penises) resulted in

The widows and children of the massacred Lena goldfield workers at a funeral service at the common grave in 1912. (Sovfoto/UIG via Getty Images)

a spontaneous strike in March 1912, at the Andreyevsky goldfield. The workers demanded better working conditions, such as a 30 percent pay increase, an eight-hour workday, better food, and the elimination of worker fines. By mid-March, the strike had spread to all goldfields with 6,000 miners on strike being organized by the Central Strike Committee and Central Bureau. The workers' demands were rejected by the owners on April 11, 1912.

The Tsarist government ordered military troops from Kirensk to break the strike in Bodaybo. On April 17, 1912, the organizers of the strike were arrested. The next day, 2,500 workers marched to the Nadezhdinsky goldfield to complain about arrest and detention of the organizers and demand their release. The marchers were met by the soldiers, near the Nadezhdinsky goldfield. Under the command of Captain Treshchenkov, the unarmed marchers were fired upon resulting in at least 150–270 deaths and 100–250 wounded.

The massacre ignited a number of strikes and protests across Russia. It is estimated that in St. Petersburg, Russia, more than 300,000 people were participating in more than 1,700 strikes in April and May 1912. These strikes lasted until late August. The administration came up with a new contract, but the offer was rejected by the goldfield workers. The strikers at Lena held out until mid to late August, when the last of the workers gave up and left the goldfields. In all, about 9,000 workers and their families left the Lena goldfields. The public demanded an investigation of the massacre, but the interior minister Maklakov declined. Alexander Kerensky (1881–1970) of the Duma commission investigated the Lena massacre. His report helped popularize the incident and grow discontent with the Tsarist government.

Andrew J. Hund

See also: Khatanga, Lena, and Yana Rivers

Further Reading

Melancon, M. *The Lena Goldfields Massacre and the Crisis of the Late Tsarist State.* College Station: Texas A and M University Press, 2006.

Lena River. *See* Khatanga, Lena, and Yana Rivers

Leopard Seal

The leopard seal (*Hydrurga leptonyx*) is one of four phocid pinnipeds that lives exclusively in the Southern Hemisphere with breeding populations confined to the circumpolar pack ice of Antarctica. The genus name is from the Greek *hudor* meaning water, and (possibly) suffix *ourgos*, a worker in, while the species is from the Greek *leptos*, small, slender, and *onux*, claw. Leopard seals grow to about 15 ft. (4.5 m) but average about 10–11.5 ft. (3–3.5 m) long. They can weigh up to 840 pounds (380 kg) with a maximum being up to 1,450 pounds (600 kg). Females are larger than males. The life expectancy is 12–15 years with a maximum life span of up to 25 years. Sexual maturity is attained at four to five years of age. Counting leopard seal numbers is fraught with problems, but a continent-wide estimate of leopard seals is somewhere from 220,000 to 440,000.

Leopard seals have relatively large, very long, and slender bodies with large shoulder and disproportionately large reptilian-looking head with long snout, marked neck constriction, and flanks tailing off. The gape is noticeably large, and the nostrils point upward rather than forward as in other Antarctic phocids. The teeth are all large, incisors and canine teeth pointed with the postcanines recurved and pointed, each with main crown and two lateral cusps, and interlocking when the jaw is closed. The robust teeth reflect their largely carnivorous diet and are adapted for eating a variety of prey as well as filtering crustaceans out of the water column. The short pelage is usually very dark (black or dark gray) dorsally and silvery ventrally, liberally spotted with light and dark gray, and black spots with relatively sharp line of demarcation along sides.

The little information on the reproductive biology of leopard seals suggests that pups are born from October to mid-November. Mating occurs from December to early January, evidently in the water, at about the same time as females wean their pups, after presumably nursing them for a month, perhaps shorter than this. However, exact timing may be dependent on the region of the Antarctic, and the pupping season probably varies with location. Leopard seals molt through January and February and are primarily shallow divers, with most dives to depths of around 30–160 ft. (10–50 m) and only occasionally as deep as, or deeper than, 650 ft. (200 m). They feed on a variety of prey including fish, cephalopods, crustaceans, penguins, and other seals, but diet composition varies between seasons and regions. These seals can be exceptionally aggressive toward humans with several known attacks and one fatality.

Although relatively little is known of the species' distribution, abundance, life history, and basic natural history, they occur all around the Antarctic continent and are most abundant in pack ice and fast-ice habitats especially along the Antarctic Peninsula. Leopard seals are primarily solitary but may congregate around large penguin colonies. The seals sometimes move north as the pack ice expands and stay in open water before moving south back to the ice edge while others do not show such pronounced north–south movement. Northward movement is consistent with numerous observations of leopard seals hauling out at subantarctic islands in winter and year-round on some islands to the south of the Antarctic polar front. Vagrants also occur at all continents abutting the Southern Ocean.

Threats

There has been essentially no commercial harvest of the species, and none are planned or likely to be considered. The nonaggregating nature and remote breeding habitat of leopard seals shelter them from most potential direct interactions with human activities. The apparent solitary behavior may also reduce direct interactions with commercial fishing activities. Perhaps the most important threat is loss of breeding habitat accompanying ocean climate warming and constriction of seasonal pack ice. The effects of changes in sea ice on leopard seal foraging seems unlikely to be detrimental since they often forage at considerable distances from the continent, beyond the sea ice, and thus may be preying on species not particularly linked with the pack ice ecosystem. On the other hand, population size and distribution may be altered through changes in food web dynamics, and their nonbreeding season foraging north of pack ice zones may overlap with southern elephant seals, fur seals, and other migratory subarctic marine vertebrates.

Conservation Status

The leopard seal is listed as lower risk, least concern on the IUCN Red List and is protected in its range under the Protocol on Environmental Protection to the Antarctic Treaty. It is also protected under the Convention for the Conservation of Antarctic Seals, Annex I, which provides for commercial harvests of limited numbers, as do the Convention on the Conservation of Antarctic Marine Living Resources, Article II.

Marthán Bester

See also: Antarctic Fur Seals; Bearded Seal; Crabeater Seal; Harp Seal; Hooded Seal; Polar Bear; Ribbon Seal; Ringed Seal; Ross Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Spotted Seal, Weddell Seal

Further Reading

Bester, M., and G. Hofmeyr. "Seals: Overview." In B. Riffenburgh, ed. *Encyclopedia of the Antarctic.* New York: Taylor and Francis Books, Inc., 2007, pp. 877–81.

Reeves, R., et al. "Leopard Seal." In *National Audubon Society Guide to Marine Mammals of the World.* New York: Alfred A. Knopf, Inc./Chanticleer Press, 2002, pp. 177–79.

Southwell, C., et al. "A Review of Data on Abundance, Trends in Abundance, Habitat Use and Diet of Ice-Breeding Seals in the Southern Ocean." *CCAMLR Science* 19 (2012), 49–74.

Lincoln Sea Dispute

The Lincoln Sea (83° N 58° W) dispute is between Canada and Greenland (Denmark) over the lack of a maritime boundary for a 77-square-mile (200-sq.-km) section of the Lincoln Sea. The offshore boundary dispute is a minor issue in Canadian Danish international relations. The Lincoln Sea is located northwest of Greenland and northeast of Ellesmere Island (Canada). The dispute started in 1973 when the maritime boundaries between Canada and Greenland (Denmark) for Davis Strait, Baffin Bay, and Nares Strait (sometimes called "Robson Channel") were established. Beyond the Nares Strait, a 65-nautical-mile (74-mile; 119-km) segment of the Lincoln Sea was left unsettled.

In 1977, the Canadian government used the customary international law of the equidistance principle to claim a fishery zone in the Arctic Ocean. The Canadians selected areas that were equidistant from their coastline to establish a fishery boundary. In 1980, Denmark mapped out an equidistance line from their coastline to establish their boundaries. As part of Denmark's maritime boundary, they included the small island of Beaumont Island (82° 44′N, 50° 40′W) off the coast of Greenland as their coastal reference point. Beaumont Island is 4 square miles (10 sq. km) in size and is uninhabited. Including Beaumont Island as the coastline resulted in Denmark's equidistance line moving westward and claiming two islands. The two islands are Distant Cape about 41 nautical miles (47 miles; 75 km) northeast of Greenland and Kap Bryant about 43 nautical miles (49 miles; 79 km) to the southwest.

In 1980, the Canadian government formally complained about Denmark's equidistance declaration on the grounds that their line did not conform to the coastline and Beaumont Island is considered to be west of the other islands. The Canadian and Denmark governments met in 1982 to discuss the issue, but were not able to resolve the issue. In 1986, Canada mapped out another equidistant boundary around the Arctic Archipelago. In 2012, Canada and Denmark reached a tentative agreement to resolve the Lincoln Sea dispute and extend the 1,500-nautical-mile border to more than 1,600 nautical miles. This new agreement almost completes the maritime boundary between Canada and Greenland (Denmark), with the exception of a seven-tenths of a mile (1.2 km) gap that includes Hans Island.

Andrew J. Hund

See also: Arctic Territorial Claims and Disputes; Baffin Bay; Greenland

Further Reading

Gray, D. "Canada's Unresolved Maritime Boundaries." *IBRU Boundary and Security Bulletin*, 1997.

Nicholson, N. *The Boundaries of Canada, Its Provinces and Territories.* Ottawa: Geographical Branch, Department of Mines and Technical Surveys: Memoir, 1954.

Little Auk

The little auk (*Alle alle*), most often referred to in North America as the dovekie, is a tiny auk and sole representative of the *Alle* genus. It breeds in the High Arctic in Greenland, Iceland, Svalbard, and a few other islands in the Barents Sea, and increasingly in small outlier colonies in the Canadian Arctic and Alaska. There are two subspecies recognized by ornithologists.

Wintering birds are pelagic, often seen from boats or even land in the North Atlantic off of New England and the British Isles, and in the Norwegian Sea. Occasionally, storms drive them south of their normal range into more temperate waters, including as far south as Florida during the winter of 1932–1933. In extremely rare occasions, birds have been found inland following severe winter storms. In the nonfictional account of her childhood *The Long Winter*, Laura Ingalls Wilder records that her family found a bird resembling a tiny great auk following a strong October blizzard in South Dakota. Although it is merely hypothesis, the description of the bird and the timing and situations of its appearance suggest this species.

The little auk is black above and white below, with a black head and cowl across the upper breast and a small, stubby black bill. Birds range between 7 and 8 inches in length, have a wingspan of 13–15 inches, and weigh 5–7 ounces. Although not as small as the least auklet of the Bering Sea, the little auk is half the size of the next largest Atlantic *Alcid.*

Little auk. (Shutterstock.com)

Like other *Alcids*, little auks are proficient swimmers, largely hunting for crustaceans, plankton, and small fish. In search of prey, they often dive to depths of up to 120 ft., often feeding at night when their food sources come closer to the surface. Auk pairs nest in large colonies in the mountainous areas adjacent to coastlines. They live in burrows, scrapes, in crevices beneath rocks on rocky screes, or upon ledges on steep cliffs. Typically, they lay just a single egg; hatching takes place after about a month, with chicks fledging after another month. At breeding colonies, birds swarm together before leaving to look for food, and upon returning, as it is during the transition from land to water and back again that they are the most vulnerable to predators, which include the Arctic fox and glaucous gull. Little auk colonies can be massive; historically, the Thule colony in northwest Greenland has had in excess of 15 million birds, representing about half the world's population. Despite such high numbers, however, populations have declined somewhat due to climate change, oil spills, egg harvesting, and Inuit hunting. In a ceremonial dish, now most often eaten at weddings and birthdays, 300–500 little auks are placed inside a hollowed-out body of a seal. The air is then removed, and the carcass sewn up and left to ferment for up to six months before being consumed.

Andrew J. Howe

See also: Arctic Seabirds; Great Auk

Further Reading

Montevecchi, W., and I. Stenhouse. "Dovekie (*Alle alle*)." In A. Poole and F. Gill, eds. *The Birds of North America.* No. 701. Philadelphia: The Birds of North America, Inc., 2002.

Lomonosov Ridge Claims

The Lomonosov Ridge is considered a natural prolongation of three countries. The three countries are Canada, Greenland (Denmark), and Russia. Each country contends that the Lomonosov Ridge is an extension of their continental shelf. This issue is being deliberated in the United Nations. The Lomonosov Ridge is an unusual geologic structure that is around 35–200 miles (60–200 km) wide and stretches around 1,100 miles (1,800 km) from roughly Ellesmere Island of the Canadian Arctic Archipelago to the New Siberian Islands located between the East Siberian Sea and Laptev Sea and north of the East Siberian coast. Most of the Lomonosov Ridge rises about 10,000–12,000 ft. (3,300–3,700 m) above the seafloor. The Lomonosov Ridge at its most shallow area or the closest it comes to the ocean surface is around 3,000 ft. (950 m).

The international agreement of the United Nations Convention on the Law of the Sea (UNCLOS) establishes exclusive economic zones (EEZs) that grants development rights over all natural resources in territorial waters and out to 200 nautical miles (230 miles; 370 km) including living resources. A claim to a continental shelf can include a natural prolongation or seabed that extends beyond the 200 nautical miles, but not further than 350 nautical miles (400 miles; 650 km). This provision allows the coastal states to have exclusive rights to and the harvesting of mineral resources to the end of the natural prolongation, but not exclusive rights over living resources beyond the limit of EEZ 200 nautical miles.

The Canadian government contends that the Lomonosov Ridge is an extension of Ellesmere Island of the Canadian Arctic Archipelago. The Denmark government contends the Lomonosov Ridge is an extension of Greenland. In 2006, the Danish and Canadian governments cooperatively worked with the project called "Lomonosov Ridge Test of Appurtenance" or LORITA-1 for short. The focus of the research was to collect bathymetric, and seismic and gravity data to substantiate respective claims to the Lomonosov Ridge. During the International Polar Year (2006–2007), the Danish government along with scientists from multiple countries conducted a joint research project called "Lomonosov Ridge off Greenland" (LOMROG). To collect the data for UNCLOS continental shelf, the LOMROG project used the Swedish Icebreaker *Oden* and the Russian nuclear icebreaker NS 50 *Let Pobedy*. Additional studies have been conducted called "LOMROG II" in 2009 and "LOMROG III" in 2012. LOMROG III collected bathymetric, gravimetric, seismic, oceanographic, and rock sample data.

In 2001, the Russian Federation submitted their claim in accordance with the UNCLOS (article 76, paragraph 8). In their continental shelf claim, the Russian Federation included the area beyond the 200-nautical-mile zone. One of the arguments for the extended continental shelf was that the Lomonosov and Mendeleev Ridges were an extension of the Eurasian continent, thus, an extension of the Russian territory. The Russian Federation claim extends only to the North Pole.

In 2007, the Russia Federation used a Finnish-made self-propelled deep submergence vehicle called "MIR" (meaning "world" or "peace" in Russia). The MIR submersible was part of the Arktika 2007 expedition, which was part of the Russian North Pole expedition and the International Polar Year 2007–2008. It was also part of the Russian Arctic territorial claim. The Arktika 2007 expedition explored the seafloor near the North Pole, collected flora and fauna samples, and deposited a Russian flag encased in a titanium tube. The MIR submersible was the first manned mission to the seabed under the geographic North Pole. The MIR reached a depth of almost 14,000 ft. (4,261 m) while exploring the North Pole seafloor. The Arktika 2007 expedition along with the MIR submersible was attempting to establish whether the Lomonosov Ridge was an extension of Russian continental shelf. The United Nations has not ruled in favor or opposition to the Russian Federal continental shelf claim proposal. The United Nations requested more research on the matter before deeming the claim valid or invalid to the Lomonosov Ridge.

Andrew J. Hund

See also: Arctic Territorial Claims and Disputes

Further Reading

Griffiths, F. "The Arctic as an International Political Region." In Kari Möttölä, ed. *The Arctic Challenge: Nordic and Canadian Approaches to Security and Cooperation in an Emerging International Region.* London: Westview Press, 1988.

McKitterick, T. "The Validity of Territorial and Other Claims in Polar Regions." *Journal of Comparative Legislation and International Law* 3rd Ser., 21, no. 1 (1939): 89–97.

Long-Finned Pilot Whale

The long-finned pilot whale (*Globicephala melas*) is a member of the suborder Odontoceti, or toothed whales, and one of the largest of the dolphin family (Delphinidae). Mature males are around 13 up to 25 ft. (4–7.6 m) in length and weigh up to 5,000 lbs (2,300 kg). Mature females are slightly smaller being around 12.5 up to 18 ft. (3.8–5.7 m) in length and weighing 2,900 lbs (1,300 kg). The life span of the long-finned pilot whale ranges between 30 and 50 years. Some whales (mostly females) have been known to reach 60 years of age or more. The size of the global population is not known precisely, but it is estimated that there may be at least 800,000 in the North Atlantic, and in the Southern Hemisphere around 200,000.

Pigmentation is mostly black or dark brown with a gray saddle patch behind the high falcate dorsal fin. This sits just forward of the center and is a distinct light-colored stripe on the belly running toward the head where it diverges, forming the shape of an anchor. Calves and juveniles are lighter in color and occasionally have gray spots. The large pectoral fins are a vital identification feature. They can measure up to 30 percent of total body length, are long and narrow, and point backward. Each jaw has 7–20 pairs of teeth. The blowhole is about 1 m high.

Two subspecies are recognized. The first is *G. m. melas*, whose habitat spans the North Atlantic, from southwestern Greenland, Iceland, and the Barents Sea in the north to Cape Hatteras and the northwestern coast of Africa in the south. Distribution of the second subspecies, *G. m. edwardii*, is extensive throughout the Southern Hemisphere, the Atlantic, Pacific, and Indian Oceans.

The staple diet of this whale in the Northern Hemisphere is squid, but it also eats several species of fish, such as cod, dogfish, herring, and turbot. Shrimp is mainly consumed by younger animals. In the Southern Hemisphere, consumption of cephalopods is less important. Foraging for food normally occurs mostly at night, at a depth of 100–1640 ft. (30–500 m). Each dive usually lasts less than 5–10 minutes. Long-finned pilot whales are gregarious and social. Between 1709 and 1990, surveys conducted around the Faroe Islands detected aggregations of 1–1,200 animals, the average number per group being around 150. More recent research figures quote groups of 3,000 animals. The composition of these groups, however, can vary.

The long-finned pilot whale is polygamous, and mating takes place all year-round. In the Northern Hemisphere, this mainly occurs from spring through fall, while in the Southern Hemisphere, the mating season is October through April. Gestation is 12–15 months. At birth, a calf is 1.6–2 m long and weighs around 150–165 pounds (70–75 kg). It is suckled for 3.4 years on average with a range of 3–5 years. However, in some cases, care extends over a much longer period, young mothers being assisted in the upbringing of their offspring by older, infertile females.

Long-finned pilot whales are known to become stranded on land, especially on beaches, and there are many hypotheses around on why this happens. These whales produce a variety of sounds, also in the earlier-mentioned circumstances.

Sigurður Ægisson

See also: Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Narwhal; Narwhal Tooth; Northern Bottlenose Whale; Southern Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Jefferson, T., M. Webber, and R. Pitman. *Marine Mammals of the World: A Comprehensive Guide to Their Identification.* Amsterdam: Elsevier, 2008.

Taylor, B., R. Baird, J. Barlow, S. Dawson, J. Ford, J. Mead, Notarbartolo di Sciara, G., Wade, P., and Pitman, R.L. *Globicephala melas.* IUCN Red List of Threatened Species, 2008.

Lost Patrol

In the autumn of 1910, the Royal Canadian Mounted Police (RCMP) inspector Francis Joseph Fitzgerald (1869–1911) was chosen to attend the coronation of the king of the United Kingdom George Frederick Ernest Albert (1865–1936) or commonly called George V. In 1903, Inspector Fitzgerald was the first RCMP officer assigned to Herschel Island (69° 35′N 139° 5′W), which was the northernmost RCMP detachment. In 1904, Fitzgerald along with Constable Forbes Sutherland established an RCMP subdistrict post on Herschel Island. To attend King George V's coronation, Fitzgerald decided to lead the yearly RCMP patrol that delivered parcels and mail from Fort McPherson, Northwest Territories, to Dawson City, Yukon. It was a 620-mile (1,000-km) sled dog trek. The trip became known as "The Lost Patrol."

On December 21, 1910, the patrol left Fort McPherson, with Constable Richard O'Hara Taylor, Constable George Francis Kinney, and Special Constable Sam Carter. The patrol consisted of three sleds pulled by 15 dogs and enough provisions for 30 days. The first part of the patrol was completed without incident. At the first stop, the patrol hired Esau George, a local native, to guide them to the second part. The team completed the second part with incident, and Fitzgerald decided that Esau was no longer needed. Carter was selected to guide the team the rest of the way to Dawson City. Carter had never traveled the route from Fort McPherson to Dawson City before; however, Carter had four years prior traveled from Dawson City to Fort McPherson.

By 22 days, on January 12, 1911, the patrol was lost. Carter was not able to locate the Forrest Creek trail that lead to Dawson City. The patrol had searched various watercourses without locating Forest Creek. The patrol encountered adverse weather conditions with deep snow and bitter temperatures estimated to be between −45° and −62°F (−43° to −52°C). With food supplies dwindling, Fitzgerald wrote in his journal: "My last hope is gone. . . . I should not have taken Carter's word that he knew the way from the Little Wind River." The next day the frostbitten, starving, and ailing patrol headed back to Fort McPherson. Out of desperation, the patrol started killing and eating the sled dogs. The patrol ate 10 dogs over the course of 17 days, from January 19 to February 5, 1911. Without the dogs, the patrol was forced to travel by foot. On February 5, Inspector Fitzgerald made his last entry into his journal. It was the 47th day of the trip, and the patrol was still lost.

Back in Dawson City, the RCMP organized a search team to locate the patrol after they were more than 30 days late. On February 28, 1911, 69 days after the patrol left Fort McPherson, a search team consisting of Corporal William John Dempster, ex-Constable Frederick Turner, Constable Jerry Fyfe, and Métis Charles Stewart of Fort McPherson left Dawson City. Sixty-six days later, on March 21, 1911, the search team found the Constables Taylor and Kinney. Taylor died as a result of an apparent suicide. Kinney appeared to have succumbed to starvation. On March 22, 1911, the bodies of Fitzgerald and Carter were located about 25 miles (40 km) from Fort McPherson. Both men had succumbed to the conditions and starvation.

Andrew J. Hund

See also: Eskimo Coast Disaster of 1885; Thule Air Base, Greenland, B52G Stratofortress Crash of 1968

Further Reading

North, D. *The Lost Patrol: The Mounties' Yukon Tragedy.* Vancouver: Raincoast Books, 1995.

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Macaroni Penguin

The macaroni penguin (*Eudyptes chrysolophus*) is a medium-sized bird that nests on islands in the Antarctic region. As with all other penguin species, it is flightless although with sturdy flippers for underwater dexterity. Typical of the penguins in the *Eudyptes* genus, the macaroni is black above and white below with a dull reddish bill and decorative yellow feathering that serves as a crest. It takes birds three to four years to attain adult plumage, although breeding does not take place for at least another year. Males average larger and heavier than females (weight ranges from 7 to 14 pounds [3–6 kg]), although there is no sexual dimorphism in plumage. On average, adult penguins reach 28 inches in length.

The macaroni penguin was first described by German naturalist Johann Friedrich von Brandt (1802–1879) in 1837. Mostly known for describing wildlife in the Gulf of Alaska and along the coast of the Pacific Northwest, von Brandt was visiting the Falkland Islands when he described this species for science. By this time, the bird had already been named informally by the English sailors who frequented the Falklands. Apocryphally, they named the bird "macaroni" as the bird's yellow crest reminded them of ostentatious headwear worn during the period. Other members of the *Eudyptes* genus would later be discovered, and the specific taxonomy of this genus would be in flux until DNA analysis clarified the picture. The royal penguin is the closest relative to the macaroni, and the two split off from one another about 1.5 mya.

More than 200 breeding colonies exist at 50 sites, mostly on islands in the circumpolar region such as South Georgia and the Falklands, although colonies do exist in Chile and on the Antarctic Peninsula. Males court females and set up territories that they defend vigorously during the Austral summer breeding period. Pair bonds are maintained by mutual display dancing, with high pair fidelity from year to year. Nests are little more than scrapes in the ground; typically, two eggs are laid per breeding season, although unlike most bird species, it is the second chick that is more likely to survive. Males perform the majority of egg incubation and can lose up to 40 percent of their body weight during this time period. Predators range from skuas and giant petrels, which predate eggs and chicks, to leopard and fur seals, which hunt the penguins while the adults look for krill and other food sources.

The macaroni is one of the world's most common penguin species, with between 10 and 20 million individuals estimated. However, rapid population decline due to climate change, pollution, and commercial overfishing has led the species to be designated as vulnerable. As with all penguin species, the bird is susceptible to even the slightest amount of oil, and increases in global shipping have led to numerous oiled and wrecked birds being discovered on the shorelines of South Africa, New Zealand, and as far north as Brazil.

Andrew J. Howe

See also: Adélie Penguin; Chinstrap Penguin; Emperor Penguin; Gentoo Penguin; King Penguin; Rockhopper Penguin

Further Reading

Cresswell, K., J. Wiedenmann, and M. Mangel, "Can Macaroni Penguins Keep Up with Climate and Fishing Induced Changes in Krill?." *Polar Biology* 31, no. 5 (2008): 641–49.

Green, J., I. Boyd, A. Woakes, N. Warren, and P. Butler. "Behavioural Flexibility during Year-Round Foraging in Macaroni Penguins." *Marine Ecology–Progress Series* 296 (2005): 183–96.

Mackenzie River

The Mackenzie River flows north to the Beaufort Sea. It is the longest Canadian river covering 1,080 miles (1,738 km). The source of the Mackenzie River is the Great Slave Lake in the Northwest Territories. The Mackenzie is a wide river that ranges from 1 to 3 miles (2–5 km) in a few places and narrows to as little as one-third of a mile (0.5 km). The narrow fast sections can be found south of Fort Good Hope and are called the "Ramparts." The elevation from the Great Slave Lake to the Beaufort Sea drops just more than 500 ft. (156 m), which contributes to the Mackenzie being mostly a slow-moving braided waterway with numerous sandbars and channels. The average water discharge of the Mackenzie is 350,000 cubic feet per second (ft^3/s) (9,910 cubic meters per second [m^3/s]).

Starting from the western end of the Great Slave Lake, the course of the Mackenzie River flows west and northwest about 200 miles (300 km) passing by the small town of Fort Providence (61° 21′N 117° 39′W). At the town of Fort Simpson (61° 51′N 121° 21′W), the Mackenzie joins the Liard River, which is the Mackenzie's largest tributary. The Mackenzie then heads north toward the Arctic Ocean running roughly in tandem with the Franklin Mountains. Along the route, the Mackenzie is joined by several more tributaries, such as the North Nahanni, Keele, and Great Bear Rivers. Before reaching the Arctic Circle, the Mackenzie passes by the small town of Norman Wells (65° 16′N 126° 49′W) then heads in a northwest direction where it is joined by two more tributaries, the Arctic Red and Peel Rivers before emptying into the Mackenzie Delta. The Mackenzie Delta is about 50 miles across (80 km) spanning the Caribou Hills in the east to the Richardson Mountains to west. The delta is an alluvial fan with a network of channels, oxbow lakes, and ponds.

ALEXANDER MACKENZIE (1764–1820) AND DISAPPOINTMENT RIVER

Scottish explorer Sir Alexander Mackenzie (1764–1820) is most famous for his East to West crossing of what is now known as modern-day Canada. In 1788, working under the North West Company based out of Montreal, Mackenzie went to Lake Athabasca and helped with the settlement of Fort Chipewyan (58° 42′N 111° 9′W). While at Fort Chipewyan, the local First Nations informed Alexander that the river, they called Dehcho, flowed the northwest. Alexander thought this might be a passage to the Cook Inlet in Alaska and set out to traverse the river. In July 1789, Alexander reached the Arctic Ocean, where he called the Dehcho "Disappointment River" because it was not a passage to the Pacific Ocean as he had hoped, but was only a passage to the Arctic Ocean. The Dehcho, renamed Disappointment River, was later named the Mackenzie River in his honor. In 1793, Alexander made it to the Pacific Ocean, which is 10 years before Captain Meriwether Lewis and Lieutenant William Clark's expedition. Sir Alexander Mackenzie passed away due to a kidney disease, at the time called Bright's disease, in 1820.

Andrew J. Hund

A snowmobiler and his dog travel next to the winter ice road on the east channel of the Mackenzie River near Inuvik, Northwest Territories. A boat waits for the spring thaw. (Shutterstock.com)

After Point Separation, the Mackenzie River breaks into three main channels. The East Channel (on the east side) flows past the town of Inuvik (68° 21′N 133° 43′W), which is about 60 miles (97 km) south of the Beaufort Sea. The Middle Channel is the main discharge of the Mackenzie to the Beaufort Sea. The Peel Channel is on the west side and flows past the town of Aklavik (68° 13′N 135° W) emptying into the Beaufort Sea. The air and sea transportation hub of the delta is Tuktoyakuk (69° 26′N 133° 1′W). Navigation of the Mackenzie Delta lasts around three to four months of year due to its freezing over the rest of the year.

The Mackenzie basin is extensive with its major tributaries covering five Canadian provinces and territories and an area of 697,000 square miles (1.8 million sq. km). Almost 20 percent of all of the drainage from Canada is connected to the Mackenzie River basin. The basin includes several major lakes (e.g., Athabasca, Great Slave, and Great Bear Lakes) and several major rivers (e.g., Athabasca, Hay, Liard, Peace, Peel, South Nahanni, and Slave Rivers). Using Thutade Lake as the origin, the Mackenzie River would be the longest river system in Canada at more than 2,600 miles (4,200 km) in total length.

In July 1789, Scottish explorer Sir Alexander Mackenzie (1764–1820) reached the Arctic Ocean, where he called the river "Disappointment River" because it was not a passage to the Pacific Ocean as he had hoped, but was only a passage to the Arctic Ocean. Disappointment River was later named the Mackenzie River in his honor. The next explorer to the area was James Franklin in 1825. After Mackenzie's exploration, traders set up posts in the region. Steamboats entered in Athabasca River in 1884.

Andrew J. Hund

See also: Colville River; Indigirka and Kolyma Rivers; Khatanga, Lena, and Yana Rivers; Ob, Pechora, and Yenisey Rivers; Yukon River

Further Reading

Burridge, M., and N. Mandrak. "104: Upper Mackenzie" and "105: Lower Mackenzie." *Freshwater Ecoregions of the World.* Washington, DC: World Wildlife Fund/The Nature Conservancy, 2011.

Malitsa

Malitsa is a male whole-cut fur coat, with a hood and half-attached mittens (see Figure 1). The word *malitsa* derives from the Nenets verb *mala, malda*, which means "to cover over the head." Many people call it an individual chum. There is also a children's riddle: what has one entrance and three exits? The answer is malitsa: indeed, one puts it on entering by the bottom hole, and then emerging from it through the collar and two sleeves.

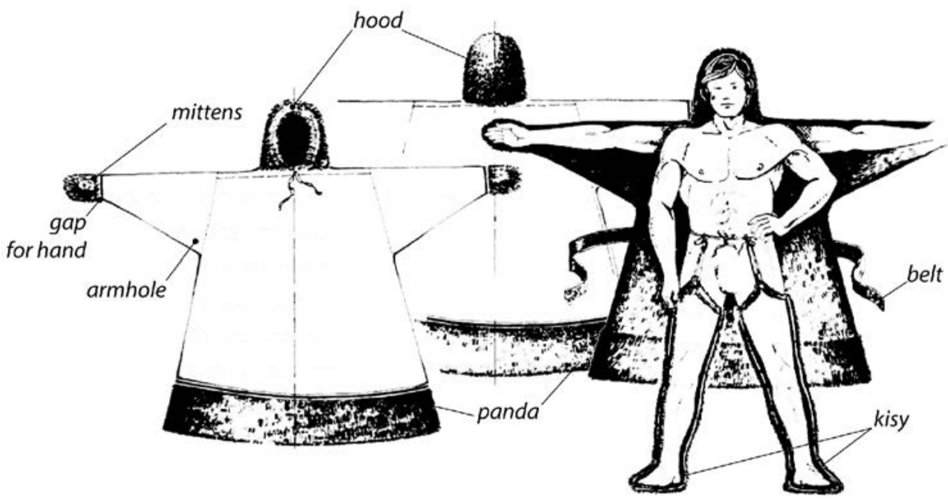

Figure 1 Male malitsa whole-cut fur coat, with a hood and half-attached mittens.

The malitsa is made of reindeer skin with the fur on the inside, close to the naked body, while the outer surface is smooth leather. This kind of surface provides aerodynamic properties. The conical shape of the coat (similar to *chum*) helps resist strong gusts of wind. A wide stripe (up to 20 cm) in the bottom of the coat is made of two layers of tough dark fur from reindeer legs (fur out) and is called a "panda." These two layers increase the weight of the bottom edge; therefore, during a sled ride, the *panda* fits tightly against the legs of the musher and protects him from the wind. This fur skirt in combination with high fur boots, the so-called kisy (their top edge comes up to the groin) form a substantial overlap to protect from contrary wind.

Mittens, as it was indicated earlier, are made half-attached from the back side. This makes it possible to use a gun or a bow, to kindle a fire, to smoke, and to perform other various activities that would be difficult to do with mittens on. Since the gap is on the inner side of the bend of the wrist, it naturally remains closed and windproof. This lock is even more reliable due to the outer fur (the mittens are sewn fur out). Because of this construction, it is easy to close the gap by a simple little turn of the hand. It works even on an old worn-out malitsa.

The hood is made of two-layered reindeer skin (fur out) and often has an additional fringe around the face hole made of wolverine, wolf, or dog fur (depends on particular ethnicity). It reduces the open part of the face and seals the gap between the face and the hood. The hole of the hood and the gaps between the mittens and sleeves serve to balance the internal heat.

There are different types of seams used in making a malitsa windproof. The seams are arranged in places that are less exposed to direct wind, that is, sides and the top (shoulders, sleeves). This location of seams is the most beneficial in terms of protecting them from all kinds of outer mechanical influences (while hunting, riding a sled, preparing firewood, working in the herd, etc.). Seams are sewn up with natural threads (i.e., reindeer tendons). This thread is naturally flexible but inelastic, very durable, and does not rot. While making a seam, a woman puts inside a piece of porous material: a bunch of reindeer hair or thin strips of cloth (in two or three layers). Both of these materials make the seam more flexible while keeping it dense, thick, and, therefore, windproof.

The cloth is more popular, due to its decorative features: different ethnicities use different colors and ornaments. Thus, the whole-cut construction of malitsa, its simple silhouette, and complicated seams provide durable protection from the wind factor.

Consideration for cold temperature is a very significant factor in making the malitsa. The main requirement for the material of clothes is to prevent airflows and drafts along the body. For example, the function of the fur is to keep warm by creating a constant air cushion between hot body and cold fleshy side of the leather. Thick and long hair securely embraces all parts of the human body, especially the most vulnerable ones, such as the back, the occipital part of the head, and the sides. The close-fitting fur forms small localities with a specific microclimate for each area of the body. The natural structure of the reindeer hair provides a very close contact between the fur and the human skin and, therefore, blocks any vertical airflow. The reindeer fur and the human skin result in close mechanical contact and increases thermal protection: when a human in malitsa moves, tough hairs massage the skin and improve the blood circulation. Apart from massage, the fur keeps the skin clean from dirt, oil, and waste products. In addition, the hair is hollow (has a tubular section); therefore, its heat emission is very low, almost zero.

All the properties described earlier make malitsa perfect clothes, but tell almost nothing about how it works as a personal shelter. Spending nights on duty with his reindeer, a herder has to sleep outdoors. For this purpose, the malitsa easily becomes a kind of sleeping bag: the man lies down on a sled or on the snow, bends his legs close to the body, and wraps them with a panda (the earlier-described fur skirt). Then he tightens the panda with his belt and folds the hood and sleeves inside. Finally, the man has packed himself closely into the fur bag, so the heat emission is decreased. The natives call this shelter a grouse chum (i.e., a white grouse usually sleeps burying itself in the snow).

Another feature of the malitsa is that the inner part above the belt forms a large and deep pocket: it is usually used for storing matches, tobacco, bullets, that is, everything required to be kept in a safe, dry, and warm place. In water, this pocket works like a float. Practically, Nenets people are outstanding fishermen and seamen. They are not afraid of high water, even of high waves. However, they cannot swim. Thus, dropping out of the boat, a man is able to keep himself above the water for a long time due to this float pocket: it gives him a chance either to climb up into the boat or to reach the shore or to wait for help, or . . . to leave for meeting Id-Yevr (i.e., the God of water).

Svetlana Usenyuk

See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit; Ket; Khanty; Koryak; Mansi; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Kaznacheev, V. *Sovremennye aspekty adaptatsii/Modern Aspects of Adaptation*. Novosibirsk, Moscow: SB Nauka, 1980.

Mansi

The Mansi, formerly known as the Voguls, live in the West Siberian Plain between the Urals and the Ob River (along its left tributaries such as Northern Sosva, Lyapin, Konda, and others). Administratively, most Mansi live in the eastern part of the Khanty-Mansi autonomous region (a.k.a. Yugra) of the Russian Federation. The Mansi can be divided into four groups—northern, southern, eastern, and western. They differ from each other linguistically as well as by material culture and subsistence practices. At the same time, the Mansi groups share many sociocultural features with their Khanty neighbors, including forms of social organization, folklore, and religion.

According to the 2010 Russian census, the Mansi population was 12,269. In the area dominated by immigrant population that number in hundreds of thousands, the Mansi constitute a tiny minority (e.g., only 0.7% in Yugra). Their number has shown some increase during the past decades. This is largely due to ethnic reidentification among the people who have Mansi ancestors.

Language

Mansi and Khanty, together with Hungarian, are known as Ugrian languages in the Finno-Ugrian (or Uralic) language family. Linguists distinguish four Mansi languages (Sosva, Pelym, Konda, and Tavda) from which only Sosva or Northern Mansi is used to some extent by older generation at present, being also the basis for the written language. At schools, Mansi is taught as a foreign language, which seems to have no power to reverse the process of quick language loss. Today, virtually all Mansi families are Russian speaking due to mixed marriages and the overall Russianization of social environment. In the 2010 census, only 6.8 percent of Mansi declared that they were fluent in their language. In less than a decade, the number of Mansi able to speak their language has decreased three times, which makes Mansi one of the most rapidly disappearing indigenous languages in Russia (e.g., 2007 vs. 682 Mansi speakers in Yugra, respectively, in the census of 2002 and 2010).

History and Subsistence

For more than the past thousand years, the Mansi have been pushed east- and northward from their earlier territories that were partly in Europe. During this period, furs have been the major reason for clashes and trade between different ethnic groups in the region. When the Russians started conquering Siberia in the sixteenth century, the Mansi, led by so-called princelings (as allies of Tatars), fought against the colonizers with longbows and arrows from their palisaded fortifications. They were gradually defeated in the sixteenth and early seventeenth centuries and made into fur taxpaying subjects. At that time, Russian traders and first peasants started to arrive to the sparsely populated territory, soon outnumbering the indigenous population. The new settlers did not always reach remote upper reaches of rivers that remained natives' safe havens.

Hunting, fishing, and gathering have been the chief means of Mansi subsistence. In addition to fur animals such as squirrel, they have hunted large animals (elk, bear) and fowl. The most common kind of fishing among the Mansi is by blocking a river with weirs and traps. Borrowed from Nenets in the late Middle Ages, Mansi have also been engaged in reindeer herding, especially those close to the Ural Mountains, which offered good summer pastures. Under the influence of agricultural neighbors, a few southern Mansi groups used to till soil and keep horses, sheep, and cows as a subsidiary occupation next to hunting and fishing. Depending on the region, Mansi have been leading either sedentary or mobile lifestyle. While southern Mansi were mostly sedentary, northern fishermen and hunters moved between seasonal camps. Every extended family had a base camp (yurt) with several log houses.

Throughout the Soviet period, the structure of the Mansi society was thoroughly changed by various repressive state campaigns, like collectivization, the boarding school system (since the 1960s' teaching was only in Russian), and relocation to large settlements, and by industrial development and the influx of newcomers from other parts of Russia. In the post-Soviet period, a small number of Mansi have continued to live in the forestland to be engaged in traditional subsistence practices. Elsewhere, the transmission of traditional knowledge and practices to the next generation has largely stopped.

Religion

Most Mansi were baptized in the often-violent campaigns of the eighteenth century organized by the Russian Orthodox Church. This and later conversions did not eradicate their own animist religion, which was to be practiced in secret, but added a few elements and characters to Mansi cosmology and ritual practices.

During the Soviet period, the ritual specialists were repressed and communal rituals forbidden.

Until today, many Mansi speak of their environment as animated by various kinds of spirits with whom communication requires appropriate behavior from humans. In some areas, clan and household deities are still addressed to, and sacrifices are made. Like Khanty, Mansi are known for their bear festivals in which a killed bear, which comes from the realm of spirits, is honored as a divine guest. During a three- to seven-day ritual that entails ritual consumption of meat, singing and dancing, the killed animal is convinced that no harm was meant by the community and is symbolically revived. The ritual activity is tied to a complex understanding of the reincarnation of souls that move between the realms of the dead, living, human, and animal.

Laur Vallikivi

See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit; Ket; Khanty; Koryak; Nenets; Nganasan; Selkup; Yukaghir

Further Reading

Skribnik, E. "Pragmatic Structuring in Northern Mansi. Congressus Nonus Internationalis Fenno-Ugristarum 2. Pars VI. Dissertaiones Sectionum." *Linguistica* III (2001): 222–39.

Spiocz, K. "Die wogulische Erde und das wogulische Volk (Mansi Country and its People)." *Specimina Sibirica* 8 (1993): 145–51.

McMurdo Dry Valleys of East Antarctica

Antarctica is not completely covered with ice. While more than 99 percent of the continental area is ice-covered, up to depths of several thousand meters, permanently ice-free areas do exist. These are restricted to coastal zones, the Antarctic Peninsula, exposed mountain peaks, and nunataks. Probably the best known ice-free area is the McMurdo Dry Valleys, comprising a roughly 1,544-square-mile (4,000-sq.-km) area of glaciated valleys on the eastern margins of the Ross Sea. This area was first explored by a party from Captain Robert Falcon Scott's 1903 Antarctic expedition and was (incorrectly) described as "an essentially sterile environment."

The valleys extend more than a 125-mile (200-km) latitudinal range (from around 75° S to 80° S) and from the Ross Sea coast for up to 25 miles (40 km) inland. Most of the Dry Valleys show a typical U-shaped topography, reflecting their glacial histories.

The valley floors comprise mixed glacial moraine deposits and are bordered by steep rocky slopes, some of which reach the 41° angle of repose. Most of the valleys are flanked or terminated by glacial tongues, which feed glacial meltwater streams in the summer months. The glacial tongues are fed by accumulating and compacting snowfall in the upper valley areas or high mountain circs and are, at present, mostly static, as shown by the limited extent of calving from the glacial walls. The ice in the lower horizons of the glacial front will be tens to hundreds of thousands of years old.

Many valleys have lakes fed by the glacial meltwater and sometimes feeding streams that flow to the sea. A well-known exception is the Wright Valley, where the Onyx River flows inland from a seaward glacier to Lake Vanda. All the larger lakes are permanently covered with a floating ice cap, although the shallow margins melt each summer to produce a moat of liquid water a few meters wide. These shallow lake margins are heavily populated by cyanobacterial mats and are some of the most bioproductive sites of continental Antarctica. A rapid freeze in late summer can produce perfect ice-rink conditions.

The climate of the Dry Valleys is extreme but still rather less extreme than that of the high cold ice cap. Mean annual temperatures are typically below −4°F (−20°C), but mean summer (November–January) air temperatures may be above 14°F (−10°C), and short periods of daytime air temperatures above 32°F (0°C) are not unknown. Soil temperatures are generally much higher than air temperatures, and midday soil temperatures of 59°F (15°C) have been recorded. Winter ground temperatures can be as low as −58°F (−50°C).

The McMurdo Dry Valleys retain their ice-free status courtesy of the very dry winds that typically sweep down (or up) the valleys. Precipitation in the Dry Valleys is also very low, averaging around 4 inches (10 cm) per year over a century of records, and all is in the form of snow. The dry winds rapidly evaporate the periodic snowfalls and little melts into the surface soils. In summer, the dry atmosphere and effects of solar heating result in evaporative clearance of snowfall within a matter of hours. The combination of low precipitation and desiccating atmosphere means that the McMurdo Dry Valleys are classified as hyperarid deserts (the most extreme of the desert classifications) and have the well-deserved status as the coldest, driest, deserts in the world.

The extreme climate of the Dry Valleys has a dramatic impact on the surface geology. A combination of freeze–thaw fracturing and sandblasting creates very unusual and often massive rock sculptures, especially in coarse and loosely grained granites. Hard fine-grained minerals can be ventifacted, with smooth, glossy, and beautiful pyramid structures generated by the constant abrasion of windblown sand and ice across the mineral surface.

Don Cowan

See also: McMurdo Dry Valleys of East Antarctica, Biology of

Further Reading

Bockheim, J. "Landform and Soil Development in the McMurdo Dry Valleys, Antarctica: A Regional Synthesis." *Arctic, Antarctic, and Alpine Research* 34, no. 3 (2002): 308–17.

Hodson, A., A. Anesio, M. Tranter, A. Fountain, M. Osborn, J. Priscu, J. Laybourn-Parry, and B. Sattler. "Glacial Ecosystems." *Ecological Monographs* 78, no. 1 (2008): 41–67.

Lewis, K., A. Fountain, and G. Dana. "Surface Energy Balance and Melt Water Production for a Dry Valley Glacier, Taylor Valley, Antarctica." *Annals of Glaciology* 27 (1998): 603–9.

McMurdo Dry Valleys of East Antarctica, Biology of

The McMurdo Dry Valleys were initially thought to be largely sterile environments, a not-unreasonable view given the extreme climate and the apparent absence of macrobiotic life (at least at first glance). However, closer inspection by scientists has proven this to be very wrong, and the Dry Valleys harbor a wide range of different habitats and a diversity of life forms, specially adapted to survive in the extremes of the Antarctic climate.

Aquatic Biology

Following the general concept that "where there is water, there will be life," the aquatic systems of the Dry Valleys are the most productive. The short Antarctic summer season produces a range of aquatic habitats: ephemeral glacial meltwater streams, shallow lake moats, glacial moraine ponds and glacial flushes. These shallow warm aquatic habitats support abundant macrobiological communities, physically and visually dominated by Cyanobacteria. The photosynthetic Cyanobacteria grow on the stream or lake beds in the form of thick plates or mats. Even if the water is still ice covered, light penetrating through the ice will support photosynthesis and oxygen production. Oxygen bubbles can be seen trapped in the overlying ice, following a slow melt path to the surface. Fragments of the dark green cyanobacterial mat also detach from the bottom and, buoyed by oxygen production and warmed by penetrating solar radiation, melt their way to the surface. This process can result in the accumulation of thick mats of dried cyanobacterial tissue around shallow highly productive lakes.

Flushes, area of level ground covered in summer by a few centimeters of glacial meltwater, are also highly productive. The shallow water depths, low flow characteristics, and solar gain from the dark cyanobacterial thalli (mostly a genus called *Nostoc*) make these the warmest of the Antarctic aquatic habitats.

Glacial meltwater streams also support cyanobacterial populations, but a combination of high peak flow rates (which can physically disrupt fragile cyanobacterial mats) and low water temperatures (limited solar heating) make these systems less productive than other aquatic habitats. However, stream margins do support some of the limited range of lower plants in the Dry Valleys, in the form of bryophyte (moss) clumps.

Two of the more unusual aquatic habitats of the Dry Valleys (and coastal Antarctic in general) are the moraine ponds and cryoconite holes. Moraine ponds are typically small (often a few meters in diameter) near circular ponds in marine ice-cored moraines. Seen from the air, the water is often colored bright green from the underlying cyanobacterial mats. Cryoconite holes are centimeter-sized surface holes in glacial ice, where a pebble lying on the surface has melted into the ice as a result of the solar heating. The melt path produces a vertical hole roughly the shape of the pebble and filled with liquid water. These short-lived aquatic microhabitats are rapidly colonized by microorganisms where the photosynthetic production of oxygen and the increased solar gain will prevent refreezing through the summer months.

Soil and Rock Biology

The mineral soils of the Dry Valley floors are, to all appearances, devoid of life. But microbiologists, using the latest DNA-based methods, have shown that these soils support extensive populations of soil bacteria and fungi. Nevertheless, cell numbers may only be 1 percent of populations found in temperate soils. The most active macrobiological communities are hidden (cryptic) and associated with translucent rocks. Cryptoendolithic (hidden, inside rocks), cryptohypolithic (hidden, under rocks), and cryptocasmolithic (hidden, in rock cracks) microbial communities are all the result of niche adaptations, where the rock provides some protection against the worst of the Antarctic climate. Endo- and hypolithic communities are all associated with translucent rock types, mostly quartz and sandstone, where the mineral structure allows sufficient light to pass through to the underlying biological community to support photosynthesis, while protecting the community from extreme desiccation, physical disturbance, and maybe even damage from UV radiation.

Lichens

Lichens represent the most obvious nonaquatic biology of the Dry Valleys. Many lichen species, the most common of which is a crustose lichen genus called *Buellia*, are found on the upper surfaces of large rocks and are completely exposed to the extreme Antarctic habitat. Strangely, such lichen growths seem to be largely restricted to higher altitude sites such as the mountains and intervalley ridges. The probable explanation for this unusual distribution pattern is that the higher frequency of fog, cloud, and snow events at high altitudes means that such habitats are wetter than the valley floors. Lichens are well known for their ability to absorb water directly from moist atmospheres and from fog.

The crustose lichens grow in a radial fashion from the outer margins and are very amenable to measurements of growth. Carefully calibrated photographic experiments, repeated in successive years, have suggested that radial growth rates may be as little as a few micrometers per year. The exception to the altitude-related distribution pattern of lichens is the coastal margins, where extensive highly colored lichen species can be found.

Don Cowan

See also: Antarctic Ice Sheet; Blood Falls, Antarctica; McMurdo Dry Valleys of East Antarctica; Microbial Survival

Further Reading

Marshall, W. and M. Chalmers. "Airborne Dispersal of Antarctic Terrestrial Algae and Cyanobacteria." *Ecography* 20 (1997): 584–94.

Ott, S. "Early Stages of Development in Usnea Antarctica Du Rietz in the South Shetland Islands, Northern Maritime Antarctica." *Lichenologist* 36 (2004): 413–23.

Mesozoic Marine Reptiles of Antarctica

Present-day marine life in the Antarctic continent is marked by the presence of medium- to large-sized marine vertebrates that reacquired the ability to live, at least part of their life, in water. These include cetaceans (whales and dolphins), pinnipeds (e.g., seals and sea lions), and penguins. However, during the Mesozoic (252–65 mya), the Antarctic seas were populated by marine reptiles that, despite being morphologically different and distantly related to their modern analogs, exhibited similar lifestyles and ecological strategies.

Mesozoic marine reptiles include groups such as plesiosaurs, ichthyosaurs, mosasaurs, turtles, crocodiles, and other less diverse and/or shorter-lived forms (geologically speaking), such as thalattosaurs, choristoderes, and pleurosaurs. In Antarctica, we have reliable records of plesiosaurs, mosasaurs, and marine turtles. Plesiosaurs lived between 200 and 65 mya and included diverse forms, such as small-headed, usually long-necked, fish and mollusk-eating plesiosauroids, and the short-necked, large-headed pliosauroids, some of which could reach at least 15 m in length and had teeth adapted for feeding on large prey. Mosasaurs were lizards highly adapted to an aquatic lifestyle. Mosasaurs lived between 93 and 65 mya, and most were adapted to capture large prey. They could be up to 17 m in length and reached a global distribution and large diversity of species within a short span of time. Turtles evolved during the Mesozoic, with the first known species coming from the Late Triassic (approx. 210 mya) of Germany, and have been interpreted as living at least partially in aquatic habitats. However, true sea turtles appear in the Early Cretaceous (105 mya) of Brazil and belong to the group Chelonioidea. This includes three families, Protostegidae, Dermochelydae, and Cheloniidae, of which the latter two still have living representatives, whereas the first one went extinct during the Late Cretaceous.

On the left, an elasmosaurid plesiosaur from Antarctica at Museu Nacional/ UFRJ in Rio de Janeiro, Brazil (picture and life reconstruction: Orlando Grillo and Maurílio Oliveira). On the right, a mounted skeleton of the mosasaur *Mosasaurus hoffmanni* at Natuurhistorisch Museum in Maastricht, the Netherlands (picture: Alessandro Palci).

Almost all of the marine reptiles, and actually most of the Mesozoic fossil vertebrate from Antarctica, come from the James Ross Basin in the Antarctic Peninsula, which includes strata from the Late Jurassic (161 mya) up to the Eocene (33 mya). Some of the oldest known marine reptiles from Antarctica are plesiosaurs from the Late Cretaceous of James Ross Island (85 mya). Plesiosaur materials include mainly vertebrae and represent specimens belonging for the most part to the family Elasmosauridae, such as *Mauisaurus.* This group included long-necked forms with teeth specialized for seizing fish and bottom-dwelling mollusks and are known from all continents. Another possible elasmosaurid living in Antarctica is *Aristonectes*, a long-necked plesiosaur with needlelike teeth. More recently, remains of plesiosaurs belonging to other families have been recovered from Antarctica, such as polycotylids, a group also found in North and South America, Africa, Asia, and Australia.

Mosasaur remains are more difficult to interpret. These include mostly teeth, which have high variability and convergent morphologies among species and families. However, combined with evidence from vertebrae and cranial material, there seems to have been representatives of both major lineages of mosasaurs in Antarctica, namely, the Mosasaurinae and Russellosaurina. This includes, among the Russellosaurina, *Taniwhasaurus antarcticus* (80 mya) from James Ross Island, the only known species of marine reptile exclusively known from Antarctica. Among the Mosasaurinae, remains of skull bones attributed to *Mosasaurus*, for example, those described by Fernández and Gasparini, have also been found on Seymour Island by Argentinean and British research expeditions.

Less well-represented fossils of marine reptiles include a chelonioid turtle of about the same age as the oldest plesiosaurs from Antarctica (85–88 mya). However, the family to which this single specimen belongs is unknown. Other well-known Mesozoic marine reptiles include ichthyosaurs, fish-shaped marine reptiles that lived between the Early Triassic and the beginning of Late Cretaceous (245–93 mya), and enjoyed a wide global distribution. Few specimens regarded as ichthyosaurians have been reported from Antarctica, but clear diagnostic material is essential. However, ichthyosaurs from the Early Cretaceous of the southernmost portion of South America have been described, already indicating that they did reach such high southern latitudes. No marine crocodile remains have been found in the Mesozoic of Antarctica, but one tooth proposed as belonging to a piscivorous crocodilian has been found in the Eocene (55–33 mya) of Seymour Island.

The diversity of mosasaurs is, apparently, wider than that of plesiosaurs, despite plesiosaur remains being more common, as suggested by Martin and collaborators. Furthermore, the fauna of plesiosaurs and mosasaurs includes representatives of taxa that are exclusive or more frequently found in the Southern Hemisphere. During the Santonian-Campanian (83–70 mya), *Taniwhasaurus* was also present in New Zealand and Japan. During the latest part of the Cretaceous (Maastrichtian, 70–65 mya), *Aristonectes* was also present in Argentina and Chile and *Mauisaurus* in Chile, New Zealand, and possibly Argentina. Therefore, at least during the end of the Cretaceous, marine dispersal was possible around these landmasses. Also, the predominance of juvenile specimens and shallow water environments in the James Ross Basin suggests that this was a site where these reptiles migrated to have their young. At the end of the Cretaceous, all these species went extinct in Antarctica, as well as all over the globe. Their ecological role as top or intermediate predators in the Antarctic marine ecosystem was partially replaced during the Cenozoic (65 mya to present) by aquatic marine mammals and birds.

Tiago Rodrigues Simões and Michael W. Caldwell

See also: Dinosaurs of Antarctica; Paleoecology of Antarctica; Pliocene Arctic Fossils

Further Reading

Fernández, M., and Z. Gasparini. "Campanian and Maastrichtian Mosasaurs from Antarctic Peninsula and Patagonia, Argentina." *Bulletin de la Societe Geologique de France* 183. (2012): 83.

Kellner, Alexander W. A., et al. "The Oldest Plesiosaur (Reptilia, Sauropterygia) from Antarctica." *Polar Research* 30 (2011).

Martin, J., and J. Crame. "Palaeobiological Significance of High-Latitude Late Cretaceous Vertebrate Fossils from the James Ross Basin, Antarctica." *Geological Society Special Publications* 258 (2006).

Motani, R. "The Evolution of Marine Reptiles." *Evolution: Education and Outreach* 2, no. 2 (2009): 224–35.

Meteorites in Antarctica

Interplanetary space is not a vacuum: it is teeming with objects of various sizes, from microscopic electrons and ions to large pieces of space debris. Some of these objects end up on earth. A *meteoroid* is a natural object with size between 10 μm and 1 m moving through space. *Asteroids* are bigger than meteoroids but smaller than a planet, and without their own atmosphere. Most meteoroids have a mass of less than a few grams, originating as fragments from asteroids, comets, and planets. They are often concentrated in a *meteoroid stream*, which is the debris left in the trail of a comet. A meteoroid or asteroid that enters the earth's atmosphere produces a *meteor* (or shooting star), which is the visible trail formed as it falls through the atmosphere. When the earth passes through a meteoroid stream, a *meteor shower* is observed.

Meteoroids enter the earth's atmosphere at speeds up to about 156,585 mph (251,999 km/h). Speed, size, incidence angle, and degree of fragmentation determine whether or not a meteoroid reaches the ground. Those meteoroids that penetrate the surface of the earth and survive the impact are known as *meteorites.* Meteorites are found everywhere on earth, but most have been discovered in Antarctica where they are clearly visible on the snowy surface or embedded in ice.

The flux of meteoritic material to the surface of the earth is between 104 and 106 kg per year. A meteorite with a size of 1 m hits the earth on average once per year. Smaller meteorites are more common, while larger ones are relatively rare. Larger meteorites can produce extensive craters like the Vredefort crater in South Africa, which is 300 km in diameter. A meteorite with a size of 3,280 ft. (1,000 m) would have a cataclysmic effect, but fortunately, such impacts are rare: roughly once every million years. Many hundred meteorites, each with a mass of a few grams, strike the earth every day. The majority of meteorites originate from tiny meteoroids that are so light that they slow down rapidly in the atmosphere. These are deposited as microscopic dust.

Meteorites are classified as stony (94% of all meteorites; composed of silicate minerals), iron (5%; alloys of nickel and iron), or stony-iron (1%; composites of stony and metallic materials). Although stony meteorites are the most common, they are more difficult to identify since they are similar to normal terrestrial rocks. Iron meteorites are readily identified since they are magnetic and denser than most terrestrial rocks. They are also the most likely to reach the ground since they seldom fragment.

Initial estimates of meteorite flux were made from eyewitness accounts. Such *meteorite falls* (where the meteor trail was observed) are naturally more common in densely populated areas. Unfortunately, such estimates are bedeviled by large uncertainties. Recent meteorite flux data have been recorded by camera networks. These too suffer from difficulties in calibrating the images of meteor trails to meteorite masses. However, *meteorite finds* (where the meteor trail was not observed, but the meteorite itself was discovered) present a robust history that extends back thousands of years. The hot deserts and Antarctica have favorable conditions for meteorite accumulation: weathering occurs slowly, and meteorites are easily recognized against a uniform background that is relatively free of other rocks. Meteorites can survive in these regions for more than 100,000 years, allowing variations in meteorite flux and mass distribution to be estimated. Some meteorites found in Antarctica had been there for more than 1 million years. Furthermore, there is evidence to suggest that some of the meteorites found in Antarctica contain material that originated either from the Moon or Mars.

More than 30,000 meteorites have been retrieved from Antarctica by various expeditions during the past 30 years. This exceeds the entire population of meteorites collected over the rest of the earth. Differences in the populations of recent meteorite falls and Antarctic meteorite finds indicate that the characteristics of meteorites landing on earth are changing with time as debris from the early solar system is progressively swept up.

The fate of a meteorite that falls onto Antarctica depends on the nature of the surface and the typical weather conditions. If it falls on ice, then it may remain exposed for a long time. Alternatively, it might become covered by snow and ultimately trapped in solid ice. There is a general flow of ice toward the periphery of the continent, so that these meteorites are eventually deposited in the Southern Ocean. The motion of the ice sheet can be slowed by mountain ranges, and meteorites embedded in the ice become concentrated in *stranding zones.* If the ice either evaporates via sublimation or is ablated by the wind, trapped meteorites become exposed, leading to high meteorite concentrations. The history of meteorite falls in the Antarctic can be deduced from stranding zones and ice cores.

Andrew B. Collier

See also: Bellingshausen Sea

Further Reading

Allen, C., J. Allton, G. Lofgren, K. Righter, and M. Zolensky. "Curating NASA's Extraterrestrial Samples—Past, Present, and Future." *Chemie der Erde* 71, no. 1 (2011): 1–20.

Bogard, D., and P. Johnson. "Martian Gases in an Antarctic Meteorite?" *Science* 221 (1983), 651–54.

Cassidy, W. *Meteorites, Ice, and Antarctica: A Personal Account.* Studies in Polar Research. Cambridge: Cambridge University Press, 2003.

Microbial Survival

The environmental conditions that are measured within the frozen realm of the earth (e.g., cryosphere) are extreme in comparison with global means. Factors such as subzero temperatures, lack of liquid water, low nutrient availability, high UV irradiation during summer months, and lack of light during winter months characterize some of these environments. Despite this, microorganisms have been found within every environment that has been studied within the cryosphere: from marine waters, rock surfaces, and permafrost soils, to the vast and seemingly barren snow and ice expanses.

Many microbial communities that have been studied within these regions have been found to be actively metabolizing. Furthermore, several research studies have found that polar microbial activity rates are comparable with those of microbial communities that are found at lower latitudes and altitudes. For microbial communities to be metabolically active under the physical and chemical parameters of the cryosphere, these organisms often possess physiological characteristics that facilitate their survival.

Cold temperatures pose a challenge to biological viability due to the destructive effects of ice crystals. In response to subzero temperatures, the cellular production of antifreeze proteins, which bind to ice crystals and extracellular proteins, and which form protective layers around cells, often reduces the damaging effects associated with crystal formation. Cryoprotectants, such as these, may additionally prevent against repeated freeze–thaw cycles.

Typically, biological activity is reduced in cold temperatures, due to factors such as reductions in molecular kinetics and restrictions in cellular membrane plasticity. Cold-adapted organisms typically have an altered membrane composition. The membranes of these organisms often contain factors such as a higher content of unsaturated, polyunsaturated, and/or methyl-branched fatty acids. Adaptations in membrane composition ensure that membranes can remain fluid and dynamic within a range of subzero temperatures. During sudden changes in temperature, cold-shock proteins can be produced to facilitate metabolic activities and membrane fluidity. Furthermore, psychrophilic (cold-loving) organisms may use cold-adapted enzymes, which have a high specific activity at low temperatures, ensuring that the optimum enzymatic kinetic activity occurs within the temperature ranges of the cryosphere.

During the polar summer months, the sensitive photosynthetic apparatus of autotrophic organisms (organisms that are able to produce complex chemical compounds using solar energy) is vulnerable to the perpetual, intense, and damaging effects of solar radiation. Within the cryosphere, many autotrophs, including Cyanobacteria, Chloroplastida, and algae, have protective pigments, which prevent against biological damage as a result of harmful UV radiation. The wide-ranging photosynthetic pigments that are contained by these autotrophic organisms include chlorophylls, carotenoids, scytonemins, phycobiliproteins, and oligosaccharide mycosporine-like amino acids.

Polar regions, winter months, present a challenging environment for microbial communities. Without solar inputs, there is an absence of autotrophic organic matter production. Therefore, as the winter progresses, biologically available nutrient resources become depleted. If communities are to survive throughout these periods, they must either preserve themselves into a state of dormancy, to reduce their consumption of nutritional supplies, or they must rely on light-independent mechanisms to obtain energy sources.

In general, autotrophic organisms have been noted for their adaptive psychrotolerant (cold-tolerant) properties against several environmental factors such as cold temperatures, high solar radiation, fluctuations in salinity, and tolerance to prolonged dormancy and freeze–thaw cycles. Heterotrophic organisms (organisms that must consume organic carbon for their growth) within these environments are thought to be more psychrophilic and are often more specifically tailored to cope with polar conditions.

The physical and chemical compositions of many ecosystems that are found within the cryosphere present interesting systems to study. For example, brine channels in sea ice establish superconcentrated saline waters, polar deserts in Antarctic are highly desiccated, and ice-covered lakes can be ultraoligotrophic (lacking nutrients). While much research remains to be done to fully understand the mechanisms that enable microbial survival within each of these environments, investigations into the associated microbial specializations continue to unlock many secrets of these underexplored communities and ecosystems.

Karen A. Cameron

See also: Cryoconite Holes; Cryoprotectorants

Further Reading

Margesin, R., and V. Miteva. "Diversity and Ecology of Psychrophilic Microorganisms." *Research in Microbiology* 162, no. 3 (2011): 346–61.

Morgan-Kiss, R. M., et al. "Adaptation and Acclimation of Photosynthetic Microorganisms to Permanently Cold Environments." *Microbial and Molecular Biology Reviews* 70 (2006).

Migration Waves of the Eskimo-Aleut

How the indigenous group's migrations waves crossed the Bering Land Bridge (BLB) from Siberia is assumed, but it remains inconclusive. It is presently assumed that there were three migration waves that crossed the BLB from Siberia rather than one unified migration wave. Evidence of the three wave migration patterns is based on genetic and linguistic differences of the three groups. Briefly, the first migration wave occurred about 15,000 BC, and this group is referred to as the Clovis. It is assumed that the Clovis group traveled more of a coastal migration path from the BLB down to modern-day North and South America. They are considered to be the modern indigenous groups living in South America and mostly in the contiguous 48 states.

Around 10,500–9,000 BP, the second migration wave that crossed the BLB from Siberia was the Na-Dene people or Athabaskans. The Na-Dene groups migrated as far south as the modern-day Four Corners area (e.g., the Navajo and Apaches of Arizona, Nevada, New Mexico, and Colorado) and the others spread across parts of coastal and prairie lands of modern-day Canada due to melting glaciers. The Navajo and Apaches and small tribes in the coastal areas of Washington, Oregon, and northern California are not frequently considered as part of the migration wave and are frequently and incorrectly included with the first migration wave of the Clovis or Native American groups.

The third wave was the Eskimo-Aleut group around 4,000 BP. This last wave was the first to populate and inhabit the Arctic coastal zones of Alaska, Canada, and Greenland. The ancestors of this group are modern-day Eskimo/Inuit and the Aleut groups. The Yup'ik, Inupiat, and Aleut groups were considered nomadic and primarily marine coastal-based groups. For example, the Yup'ik and Eskimo economies were traditionally based on marine mammals (e.g., whales, seals, and walrus), birds, and fish, which they used for food, heat, tools, and the making of clothing. The Aleut group had similar cultural and subsistence uses of marine mammals (e.g., birds and fish), but differed enough to be considered unique from the Yup'ik and Eskimo/Inuit groups. The Aleut group is considered distinct from the Inuit/Eskimo groups.

The genetic evidence lends some support to the three migration waves, but it remains inconclusive. Those arguing in favor of the three waves claim that the Na-Dene (Athabaskans) and Eskimo-Aleut have a genetic mutation that differentiates them from the Clovis group and other populations. Alaskan Natives exhibit a genetic mutation in the haplogroup Q (Y-DNA). Identification of this distinct genetic mutation has aided researchers in identifying ancestral differences between the three discrete migration waves. The genetic differences between the three migration waves also enabled researchers to determine the approximate time of the migration waves. The genetic evidence supports the three migration wave hypothesis; however, researchers have noted that the second and third waves mixed with the first wave. For example, the Inuit/Eskimo groups have inherited approximately half of their DNA from first migration group and the other half from the second wave, thus making it difficult to use genetic studies as conclusive evidence of the three distinct migration waves.

Although originally the majority of linguists supported the three wave migration hypothesis, some linguistics claim the three migration waves based on language are from a single ancestral language originating in Asia and most likely the Amerind group. In other words, the three groups were from the same ancestors but crossed the BLB from Siberia at different times, which resulted in culturally different groups. Genetic studies have not confirmed this hypothesis conclusively. Other linguists claim that the groups do not share a common Asian ancestor and are three discrete groups. The use of linguistic patterns to support genetic evidence is inconclusive because of disciplinary differences in classification schemes and difficulties in tracing ancestry because of the genetic mixing (e.g., admixture) overtime.

Andrew J. Hund

See also: Aleuts/Unangax; Chukchi; Eskimos

Further Reading

Langdon, S. *The Native People of Alaska.* 4th ed. Anchorage, AK: Greatland Graphics, 2002.

McClanahan, A., and H. Bissett. *Na'eda, Our Friends: A Guide to Alaska Native Corporations, Tribes, Cultures, ANCSA, and More.* Anchorage, AK: CIRI Foundation, 2003.

Sháa Tláa Williams, A., ed. *The Alaska Native Reader: History, Culture, Politics.* Durham, NC: Duke University Press, 2009.

Musk Oxen

The musk ox (*Ovibos moschatus*) is a large Arctic mammal native to the Arctic regions of Greenland, Canada, and Alaska, yet it has been extirpated from Alaska in the last half of the nineteenth century. Today, native populations of musk oxen are found in northeastern Greenland, as well as in the Canadian Arctic Archipelago and mainland. Introduced populations are found in western Greenland, Alaska, Sweden, Norway, and Russia. The musk ox is an iconic Arctic mammal, recognized for its characteristic appearance, its ecological role as one of the few large Arctic herbivores, and its importance in Inuit lifestyle for centuries.

Musk ox. (Shutterstock.com)

The musk ox is a gregarious Arctic ungulate easily recognized for its long and curved horns found in both sexes, as well as its outer coat of long guard hairs that hang near to the ground. Underneath this outer shaggy coat is found a fine, soft, and insulating fur, referred to as "qiviut" by Inuit people. Musk oxen can attain up to 5 ft. (1.5 m) in height at the shoulder and measure up to 6.5–8 ft. (2.0–2.5 m) in length. Bulls can weigh between around 600 and 830 pounds (270–380 kg), and cows are estimated to weight approximately 60 percent of males' weight (around 360–500 pounds [165–225 kg]).

Graminoids and shrubs constitute important components of musk ox diet. During summer, musk oxen feed in bogs and wet meadows, whereas winter feeding occurs mostly in areas where wind reduces or eliminates snow cover, making forage more easily accessible. The wolf is the main predator of musk oxen, although predation by grizzly or polar bears has been observed. When circled by wolves, musk oxen will adopt a defense formation shaped as a circle or a star, but can also line up if the threat comes from one direction. Musk ox's defense formation has sparked popular interest. It can be triggered by any disturbance, which leads cows, calves, and juveniles to run to a bull.

The musk ox, refer to as "umingmak" or the bearded one by Inuit people, is one of the species that has been at the heart of Inuit culture for centuries. Its meat has been used as an important traditional food source in some parts of its distribution, whereas hides and fur have provided the much-needed insulation and protection required in these cold lands.

At the end of the nineteenth century, a general decline in musk ox numbers was observed across Alaska and Arctic Canada mainland. In Alaska, this decline led to extirpation in the late 1800s or early 1900s. This decline was attributed to unsustainable harvesting pressures, as well as to climatic variations and natural fluctuations in numbers. The Canadian government prohibited musk ox harvest between 1917 and 1969, and the American Government launched a reintroduction program in the 1930s. Canadian musk oxen populations have now recovered in most of their historical range, while a small fraction of the historical Alaskan range has been recolonized.

Marie-Andrée Giroux

See also: Arctic Fox; Arctic Ground Squirrel; Arctic Hare; Arctic Seabirds; Arctic Wolf; Caribou; Dogs in the Arctic; Lemmings; Polar Bear; Wolverine

Further Reading

Bennike, O., and C. Andreasen. "New Dates of Musk-Ox (*Ovibos moschatus*) Remains from Northwest Greenland." *Polar Record* 41, no. 2 (2005): 125.

Gray, D. "Standing His Ground: How the Musk Ox Survives the Rigors of an Arctic Winter." *Nature Canada* 15 (1986): 19–26.

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Naklik. *See* Inuit Concepts of "Naklik" and "Ilira"

Narwhal

The narwhal (*Monodon monoceros*) is a medium-sized odontocete, or toothed whale, famous for the long spiral tusk that erupts from the head of males. A narwhal has only two teeth. The teeth usually do not erupt through the gum at all in females, but in the males, the left tooth generally grows outward in a spiral up to 10 ft. long. Narwhal sightings long ago are believed to have started, or reinforced, the legend of the unicorn. In very rare cases, a female is found with a tusk, or a male is found with two tusks. Narwhals spend their lives migrating through the Arctic waters bordering North America, Greenland, and Russia.

Appearance

The skin color of the narwhal changes with age. Newborns are a mottled blue-gray. Juveniles are solidly dark gray and become increasingly spotted with white as they age. Very old narwhals can be almost completely white. They have small rounded heads and short flippers with upturned tips. Where most other whales and dolphins have a dorsal fin, the narwhal has a low bumpy ridge along their spine. They also have a thick layer of blubber to insulate them from icy Arctic waters. Males can grow to about 16 ft. long (5 m) and weigh up to 4,000 pounds (1,800 kg). Females are smaller, reaching a length of 13 ft. (4 m) and 2,200 pounds (1,000 kg).

The scientific name of the narwhal (*Monodon monoceros*) is derived from the Greek "one tooth, one horn." Their mottled skin coloration likely contributed to their common name. Narwhal comes from the Norwegian *nar* for corpse and *hval* for whale. It is assumed the corpse whale was named for its blotchy, corpse-like coloration, but the name could also reflect its habit of swimming slowly along in a sideways or completely upside-down position.

Migration and Reproduction

Narwhals have a distinct seasonal migratory pattern. They travel in pods that can be as small as two animals and as large as several hundreds. Narwhals are the only whale to spend the winter in small groups deep under pack ice. They surface to breathe at long thin openings in the ice called "leads," created when currents or wind shift sheets of pack ice. The openings constantly change and are not permanent. It is not clear why these animals travel to such an inhospitable place for the winter. It has been suggested that reliable halibut resources in very deep waters are enough of a draw to withstand the ice or that the ice is protection from their main predator, the killer whale. They migrate northward through the pack ice in late May and June, summering in large groups in the open coastal waters around northern Baffin Island and the shores of northern Greenland. Prior to the formation of new ice in October, they again travel southward to their wintering grounds far offshore.

Most narwhal births occur during the summer months. Females reach sexual maturity after five years, and males breed at eight years. Mating season occurs in late spring, with most births happening the following July. After a 15-month gestation period, a female narwhal gives birth to one calf that stays by her side for about 20 months. Therefore, female narwhals give birth only every three years. Narwhals are very elusive animals, so the actual population is difficult to determine, but most estimates range between 50,000 and 80,000 narwhals worldwide.

Diet

A narwhal's diet is fairly restricted. In summer, they make relatively shallow dives, usually lasting a few minutes. Polar cod and Greenland halibut are the primary food source, although Arctic cod, squid, and shrimps are also eaten. As narwhal begin their migration in the fall, dive depths and durations increase, even though they are traveling rapidly out to sea. Once they arrive at their wintering grounds, they stay in a limited area and start doing some of the deepest dives ever recorded by marine mammals. Narwhals will typically dive more than 1,500 ft. down (450 m), up to 25 times per day. Many dives will reach more than 4,500 ft. (1,300 m), lasting about 25 minutes each. At that depth, there is intense pressure, no oxygen, and no light. Narwhals have unique features to enable these activities. Their lungs, blood, and muscles can carry more oxygen than almost any other animal and their rib cages are able to compress, to resist the pressure. Narwhals can also selectively cut off the flow of oxygen to noncritical body parts to reserve oxygen. All this is to enable them to feed on halibut and squid found at the bottom of the sea in winter.

Narwhals are very important to native communities in the Arctic. Inuit hunters have been harvesting this mammal for thousands of years. Today, researchers work with native populations to ensure that hunting is carried out in a sustainable way, so this fascinating mammal does not become endangered.

Jill M. Church

See also: Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal Tooth; Northern Bottlenose Whale; Southern

Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Bruemmer, F. *The Narwhal: Unicorn of the Sea.* Toronto: Key Porter Books, 1993.

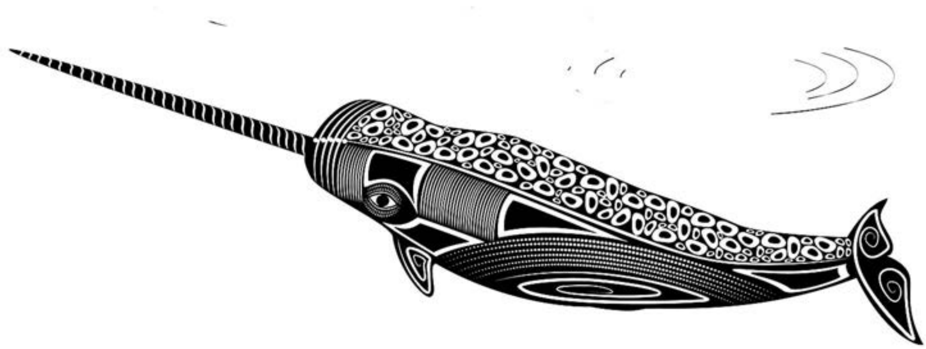
Paine, S. *The World of Arctic Whales: Belugas, Bowheads, and Narwhals.* San Francisco: Sierra Club Books, 1995.

Tucker, A. "In Search of the Mysterious Narwhal." *Smithsonian* 40(2) (2009). http://www.smithsonianmag.com/science-nature/in-search-of-the-mysterious-narwhal-124904726/?no-ist.

Narwhal Tooth

The narwhal is one of two living species of white whales that belong to the Monodontide superfamily. Monodontides are characterized by having a large forehead, a short snout, two arm-like flippers, and a large split tail. Narwhals live year-round in the Arctic and are primarily found in Greenland and the Canadian Arctic. Narwhal males are distinguished from their female counterparts by a long straight helical tooth that protrudes out from their mouth. The species name for the narwhal is *Monodon monoceros*, which comes from the Greek meaning "one-toothed unicorn." The name "narwhal" is derived from the Old Norse word *nár*, which means "corpse" and makes reference to the gray-like color of a person who has drowned. Dolphins and porpoises are also known as "white whales," but narwhals and beluga whales make up a separate genetic category, which is known to have come into existence within the past 11 million years. The narwhal whale is considered a nearly threatened species that is vulnerable to climate change due to its limited diet and geographical location. For approximately the past thousand years, the narwhal has continued to be a part of subsistence hunt carried out by Natives of Greenland and northern Canada known as the "Inuit."

In most cases, the unique tooth of the male narwhal consists of a single spiral or helical canine tooth, which looks like the tusk of the fictitious unicorn. The tooth protrudes out of the left side of the upper jaw. In rare instances (approx. 1 in 500), narwhals can have up to two teeth. In addition, there are some narwhals that have one small tooth inside their mouths, but appear to be toothless. The tooth of the female narwhal whale is shorter and straighter in comparison with the tooth of the male. There is only one recorded case of a female with two teeth. The narwhal tool is hollow and light (less than 25 pounds in adults) and grows slowly throughout its lifetime. Darwin hypothesized that the narwhal tusk represented a secondary sexual characteristic similar to the tail feathers of a male peacock. The tooth helps young males develop skills necessary for social dominance hierarchies. One way that male narwhals are known to maintain their social dominance is to participate



A decorative narwhal totem depiction. (Shutterstock.com)

in an activity known as "tusking." During this activity, bulls rub their tusks together. Instances where the narwhal whale tooth has been used for aggressive acts such as fighting are rare. Narwhals catch their prey by powerfully sucking it into their mouths. Overall, narwhals are known to be a migratory species, and as spring comes, they return to coastal bays in pods. In summer, several pods may join together to form a larger community as large as 1,000 whales.

Karen Knaus

See also: Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Northern Bottlenose Whale; Southern Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Heide-Jørgensen, M. P., and K. L. Laidre. *Greenland's Winter Whales: The Beluga, the Narwhal and the Bowhead Whale.* Nuuk, Greenland: Ilinniusiorfik Undervisningsmiddelforlag, 2006.

Silverman, H., and M. Dunbar. "Aggressive Tusk Use by the Narwhal (*Monodon monoceros* L.)." *Nature* 284, no. 5751 (1980): 56–57.

National Petroleum Reserve—Alaska (NPR-A)

For thousands of years, Alaska's Arctic has been inhabited by many indigenous tribes and people. These native people never lost in a traditional warfare against the white man. Instead, when Russia claimed Alaska, and when the infamous Seward's Folly was completed with America, all land rights were simply transferred to the

U.S. government (including the Alaskan native tribal rights of their obtained land and resources).

At that time, neither the oil and gas resource wealth nor the strategic position of Alaska was really appreciated yet. But now, that situation has changed dramatically. Together with the large military impact, the income from the oil companies acting in Prudhoe Bay (Deadhorse) and at other places has become the major topic for the state of Alaska and for its people: financially, socially, and environmentally. Consequently, the political power of international oil and gas companies has risen dramatically, changing virtually the entire U.S. culture, as well as those of Canada, Norway, the Western world, and now also Asia (e.g., Russia, China, Japan, South Korea, Taiwan, and Singapore). Without Arctic oil and gas, the global fabric would be very different.

It is in that wider context in which the situation of the National Petroleum Reserve—Alaska (NPR-A) operates. With approximately 23 million acres (9.3 million hectares), it is the largest tract of undisturbed land (wilderness) in the entire United States. It was initially designated by President W. G. Harding in 1923 as a petroleum reserve for the navy and currently is administered by the Bureau of Land Management. But NPR-A is not the only potential place for Arctic oil: the Arctic National Wildlife Reserve (ANWR) is located just to the east, and another major oil reserve (Area 1002) is readily located adjacent on the coast. (Offshore reserves are also becoming attractive.) This is all embedded by tribal lands.

Most of the oil- and gas-related land claims in Alaska were basically settled by 1980 with the Alaska National Interest Lands Conservation Act through President Jimmy Carter; it allowed for drilling but only when an Environmental Impact Statement was done first. In the aftermath of the Exxon Valdez oil spill, drilling in the Arctic became a buzzword for the environmental movement and with large implications for NPR-A. After much public haggling, initial deals were reached where exploration, as well as extractive activities, could go on outside of NPR-A (e.g., offshore), so that NPR-A in itself would basically be spared. For subsequent decades, though, the pendulum swung between development/drilling and protection. Caribou, waterbirds, high grizzly bear concentrations, social impact, and climate change impacts were widely cited as reasons not to drill. Four special areas have been designated in NPR-A (Teshekpuk Lake, Colville River, and Uktokok River Uplands and Kasegaluk Lagoon); they are seen as most precious locations for nature and on a global scale. Jobs, national security, and estimated resources located on the North Slope were put forward in favor of drilling. Sarah Palin ran a political campaign shouting “Drill Baby Drill” in support of NPR-A development, and drilling has been promoted by the Bush administration and virtually all of the Alaskan senators, governors, representatives, and legislatures during the past 25 years. In 1986, the U.S. Fish and Wildlife

Service wanted to open the entire Arctic coast for oil and gas development with the argument of national security and jobs. The U.S. Geological Service (USGS) hardly sees it any differently.

Many lease sales have already been made in NPR-A. The sole explorer currently is Linc Energy, an Australian company. But the Anchorage-based NordAq Energy company and a subsidiary of the Canadian Talisman Energy Inc. hold offshore leases. Other companies considered for such work are Conoco Phillips from Texas and Anadarko Petroleum Co. Most environmental activists campaigned against drilling. The native population is usually also against drilling. For example, Alaska's Inter-Tribal Council, including the Gwich'in tribe in Canada, officially opposes any development in ANWR. And the village of Kaktovik has officially declared the Shell Oil Company *a hostile and dangerous force*.

NPR-A is a federally owned reserve. But the actual undersurface rights are owned by all Alaskans (an inherent right in the state constitution). Therefore, taxes are to be paid either way. NPR-A's fate is obviously directly related to Alaska's oil and gas production tax (ACES) and whether it is profitable enough to operate there. Keep in mind: most development projects in Alaska have basically waived their cleanup costs, which creates a public subsidy favoring the destruction of Alaskan environments.

The USGS now only estimates one-tenth of the oil that was initially assumed to be there in 2002 (instead consisting of natural gas). Further, it was pointed out by experts that OPEC's marketing campaigns alone could easily nullify Alaska's oil from NPR-A. Most of the other oil production in Alaska is already way over the peak and declining.

Arguably, development of NPR-A would leave a massive footprint, not only in the atmosphere but also on the ground and with the wilderness and ecological services (fresh air, clean water, subsistence harvest, social fabric, landscape esthetics, sound scape, light pollution, new road and bridge constructions, etc.). Even the industry itself predicts oil spills on the North Slope, and many saltwater spills are already known and part of the long list of environmental problems in Alaska (a state where more than three superfund sites are already located). Despite no development, NPR-A holds already more than 130 test wells.

Drilling or not, the dynamics of NPR-A are driven by politics, public opinion, the media, some science, outside lobbies, funding, and global dynamics. Contractors and investments play a huge role in this setup, for example, for exploration, development, lobbying, environmental impact assessment, cleanup, and mitigation. With that, the fate of NPR-A and Alaska's wilderness is not in the hands of Alaskans really and hardly with Americans anymore. Instead, global politics will shape this unique piece of Arctic tundra and wilderness, which acts as a climate chamber for the entire earth. Considering that Arctic shipping is on the rise, the human population is growing toward 9 billion, sea ice is retreating, polar bears and other ice-related species will likely to go extinct in the next 50 years, sea level is rising, permafrost is melting, and coastlines are eroding, there can be no good future for NPR-A as long as a high resource consumption paradigm remains in the United States and globally.

Falk Huettmann

See also: Alaska Native Claims Settlement Act (ANCSA) 1971; Colville River

Further Reading

Banerjee, S. *Arctic Voices: Resistance at the Tipping Points.* New York: Seven Stories Press, 2012.

Huettmann, F. *Protection of the Three Poles.* Tokyo: Springer, 2012.

National Research Council. *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope.* Washington, DC: National Academies Press, 2013. www.nap.edu.

Natural System of Wrangel Island Reserve

A critically important cultural or physical space on the planet if deemed significant can be designated as a world heritage site under the United Nations Educational, Scientific, and Cultural Organization (UNESCO). To date, there have been 981 UNESCO world heritage sites, of which 5 are located in the Arctic. The Natural System of Wrangel Island Reserve is one of five Arctic UNESCO world heritage sites.

The Natural System of Wrangel Island Reserve was listed as a UNESCO world heritage site, in 2004. The UNESCO listing includes Wrangel (71° 14′N 179° 25′W) and Herald (71° 23′N 175° 40′W) Islands and the surrounding waters. Most of Wrangel Island is a federally protected nature sanctuary of the Russian Federation. It was listed as a world heritage site because of its unique and diverse flora and fauna. During the Quaternary Ice Age, Wrangel Island was not glaciated, and this resulted in it being an especially diverse ecologically region. Up until about 2500–2000 BC, the island was inhabited by the last remaining woolly mammoths. Presently, the island is home to a high concentration of polar bears and dens, walruses, and is a major feeding area for gray whales that migrate from Mexico. It is also home to more than 400 plant species and two dozen resident bird species, and is a northern nursery for about 100 migratory bird species.

Andrew J. Hund

See also: Ilulissat Icefjord; Laponian Area; Putorana Plateau; Rock Art of Alta

Further Reading

"Natural System of Wrangel Island Reserve," UNESCO. http://whc.unesco.org/en/list/1023. Accessed January 13, 2014.

Nenets

The Nenets (marks the singular and plural nouns, and the adjective form in English) are the largest among the so-called numerically small indigenous peoples of Arctic Russia. While they were earlier known as Samoyeds or Yuraks, their current ethnonym is derived from the indigenous word *nenets*, meaning "man," "human." There are two main Nenets subgroups called the "Tundra Nenets" and the Forest Nenets that speak closely related languages. The overall number of Nenets is around 45,000 and has been on increase for a long time (44,640 in 2010 compared with 41,302 in 2002). It is estimated that around one-third of them are still nomads.

As their name shows, the Tundra Nenets live in the tundra (but also in the forest tundra in winter) occupying a 2,000-km long stretch along the Arctic Ocean from the Mezen River in the west to the estuary of the Yenisei River in the east. Most Nenets live in the Yamal-Nenets and Nenets autonomous regions, Komi republic, and Taimyr municipal district. Small communities inhabit also the Kolguev and Vaigachislands, as well as the Kola Peninsula.

The Forest Nenets, who call themselves *nyeshchang*, number around 2,000. They live further south in the boggy lowland areas where the open tundra transforms into

An elderly Nenets reindeer herder sits on his sled among the buildings of the Val. (Misha Japaridze/AP Photos)

A Nenets family—father and son—reindeer herders, in the Far North, Russia. (Stphoto/Dreamstime.com)

the taiga along the Pur River in the Yamal-Nenets autonomous region and the tributaries of the Ob (Agan, Lyamin, Kazym) in the Khanty-Mansi autonomous region.

Language

The Tundra and Forest Nenets languages belong to the Samoyed branch of the Finno-Ugrian (Uralic) linguistic family. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the Tundra and Forest Nenets languages are endangered. There are about 30,000 fluent speakers of the Tundra Nenets language and 1,500 fluent speakers of the Forest Nenets language. UNESCO classifies Tundra Nenets as definitely endangered and the Forest Nenets language is listed as severely endangered. Currently, less than half of all Nenets (44 percent) can speak their heritage language. Speakers of Tundra and Forest Nenets do not understand the other languages. The standardized written language was created in 1932 for Tundra Nenets and 1993 for Forest Nenets.

History and Subsistence

The Tundra Nenets who spend most of the year in the treeless areas as pastoral nomads rely on the reindeer—the species that has made continuous human presence in the Arctic possible for millennia. Two thousand years ago, the inhabitants of the lower Ob area (possibly Nenets' ancestors) had domesticated reindeer for pulling sledges, while wild reindeer remained the main source of meat and hides. Only in the seventeenth–eighteenth centuries, we see a sudden increase in domesticated reindeer among the Nenets, most likely because of the decline of wild reindeer populations as well as because of the need for greater mobility when confronted with growing Russian pressure. Although Novgorodians visited the Nenets areas already in the eleventh century with the aim of obtaining precious furs, the first Russian fort in the tundra was erected in 1499 (called "Pustozersk" on the lower Pechora). From then on, the Russian settlements served as tax-collection and trading points. Until the mid-eighteenth century, reindeer herders attacked these settlements from time to time to free the hostages taken by Russians. Remote areas, like the interior parts of the Yamal and Gydan Peninsulas, remained reindeer herders' safe havens until the early twentieth century, as these were inaccessible for the Russians.

With the arrival of the Soviet power, reindeer nomadism suffered heavily. This process started with forced collectivization in the 1930s, which caused widespread resistance among the Nenets, and in a few cases ended with armed clashes known as the *mandaladas* (1934, 1943). A further attack against nomadism took place from the end of the 1950s, when the authorities of the Nenets autonomous region began to settle reindeer herding families in the villages on a massive scale. The aim was to turn reindeer herding into profitable meat production and stop the family-based nomadic lifestyle, which was considered backward. Women and children had to become permanent residents of newly built Russian-style villages while men worked in shifts spending every other month in the tundra with reindeer. Since then, in the Nenets autonomous region, reindeer-related knowledge and skills alongside with the Nenets language began to erode rapidly. On the contrary, in the Yamal-Nenets autonomous region, the Soviet policies were less radical, and the families, while working for a collective or state farm, managed to maintain a considerable number of personally owned reindeer. These circumstances motivated the families to stay in the tundra and migrate with reindeer.

Exceptionally among the reindeer societies of Arctic Russia, dozens of Nenets families in the Polar-Urals and nearby (many of them of the descendants of the participants of the *mandaladas*) were never collectivized and lived completely outside of the Soviet legal system.

Since the late 1960s, Nenets have witnessed their lands becoming one of the world's biggest petroleum developments, which have drastically changed the demographic, economic, and environmental features of the area. Hundreds of thousands of Russians, Ukrainians, and others have arrived to work in the industry, which provides more than half of the Russian Federation's budget revenues. The indigenous population that, only a hundred years ago, had made up the absolute majority of the population is a minority today. Oil and gas companies have turned large areas of reindeer pastures and fishing waters into polluted deserts. While some have profited from the trade with the immigrant workers, many Nenets have been forced to quit their pastures.

Despite the pressure of industrialization, the Nenets tundra (particularly in Yamal and Gydan) was virtually the only region in Arctic Russia, which in the 1990s did not suffer from the collapse of the subsidized model of economy. Currently, the Nenets herd more than a third of all the domestic reindeer in the world. Reindeer have a unique material, social, and religious role for the Nenets, as these animals are used for food, clothing, tent covers, transport, as well as sacrifices to foster relations with spirits and as gifts to create human partnerships (e.g., bride price and dowry). Most Nenets families living in the tundra have 200–500 reindeer, while a few reindeer-rich (*tysyvei*) families have up to 3,000–4,000 animals. Pastoralists live in the tepee-like nomadic tents called *mya*, which are made of wooden poles and covered with reindeer skins or tarpaulin.

Living with reindeer requires a symbiotic relationship with the animals following a strong instinct to move south in winter and north in summer. Most Tundra Nenets spend their winters in the sparse forest tundra and move toward the coast of the Arctic Ocean in spring to avoid biting insects and higher temperatures that distress the reindeer. The longest migration routes can be more than a thousand kilometers a year. Although most Nenets consider reindeer herding as the most prestigious and stable form of livelihood, many are engaged in fishing and hunting. Fish constitutes a substantial part of the Nenets diet and is a source of cash, especially in the families with small herds. Hunting hares and geese is widespread in spring (the time when reindeer are rarely slaughtered because of calving). Fur animals like Arctic fox has been important for the trade and taxpaying, but recently the trapping has largely disappeared because of the dwindling of the fur market.

Compared with the Tundra Nenets, the Forest Nenets have smaller reindeer herds (usually a few dozen) as large-scale herding is not viable in the forest. Instead, they rely heavily on hunting and river fishing both as source of food and as cash. Reindeer are used mainly for transport, although in recent decades, snowmobiles have drastically decreased the use of reindeer as draft animals. Compared with the tundra nomads, their seasonal migrations are less frequent and considerably shorter. Other differing herding techniques are the summer smudge fire that protects reindeer from mosquitoes, also fencing pastures and leaving reindeer unguarded for weeks.

Religion

Nenets traditional religion is tightly related to the environment that is perceived to be animated. The most common spirits are called *erv* ("masters") who dwell in natural places like lakes and mountains. Nenets conceptualize these spirits (sometimes also various animals like wolves or natural features like thunder) as persons with their own agendas. Until the mid-twentieth century, shamans often served as mediators who were thought to be able to negotiate with the spirits causing illness and loss to humans and reindeer. Still today, sacrificial strangling of reindeer is widespread. The ritual killing is often followed by feeding the family spirit figures (*khekhe*, kept in a special sacred sledge) with fresh reindeer blood and vodka. This kind of engagement with spirits is the men's domain. In cases of illness or misfortunes of the family and herd, men visit sacred sites (not allowed for women). Women engage with the fire and tent spirit who takes care of the birth-giving women. Women also carry out purification rites to protect living people from the contamination (*syamei*) that may come through a menstruating woman, newborn baby, dead person, or someone who returns from a settlement.

In the 1820s, most western Nenets were baptized by the Russian Orthodox Church. This did not though instill the Christian dogmas in the Nenets but rather added various details (icons, saints, holidays, rite of baptism) into the religion of the reindeer herders. Most eastern Nenets were never baptized and continued with their ancestral religious practices. A more radical rupture came with the Soviets who in the 1930s launched an attack against the shamans, declared to be cheats who manipulate with people both ideologically and economically. Unlike in some other parts of Siberia, the Nenets have not seen a resurgence of shamanism today. Instead, since the 1990s, many Nenets have converted to evangelical Christianity and burned their sacred items.

Laur Vallikivi

See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit; Ket; Khanty; Koryak; Kosterkin, Tubyaku (1921–1989); Mansi; Nganasan; Selkup; Yukaghir

Further Reading

Salminen, T. "Ecology and Ethnic Survival among the Nenets." In H. Shoji and J. Janhunen, eds. *Northern Minority Languages: Problems of Survival.* Senri Ethnological Studies 44. Osaka, Japan: National Museum of Ethnology, 1997:. 93–107.

Salminen, T. "Four Orthographies for Forest Nenets?" In Nicholas Ostler and Blair Rudes, eds. *Endangered Languages and Literacy. Proceedings of the Fourth FEL Conference, University of North Carolina, Charlotte, 21–24 September 2000.* The Foundation for Endangered Languages 73 (2000).

Neumayer Station/Neumayer III Station. *See* Georg von Neumayer Station, Neumayer Station, Neumayer III Station

New Siberian Islands

The New Siberian Islands (75° 16′N 145° 15′E) are situated between the Laptev Sea (west) and the East Siberian Sea (east). South of the New Siberian Islands is the Dmitry Laptev Strait and the northern coast of the Sakha (Yakutia) Republic. North is the Arctic Ocean. The highest point of the New Siberian Islands is Mount Malakatyn-Tas at about 1,200 ft. (374 m) on Kotelny Island. The New Siberian Islands are a low-lying archipelago that consists of two major island groups that are the Anzhu and Lyakhovskiye Islands.

The New Siberian Islands were officially discovered by the Russian explorer Ivan Lyakhov in 1773. In 1805, Russian explorer Yakov Sannikov delineated the Faddeyevsky Island. In 1809–1810, Yakov Sannikov along with Swedish born explorer Matvei Matveyevich Gedenschtrom mapped the New Siberian Islands. The New Siberian Islands is known as a place with a significant collection of well-preserved mammoth and other megafauna tusks, bones, and carcasses dating around 9450 BP (C^{14}) to more than 50,000 BP based on radiocarbon dating.

Anzhu Islands

The Anzhu Islands are the northern group of the New Siberian Islands. These islands cover an area of around 11,200 square miles (29,000 sq. km). The biggest island is Kotelny Island (75° 20′N 141° E) at 4,500 square miles (11,700 sq. km). Traditionally, the neighboring Faddeyevsky Island was viewed as being a separate island because the land (called "Bunge Land") linking the two is sometimes submerged under storm surges. Presently, Kotelny, Faddeyevsky, and Bunge Land are considered just one island and called "Kotelny." Collectively, the entire area of the combined Kotelny Island is around 9,000 square miles (23,200 sq. km). Two small islands off of Bunge Land are the Zheleznyakov and Matar Islands. North of Kotelny Island is a small C-shaped island called "Nanosnyy Island" (76° 17′ 22″N 140° 20′ 18″E), which is the northernmost point of the New Siberian Islands. The easternmost island of the Anzhu Islands is New Siberia Island (75° 5′ 14″N 148° 27′ 30″E) and the westernmost is Belkovsky Island (75° 33′ 9″N 135° 50′ 28″E).

Lyakhovsky Islands

The Lyakhovsky Islands cover an area of 2,350 square miles (6,095 sq. km) and are the southern group of the New Siberian Islands. There are three islands and one island that submerged between early 1950s to the early 1960s called "Semyonovsky Island" (74° 15′N 133° 55′E). The biggest of the Lyakhovskiye Islands is the Bolshoy Lyakhovsky Island covering an area of 1,780 square miles (4,600 sq. km). The second largest island of the Lyakhovskiye Islands is Maly Lyakhovsky Island measuring just more than 500 square miles (1,325 sq. km). In 2013, scientists from the North-Eastern Federal University found a 10,000-year-old mammoth on Maly Lyakhovsky Island. The smallest Lyakhovskiye Island is Stolbovoy Island (74° 4′ 10″N 135° 49′ 26″E) at 65 square miles (170 sq. km).

Andrew J. Hund

See also: Arctic Basin

Further Reading

Kos'ko, M., and G. Trufanov. "Middle Cretaceous to Eopleistocene Sequences on the New Siberian Islands: An Approach to Interpret Offshore Seismic." *Marine and Petroleum Geology* 19, no. 7 (2002): 901–19.

von Bunge, A., and B-E. Von Toll. *The Expedition to the New Siberian Islands and the Jana Country, Equipped by the Imperial Academy of Sciences.* 1887: n.p.

Nganasan

The Nganasan are a Samoyedic people living in the northernmost ethnic group in Eurasia inhabiting the Taimyr Peninsula. They live on the margin of the world's northernmost forest and in the vast open tundra beyond it. Because of the high latitudes, summers are very short, ending in September. After an even shorter autumn starts a nine-month-long winter with temperatures dropping to −76°F (−60°C).

The Nganasan is the second smallest Samoyed-speaking group with its 862 individuals in Russia (according to the 2010 All-Russian census). As a result of the Soviet policies of sedentarization, most of the Nganasan were settled down in a few

Folk dance ensemble performed by national Nganasans at the annual Festival of Peoples of the Far North "Bolshoy argish" in Norilsk, Russia. (Shutterstock.com) villages where they lived side by side with Dolgans and Russians. Currently, the majority of the Nganasans live in the villages of Ust-Avam, Volochanka, Novaya, and also in the regional center Dudinka, the capital of the Taimyr municipal district (until 2007 an autonomous region) in the Krasnoyarsk Territory (*krai*).

Their self-designation in Nganasan is Nya, meaning "friend" or "companion." The term *Nganasan* ("man") was introduced in the 1930s by a Russian scholar. In the earlier literature, they were often referred to as the "Tavgi Samoyeds." Also the names "Avam Samoyeds" or "Vadeyev Samoyeds" can be found that respectively mark the Western and Eastern Nganasans who speak slightly different dialects. Nganasan is a Samoyed language of the Uralic language family.

Language

The Nganasan languages belong to the Samoyed branch of the Finno-Ugrian (Uralic) linguistic family. The Nganasan and their children have been taught the Russian language since the 1950s–1960s. In the late Soviet period, there were elderly Nganasans who could not communicate with their Russian-speaking grandchildren as the old did not know Russian and the Nganasan village youth did not understand Nganasan. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the Nganasan language is considered severely endangered with 505 fluent speakers. Today, only Nganasans more than 60 years old are fluent speakers in their language. In the 1990s, the first schoolbooks in Nganasan were published, marking the beginning of the standardized Nganasan written language. Its use is very limited and restricted to village primary schools in Ust-Avam and Volochanka, where it is taught as a foreign language a few hours per week.

History and Subsistence

Over the past thousands of years, various reindeer hunting groups have lived on the Taimyr Peninsula. The Nganasan were the only occupiers of the peninsula when the Russian Cossacks arrived in the early seventeenth century. This marks the beginning of the Russian colonization of the region. The Nganasan had considerably less contacts with the Russian administration than many other Siberian ethnic groups. Even if it was difficult to master the nomads in the north, Russians managed to make Nganasans pay fur tax, mostly in valuable sables, sometimes taking hostages until tribute was paid. Gradually, taxpaying started to look more like trading. By the end of the seventeenth century, Nganasans were given flour, knives, beads, and so forth, in return for furs. At that time, Evenkis and Yakuts (the ancestors of the Dolgans) moved to the southern part of the Taimyr Peninsula and pushed the Nganasan further north. As in many other places, smallpox brought by Russians decreased the local indigenous population considerably. Also alcohol that was traded for furs had a devastating effect.

The Nganasans are known for being skilful wild reindeer hunters. In the past, they followed the seasonal migrations of herds to south in autumn and to north in spring. Living in small nomadic kin groups, Nganasans practiced on-water wild reindeer hunt on river crossings, using arrows and spears (from the late nineteenth century, also guns). The first kill of a wild reindeer marked a boy's initiation into maturity. While waiting for migrating wild reindeer, Nganasans subsisted on freshwater fish, waterfowl (especially flightless molting geese on lakes), hares, and so on. By the mid-seventeenth century, most Nganasans had adopted the Nenets' domestic reindeer herding style. They used reindeer mainly for pulling sleds but also as decoy animals while hunting for wild reindeer. They lived in easily movable conical pole tents covered with reindeer hides. By the early twentieth century, Nganasans had large domestic herds (up to a few thousand strong) that were herded with dogs. In the 1930s and 1940s, like all other Soviet rural groups, the Nganasans' animals and work were collectivized. Thousands of private reindeer had to be turned over to Soviet collective farms and people had to fulfill working plans set out by the central authorities. Singling out better-off people as class enemies, taking away their animals, and demanding indigenous children to be turned in for education caused widespread resistance, which culminated in the rebellion of Volochanka in 1932 in which 20 Communist Party activists and four rebels were killed.

TWO TALES OF THE WOLF-TAILED SHAMAN

Within the oral history of the Nganasan people is the legend of the wolf-tailed shaman. The wolf-tailed shaman is said to be related to Kosterkin family. The first story of wolf-tailed shaman was noted by Andrei Popov. Popov's recorded oral history contends that a wolf was killing the villagers' reindeer, and the villagers were not able to capture the wolf. The local shaman was summoned and requested to deal with the elusive wolf. The shaman intervened by going into the spirit world for three days where he caught the spirit of the wolf and placed the captured wolf in his wife. His wife became pregnant and had a child with a wolf tail. This child was noted to be Dyukhade Kosterkin's grandfather and lived with the wolf tail his entire life. Another researcher named Gracheva noted a slightly different story of the origin of the wolf-tailed shaman. In this story, a woman could not conceive a child so she contacted the shaman. The shaman instructed her to go outside the village. She traveled a considerable distance as was told to face the moon in winter. Standing facing the moon and in the moonlight, a wolf ran between her legs. The women became pregnant and had a child with a tail. She named the child "Taybula," which means "tale" who became a powerful shaman.

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After the 1930s, the Nganasans were gradually settled in small villages and most of them, especially women and children, cut the ties with earlier way of life in the landscape. In the 1960s, small villages were closed, and all the nomads were moved to larger villages from where state farms were managed and where goods were concentrated. In the early 1970s, domestic reindeer herding ended, partly because of great loss of domestic reindeer to wild herds and partly because of administrative decisions. The Nganasans in Ust-Avam were employed as hunters and fishermen who fed the growing Russian population in Norilsk with meat and fish. Most of the state farms' income came from trapping the polar fox (until the early 1990s when the international demand diminished because of the pressure by animal rights groups) and hunting wild reindeer on water with motorboats. In the 1990s, when the Soviet economy collapsed, the state-subsidized reindeer hunting economy turned out not to be profitable enough. As a result, Nganasans and Dolgans revived old practices like widespread meat sharing in the community, which was common before the collectivization. The world's largest wild reindeer population (fewer than a million) still gives an important part of subsistence for the Nganasan.

Religion

Unlike their neighbors Dolgans, the Nganasans did not convert to Christianity in the tsarist period. Nganasans consider that the tundra is populated not only by humans and animals but also by nonhuman persons, including spirits (*nguo*) of lakes, hills, other natural phenomena or man-made items, the deceased, and various deities and shamanic spirit helpers. Tundra dwellers maintain contact with these beings through various rituals, for instance, by feeding anthropomorphic spirit figures (*kuoika*) with wild reindeer fat, which grants luck in hunting. Nganasans have been known for their shamans. The so-called strong shamans go into trance and thus become mediums between humans and nonhumans. The most famous shamanic ritual has been the clean tent ritual that celebrates the sun rising above the horizon after the two-month long polar night in February. During this 3- to 9-day long ritual, shamans asked the deities for health and prosperity on behalf of the community for the coming year. Despite repressive state policies toward shamans in the Stalinist period, there were still a few Nganasan shamans active even in the late Soviet period. For instance, a Nganasan shaman called Demnime Kosterkin was invited in 1973 to a conference in Moscow to demonstrate his skills. While spectators considered it to be a folklore performance, the shaman did all the necessary ritual elements to ensure that his helping sprits would not be offended. Demnime's brother Tubyaku, having learned to shamanize from his father, was accepted as a last great shaman by the Nganasan. He was shortly imprisoned in the 1940s after which he continued with his séances entailing shamanic songs that even mentioned Lenin as a cosmological figure. He died in 1989.

Laur Vallikivi

See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit; Ket; Khanty; Koryak; Kosterkin, Tubyaku (1921–1989); Mansi; Nenets; Selkup; Yukaghir

Further Reading

Chard, C. "The Nganasan: Wild Reindeer Hunters of the Taimyr Peninsula." *Arctic Anthropology* 1, no. 2 (1963): 105–21.

Ziker, J. "Kinship and Exchange among the Dolgan and Nganasan of Northern Siberia." *Research in Economic Anthropology* 19. (1998): 191–238.

Nimrod Expedition (1907–1909)

The Nimrod Expedition or known officially as the British Antarctic Expedition was a privately funded British expedition with the ultimate goal of reaching the South Pole or at least a new farthest south. The expedition took place between 1907 and 1909. While the first goal could not be achieved, the expeditions reached farthest south less than a 100 nautical miles off the pole, which remained the southernmost position ever reached by an expedition up to Roald Amundsen's success in reaching the pole itself.

A few of the scientific personnel and crew members of the *Nimrod*, the boat for Ernest Shackleton's 1907–1909 expedition to Antarctica. From left to right: Frank Wild, Shackleton, Eric Marshall, and J. B. Adams. (National Oceanic and Atmospheric Administration)

Ernest Shackleton (1874–1922), who was knighted after the completion of the Nimrod Expedition, led the expedition. Shackleton's plan for the expedition rose after his participation in Robert F. Scott's Discovery Expedition and his treatment by Scott during the expedition that included sending him home on the base of assumed lack of physical ability. Thus, Shackleton's goal for the Nimrod Expedition was also to outperform Scott.

With basically no public funding available for the expedition, besides some small funds from the Australian and New Zealand governments, the Nimrod Expedition needed to resort to private funding and sponsoring. Besides funding raised in Shackleton's private sphere, sponsors included Edward Cecil Guinness (1847–1927) of Guinness Brewery and the Scottish car manufacturer Arrol-Johnston-Company, which provided the first automobile to be used in Antarctica. While the car gained a lot of publicity prior to the expedition, ponies, sledge dogs, and man hauling should become the main means of transportation in Antarctica.

Fridtjof Nansen (1861–1930) advised Shackleton to rely mainly on sledge dogs and skis, but Shackleton favored the Siberian ponies due to personal negative experiences during earlier expeditions. A major controversy with Scott occurred even before the expedition left for Antarctica, as Scott and Shackleton could not agree on the use of the base camp of the former Discovery Expedition at McMurdo Sound. Finally the *Nimrod*, an auxiliary steamer used for sealing off Newfoundland, was bought by Shackleton earlier the year as he could not afford a larger or better equipped vessel and left the United Kingdom in August 1907.

After port calls in South Africa and New Zealand, the *Nimrod* was finally towed to the Southern Ocean as Shackleton hoped to preserve the limited supplies of coal on board for operations during the expedition itself and reached finally on January 25, 1908, at McMurdo Sound. Opposite to the agreement with Scott, the base camp for the expedition was established at McMurdo Sound, but Scott's Discovery Hut wasn't used. Instead, the base camp was established 23 miles (37 km) north in the vicinity of a freshwater lake that provided the water supply for the expedition. As weather and ice conditions prohibited an immediate beginning of the depot laying for the trip south, members of the expedition ascended Mount Erebus in March 1908 and brought geological specimen of the volcano to the base camp at Cape Royds. During winter 1908, the main trip to the south was prepared, but suffered substantial setbacks when four ponies died.

On October 29, 1908, finally the march south began for the four men team of Shackleton, Marshall, Adams, and White. During the journey south, all of the remaining ponies died, and the expedition had to resort to man hauling for the rest of the expedition. Running out of fuel and supplies, the men finally realized that they would not be able to reach the pole, but at least managed to reach a new farthest south, less than 100 nautical miles north of the pole. After 73-day traveling southbound, they turned on January 9, 1909. The return voyage was characterized by severe shortage of food, and Shackleton and Wild reached the base camp on February 28 with the two other members of the southern party to be picked up from one of the last depots a couple of days later.

While the southern party contested the pole, another group of the Nimrod expedition tried to reach the magnetic south pole and achieved this goal on January 17, 1909, at a position of 72° 15′S 155° 16′E at an elevation 7,250 ft. (2,210 m). Suffering similar hardships as the southern party, this group was finally picked up by the *Nimrod* at the beginning of February 1909.

Finally, on March 23, 1909, the *Nimrod* reached New Zealand, and Shackleton immediately cabled a news release on his achievements to the *Daily Mail* in England. With the South Pole still unconquered, the expedition had achieved at least a new farthest south, and Shackleton needed to admit that his decision against the sledge dogs was a major factor for not achieving his ultimate goal.

Ingo Heidbrink

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

Further Reading

Riffenburgh, B. *Nimrod: Ernest Shackleton and the Extraordinary Story of the 1907–09 British Antarctic Expedition.* London: Bloomsbury Publishing, 2005.

Nordenskjold, Adolf Erik (1832–1901)

Prior to World War I, most scientific knowledge was gathered by expeditions and travelers to various parts of the world. Sweden has a long tradition of scientific explorations, a practice that has been pioneered by Carl Linnaeus and his pupils. Probably, the most important of all the Swedish expeditions in the nineteenth century was the Vega Expedition, organized and headed by Adolf Erik Nordenskjold at the end of the 1870s.

Nordenskjold was born on November 18, 1832, and he grew up in Finland. He studied at Helsinki University, made a brief expedition to the Ural Mountains in 1853, and graduated in 1855. In 1856, he published a scientific article on native mollusks. Finland was then ruled as a part of Imperial Russia, and in 1858, Nordenskjold left Finland for Sweden for political reasons. He kept his political radicalism through the years and made acquaintance with the Russian revolutionary, explorer, and geographer Peter Kropotkin (1842–1921) among others. In December 1858, Nordenskjold became a professor and curator in mineralogy at the Natural History Museum of Stockholm, a position he kept until his death. Nordenskjold became a Swedish citizen in 1860. In 1863, he married Anna Maria Mannerheim (1840–1924).

Although he had a background as a geologist, Nordenskjold was a true polymath with extensive knowledge in many fields. He was a skilled field researcher also interested in the local wisdom of the sailors and fishermen. Nordenskjold soon became a prominent figure within Swedish polar research and conducted several expeditions to the Arctic and subarctic regions, including several expeditions to Spitsbergen (1858, 1861, 1864, 1868, and 1872–1873), to Greenland (1870, 1883), and to the subarctic areas of Russia (1875, 1876). Results from these expeditions were published in travelogues and scholarly papers.

Vega Expedition

The Vega expedition in 1878–1880 searching for the Northeast Passage became the most important of Nordenskjold's scientific expeditions. It was sponsored by the Swedish bulk merchant Oscar Dickson (1823–1897) and the Russian gold mine owner Aleksandr Sibirjakov (1849–1933). The expedition started from southern Sweden on June 22, 1878, with 30 crew members, seven of whom were scholars. The ship *Vega* rounded Cape Chelyuskin, the northernmost point of mainland Russia, in the following August. At the end of September, the steamship ran aground at Pitlekay trapped in the ice not far from the Bering Strait. The members of the expedition gathered a large amount of data and material during their involuntary winter stay at Pitlekay. Vega completed the voyage successfully the following summer. The expedition had sailed around the north coast of Asia, thus being the first to make the whole length of the Northeast Passage, or the Northern Sea Route as it is called today. They arrived home to Stockholm in triumph in April 1880. At the return, Nordenskjold was created a baron by King Oscar II and hailed as a hero by his contemporaries.

The results of the Vega expedition were published in a two-volume travelogue, *The Voyage of the Vega round Asia and Europe, with a Historical Review of Previous Journeys along the North Coast of the Old World* (London: Macmillan 1881) published simultaneously in many languages, and the scientific results in two volumes, *Vega-expeditions vetenskapliga iakttagelser, bearbetade af deltagare i resan och andra forskare*, ed. A.E. Nordenskjold (1882–1883; also published in German in the same years) as well as in numerous articles in various journals. There are considerable data given in the reports, which deal with zoology, botany, and geodesy. The travelogue, in particular, also includes geographical, historical, meteorological, and ethnographical information. Results from the expedition are still being published, a recent example being James W. Van Stone's *The Nordenskjold Collection of Eskimo Material Culture from Port Clarence, Alaska* (1990).

The zoological collection was extensive and included an impressive quantity of whale bones (recently discussed by Nicholas Redman), which are now kept in the Natural History Museum in Stockholm. Among his many important collections are also skeletal remains of Steller's sea cow, *Hydrodamalis gigas*, an Arctic species regarded as extinct since 1768. The expedition also brought back large numbers of ethnographical specimens and a huge Japanese library. Thanks to Nordenskjold, the museum also has one of the largest collections of minerals from the polar area as well as meteorites in the world.

Later Scholarly Endeavors

After publishing the scientific results from the Vega expedition, Nordenskjold made a last polar expedition researching the ice sheet on West Greenland. Although he first and foremost achieved fame for his polar research, he also made important progress in other fields. Nordenskjold was characterized by a certain scientific impatience, but devoted himself to analyze the earth's formation and climate change. An important step for this research was the establishment of a paleobotanical department in 1884–1885 at the museum. Later, he concentrated on the history of cartography and brought together a large library of 8,000 volumes on the topic. It was bought by Helsinki University library in 1902. Nordenskjold published several scholarly books on cartography. He was a pioneer in promoting conservation of the landscape and in wildlife protection. In 1893, he became a member of the Swedish Academy. He maintained good relations with Russian scholars, and even after the Russian revolution, his name was held in high regard by Soviet colleagues. He died at his manor Dalbyö south of Stockholm on August 12, 1901. The bay Nordenskiöldbukta of the North East Land of Spitsbergen and the Nordenskjold Archipelago in the Kara Sea west of Taymyr Peninsula are named after him.

Ingvar Svanberg

See also: Amundsen, Roald Engebrecht Gravning (1872–1928); Bransfield, Edward (1785–1852); Rasmussen, Knud (1879–1933)

Further Reading

The A.E. Nordenskiöld Collection in the Helsinki University Library: Annotated Catalogue of Maps Made Up to 1800. Vols. 1–5. Helsinki, Finland: Helsinki University Library, 1979–1995.

Malm, A. *Skelettdelar af hvalinsamlade under Expeditionen med Vega 1878–1880.* Stockholm, Sweden: P. A. Norstedt and Söner, 1883.

Nordenskiöld, A. "Vega-expeditionens vetenskapliga iakttagelser bearbetade af deltagare i resan och andra forskare." Smithsonian Institution Libraries. 1882.

Nordenskiöld, A. "The Voyage of the Vega round Asia and Europe, with a historical review of previous journeys along the north coast of the old world/ translated [from the Swedish] by Alexander Leslie." London: Macmillan, 1881.

Northeast Greenland National Park

The Northeast Greenland National Park (76° N 30° W) covers the entire northeastern part of Greenland north of Ittoqqortoormiit (Scoresby Sound), which was set aside as a national park in 1972. With an area of more than 375,000 square miles (972,000 sq. km), the park is the largest in the world, stretching from Knud Rasmussen's Land in the north, almost to Mestersvig in the southeast.

The coastline covers around 11,250 miles (18,000 km) and includes the most northern land in the world. The park also includes the Northern Hemisphere's largest ice cap. For thousands of years, various Inuit cultures have lived and survived here thanks to the abundance of Arctic animals.

A Danish Armed Forces surveillance unit, the Sirius Patrol, has its main base at Daneborg along the northeast coast. The patrol is responsible for monitoring the area by dogsled and boat. They control and monitor expeditions and conservation regulations within the national park. Weather stations at Nord (81° 36′N) and in Danmarkshavn are also staffed. The regular task of the staff in these stations is to launch weather balloons twice a day. Workers also occupy Mestersvig (just south of the park) and, especially in summer, staff this old mining town to keep the airstrip open.

Today, hunters from Ittoqqortoormiit are the only ones who have regular access to the area. They go on dogsled trips and hunt in the National Park, which is basically uninhabited, except approximately 40 Sirius Patrol wardens who live regularly in the park at five monitoring posts.

The Zackenberg Research Station lies about 280 miles (450 km) north of Ittoqqortoormiit. Monitoring and research take place here regarding the effects of

Iceberg Bay—Northeast Greenland National Park. (Shutterstock.com)

CLAVERING ISLAND

Clavering Island (74º 16'N 21ºW) is located within the Northeast Greenland National Park. Its name honors the German Captain Douglas Charles Clavering (1794–1827), whose party explored this region in 1823. These first explorers encountered a small band of Inuit, all of whom are believed to have died out by the time the island was next visited—perhaps because of the exhaustion of local musk oxen, generally the staple food for such bands.

This relatively large island held the original headquarters site for the Sledge Patrol during World War II (see Sirius Sledge Patrol) at Eskimonses, on the south shore. In early 1943, a couple of the patrol members discovered a recently established German weather station on an island further to the northeast. The Germans then followed the Greenlanders back to Eskimonses and attacked. More recently, a variety of wildlife observers and other recreational visitors have visited the island. Daneborg, the current headquarters of the Sirius Sledge Patrol lies on the headland immediately north of the island, as does the ecosystem research and monitoring facility site of Zackenberg, about 15 miles (25 km) to the west of Daneborg (74º 18'N 20º 14'W).

On the headland west of the island lies one of the many old trappers' huts that dot the outer coast, from which one can generally walk onto the island during low tide without getting wet. A number of high hills lie in the center of the island, with the highest point slightly more than 5,000 ft (1,500 m).

William (Bill) F. Isherwood

climate change. The station lies in the High Arctic climate zone, which responds more quickly than other zones to changes in global weather. Increasingly, each year, scientific expeditions visit the National Park, which is rich in Arctic flora and fauna, and many come to explore the many traces of ancient settlements. The remains of ancient Inuit settlements, some from thousands of years in the past, lie along the long coastline.

The National Park in Greenland is an Arctic paradise and a wilderness with wildlife that cannot be matched with that in the inhabited areas of the country. However, due to its size and relative inaccessibility, it does not resemble a traditional national park. In the late 1990s, an average complement of outside visitors would consist of only two recreational adventure parties.

In modern times, one can experience the park's unique unspoiled scenery by joining an expedition cruise and can observe some of the most exciting wildlife found in the Northern Hemisphere, including musk ox, polar bear, Arctic fox, snowshoe rabbits, lemmings, walrus, narwhal, and a variety of birds, including the majestic gyrfalcon. This wealth of fauna now draws numerous international scientific surveys and expeditions to the region.

To travel and stay in the National Park, visitors must have a permit from Greenland's Ministry of Domestic Affairs, Nature and Environment. If you are taking part in an organized tourist trip such as a cruise, then the organizers will already have secured the necessary permits.

Ittoqqortoormiit in Northeast Greenland is the gateway to the park and is also one of the most remote towns in Greenland. It takes a keen sense of adventure and an appetite for the unexpected to venture into this region—but anyone who does so will be more than rewarded by the humbling and breathtaking scenery.

William (Bill) F. Isherwood

See also: Greenland; Tuktut Nogait National Park; Vuntut National Park of Canada

Further Reading

Lovgren, S. "Greenland Melt May Swamp LA, Other Cities, Study Says." *National Geographic News*, 2004. http://news.nationalgeographic.com/news/2004/04/0408_040408_greenlandicemelt.html.

Rasmussen, H. "Sustainable Greenland and Indigenous Ideals." In *Toward a Sustainable World: The Earth Charter in Action.* Amsterdam: Royal Tropical Institute, 2005.

Northeast Passage

The Northeast Passage was formerly known as the Northern Sea Route. The Northeast Passage is a shipping lane running from the Atlantic Ocean to the Pacific Ocean along the Northern Russian Arctic coast. The Northwest Passage was officially defined by the Russian Government and is from Murmansk (68° 58′N 33° 5′E) on the Barents, Kara, Laptev, East Siberia, and Chukchi Seas along the northern Russian coastline to the Bering Strait. Lands located within the Arctic Circle (located above the parallel of latitude at 66° 33′ 44″) comprise the Arctic region. Prominent land areas that lie within the circle include the northern Alaskan and Canadian coasts, the Canadian Archipelago, the mainland of Greenland, the Svalbard Archipelago, the northern coasts of Scandinavia, and the long seaboard of European Russia. The Bering Sea lies to the far north, opening out to the North Pacific Ocean. To the south, the Greenland and Norwegian Seas open into the North Atlantic Ocean, where Iceland, the United Kingdom, and the western European countries are located.

Because of its proximity to prime global maritime markets, the frigid waters of the Arctic Circle have played a prominent role in international affairs for centuries. Lucrative Asian markets lie beyond the Bering Straits, connecting trading networks of the far north with ancient East Asian and Indian markets along the stretch of the western Pacific Ocean and the Indian Ocean to the southwest. For centuries, European nations sponsored explorers and shipping ventures to chart the Arctic region in hopes of mapping viable routes across the north to connect Atlantic and Pacific markets. As mass communication technologies advanced, the exploits of intrepid Arctic explorers enjoyed worldwide acclaim. Posterity preserves the memory of the exploits of Martin Frobisher, Hugh Willoughby, Sir John Franklin, Semyon Dezhnev, Vitus Bering, Vasiliy Chicagov, Joseph Billings, Ferdinand Petrovich Wrangel, Pyotr Fyodorovich Anjou, Count Fyodor Litke, Fridtjof Nansen, Roald Amundsen, George W. DeLong, Stepan Osipovich Makarov, and others involved in the great northern expeditions of the eighteenth and nineteenth centuries.

Nils Adolf Erik Nordenskjold (1832–1901) is remembered for the Vega Expedition, during which he successfully chartered the ship *Vega* across the northeastern Arctic and through the Bering Straits in 1879. In 1906, Roald Amundsen received critical acclaim for successfully navigating the Northwest Passage. Today, the Northeast Passage, now known as the Northern Sea Route, follows the eastern flank of the Arctic region, beginning at the city of Murmansk just beyond the northeast corner of Scandinavia on the Barents Sea, out across the coastal waters of the Laptev and East Siberian Seas, around the eastern Chukot flank of the Bering Straits.

Rapid changes in the condition of the traditionally icebound waters of the Arctic suggest that ice-free waters will be the norm sooner than anticipated by the Arctic Climate Impact Assessment, published in 2004. If the waters of the Arctic Ocean become accessible for regular shipping charters, Euro-Asian shipments through the Panama Canal could be rerouted with distances reduced by around 6,800 miles (11,000 km); traffic around Cape Horn would be reduced by about 11,800 miles (19,000 km). Future summer shipping could increase from the current average of 30 days to a maximum of 120–170 days annually. These projections are a potential boon to Russian maritime interests.

Today, Russia manages the world's largest fleet of icebreaker shipping vessels, including the world's only fleet of nuclear-powered vessels, supporting domestic markets for natural resources including exports of oil, timber, ores and metals, and food and building materials for inland settlements. Article 234 of the UN Convention on the Law of the Sea gives Russia full sovereignty over its coastal waters. On November 17, 2011, the Russian State Duma adopted the first draft of a law "on amendments to some legislative acts of the Russian Federation in the state regulation of merchant shipping in the waters of the Northern Sea Route." This legislation, prepared by the Ministry of Transport of Russia, was supported by 417 deputies. It provides for the creation of a new institution, the Northern Sea Route Administration, with authority to protect the interests of the Russian Federation in the Arctic while providing equal access to interested foreign entities.

Victoria M. Breting-Garcia

See also: Arctic Council; Arctic Ocean; Iceberg Monitoring and Classification; Kara Sea; Northwest Passage; Northwest Passage Claims and Disputes

Further Reading

Kerr, R. "A Warmer Arctic Means Change for All." *Science* 30, no. 297 (5586) (2002): 1490–93.

Trenin, D., and P. Baev. *The Arctic: A View from Moscow.* Washington, DC: Carnegie Endowment for International Peace, 2010.

Yu, Y., G. Maykut, and D. Rothrock. "Changes in the Thickness Distribution of Arctic Sea Ice between 1958–1970 and 1993–1997." *Journal of Geophysical Research* 109, C08004 (2004): 109.

Northern Bottlenose Whale

The northern bottlenose whale (*Hyperoodon ampullatus*) is a member of the suborder Odontoceti, or toothed whales, habitat the North Atlantic Ocean. It is the largest member of the beaked whale family (Ziphiidae) in that area. The whale was first depicted by Johann Reinhold Forster (1729–1798) in 1770. For various reasons, it is difficult to give a reasonably accurate assessment of the number of northern bottlenose whales in the North Atlantic; for example, data on the diving frequency of the species is scanty. A conservative estimate, however, would be around 50,000–100,000 animals.

Mature males are 27–30 ft. (8.5–9 m) in length with the longest male measured so far was 32 ft. (9.8 m). There have been reports of the northern bottlenose whales reaching almost 37 ft. Adult males weigh around 9,900–16,500 pounds (4.5–7.5 tons). Mature females are smaller and are typically 22–24 ft. (7–7.5 m) in length, with the maximum length being around 29 ft. (8.7 m). Adult females can weigh around 7,700–13,200 pounds (3.5–6 tons).

The northern bottlenose varies in color, being black, gray, or brownish on the top and sides but lighter on the belly. The melon on an adult bull whale is very pale, high, short, and bulbous, with a short but conspicuous beak. The dorsal fin, lying slightly behind the middle of the back, is fairly high, strong, and sickle shaped, curving toward the rear. The flukes are powerful, and a median notch is usually absent. The flippers are fairly small and blunt. The two to four long forward slanting teeth at the front of the lower jaw are usually seen only in males that have reached the age of 15–17 years. The spout, which takes the form of a round column, is apparent only in favorable conditions and is about 3.3–6.5 ft. (1–2 m) height.

This whale is a powerful diver and commonly dives to 2,600 ft. (800 m). It can descend to depths of at least 4,600–5,000 (1,400–1,500 m). Most dives last for less than 10 minutes with some dives being up to two hours. This animal feeds almost exclusively on cephalopods but also consumes fish, sea cucumbers, shrimp, and similar animals. The northern bottlenose whale migrates to some degree depending on the season but prefers to remain in the open ocean. Its pace is generally relaxed but when necessary can travel at speed. Curiosity is one of its hallmarks, and it likes to check out and follow boats in the vicinity.

The male northern bottlenose whales prefer being solitary, while females are often found alone with their calves, or in small groups. However, larger mixed aggregations have been reported. Mating and birthing season is between April and June, the calves being 10–11.6 ft. (3–3.5 m) in length at birth and are thought to weigh around 600 pounds (300 kg). They are suckled for at least 12 months. Puberty is reached between 7 and 11 years of age in females and 8 and 13 years of age for males. Females appear to give birth every second or third year. The maximum age of this species is unknown, but records exist of a female that was 27 years old when killed and a male that was 37.

Northern bottlenose whales emit various noises such as whistling, pounding, and squealing. They enjoy lobtailing and indulging in other energetic displays, sometimes completely clearing the water in the process.

Sigurður Ægisson

See also: Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Southern Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Taylor, B., R. Baird, J. Barlow, S. Dawson, J. Ford, J. Mead, G. Notarbartolo di Sciara, P. Wade, and R.L. Pitman. *Hyperoodon ampullatus.* IUCN Red List of Threatened Species, 2008.

North Pole

The North Pole (90° N) is located amid the Arctic Ocean and is the northernmost location of the earth. It is the place where the earth's axis of rotation intersects the earth's surface. Sometimes the North Pole is called the Terrestrial North Pole, Geodetic Pole, or the geographic North Pole. The North Pole sits atop 6–10 ft. (2–3 m) of sea ice that is constantly shifting. Sea ice has historically covered the North Pole, but recently the North Pole has been seen to have no ice on occasion. The depth of the sea at the North Pole is about 14,000 ft. (4,261 m).

Kaffeklubben Island, Greenland (83° 40′N 29° 50′W), is the nearest land to the North Pole, which is about 450 miles (725 km) away. The nearest human settlement is more than 500 miles (800 km) away. The settlement is called "Alert" (82° 30′N 62° 20′W) and is located in the Qikiqtaaluk Region, Nunavut, Canada.

Geographic North Pole. (Shutterstock.com)

There are no visible native plants or animals. Various animals have been seen within about 40 miles (60 km) of the North Pole such ringed seals, Arctic foxes, and various birds (northern fulmar, Arctic tern, snow bunting, black-legged kittiwake). There has been a rare sighting of polar bears within a mile of the North Pole. Amphipods, shrimp, and crustaceans as well as can fish, such as Arctic cod be found in the waters around the North Pole.

Temperatures are significantly warmer at the North Pole compared with the South Pole, because the North Pole is in the middle of an ocean and at a lower elevation (just above sea level). The ocean acts a heat reservoir. The North Pole average summer temperature is 32°F (0°C) or the freezing point. The average winter temperature is −29°F (−34°C) with a range of −45°F (−43°C) to −15°F (−26°C). The highest temperature recorded in the North Pole was 41°F (5°C), while the lowest temperature was −90.4°F (−68°C).

There are technically three locations for the North Pole. The first is the geographic North Pole, while the other two are the Magnetic North Pole and the Geomagnetic Pole. The Magnetic North Pole is migrating in a northwest direction at just under 40 miles per a year and as of 2010 was 85° N, 132° 6′W. The Geomagnetic Pole (also called the "dipole pole") should not be confused with the Magnetic North Pole. The Geomagnetic Pole is the place where two points that are antipodal intersect the earth's surface, and as of 2010, its location was found at 80° N 72° 2′W. There is no time zone in the North Pole, and thus people, expeditions, and others, can use whichever time zone they choose or find fitting.

Over the past decades, the general trend has been that the average thickness of the ice has been decreasing; however, recent reports have recorded the ice as increasing in the polar regions. As the polar ice caps melt, the sea levels will rise and coastal erosion will increase, which will be detrimental to wildlife, such as polar bears and coastal groups living on the Arctic coast and elsewhere. It is anticipated that as the Arctic sea ice retreats, global warming will accelerate, because there will be less ice cover, which presently reflects solar radiation from the sun. Some present scientific models predict that the Arctic Ocean will be seasonally ice free in the next few decades.

In 1908, American explorer Frederick Albert Cook is credited with reaching the North Pole. There are no permanent settlements at the North Pole, and since the ice is consistently migrating, it is not possible to build permanent structures at the North Pole like at the South Pole. The Soviet Union has built drifting stations that essentially ride on top of the drifting ice. Some of these drifting stations have come close to passing over the pole. Yearly, since 2002, the Russian Federation has set up a base at Camp Barneo. Camp Barneo is a temporary ice floe camp near the North Pole (approx. 89° N 30° W).

There are two seasons at the geographic North Pole, which are six months of summer (March to September) and six months of winter (September to March). The North Pole has one day per year with six months of daylight where the sun never sets and six months of night where the sun never rises. During summer, the sun is low in the sky and continuously moves above the horizon.

The current Pole Star (commonly called the "Polaris" or the "North Star") is a fixed point that sits motionless above the North Pole resulting in it being effective for navigation in the Northern Hemisphere.

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See also: South Pole; Three-Pole Concept

Further Reading

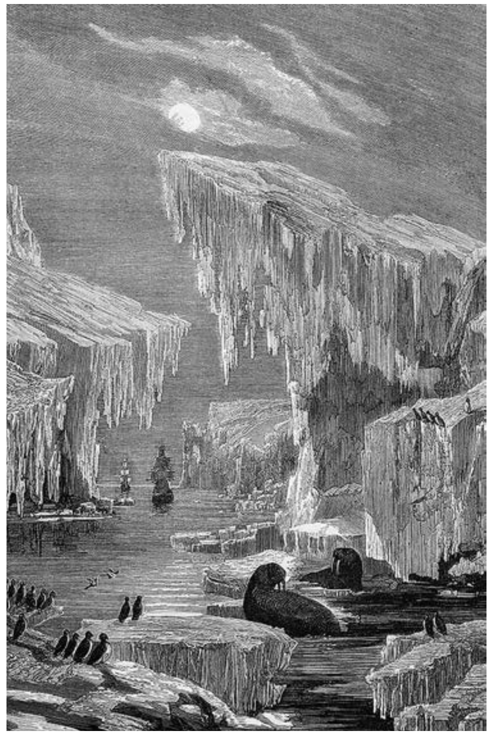
Bryce, R. *Cook and Peary: The Polar Controversy Resolved.* Mechanicsburg, PA: Stackpole 1997.

Frederick, A., R. Cook, G. Peary, and W. Melville. *Finding the North Pole.* Guilford, CT: The Lyons Press, 2003.

Northwest Passage

The term "Northwest Passage" refers to an Arctic sea passage woven across the northern Canadian border of the North American continent, linking the maritime routes of the northern circumpolar region with Atlantic and Pacific trade routes. It is more accurately referred to in the plural sense of passages, as seven different waterways through the Canadian Archipelago are used to connect the North American rim of the Arctic Ocean, a semi-enclosed body of water, with Eurasian landmasses, the Pacific Ocean and its contiguous seas, and North Atlantic maritime routes. The Arctic Archipelago is a series of 94 major and 36,469 minor islands covering

540,543 square miles (1.4 million sq. km) stretching across the northern Canadian mainland. The archipelago is considered the world's largest High Arctic landmass after Greenland, whose land area is a geological extension of the island complex. Important islands include Baffin, the Queen Elizabeth Islands, Victoria, Ellesmere, Banks, Devon, Axel Heiberg, Melville, and Prince of Wales. Hazardous Arctic sea routes include passage through a series of nearly 50,000 icebergs stretching from Greenland and Baffin Island.



Depiction of the Northwest Passage. (Shutterstock.com)

The exploration and charting of the Northwest Passage, both by land and water transport, are a process that links present climate conditions and cultural technologies with those extending back to the time when humans first ventured out across the Bering Strait into the lands of the Arctic. The Arctic region, within whose boundaries the Northwest Passage is mapped, was first explored and inhabited by a single population of Siberians who crossed the Bering Strait into Alaska and migrated outward into North and South America during the late Pleistocene and early Holocene eras. The Inuit (Inuvialuit) are one of nearly 40 interrelated indigenous groups; they reside primarily in the northern Canadian provinces, sharing cultural customs and traditional livelihoods specific to their particular environments. Indigenous technologies and ecologies, derived from generations of accumulated knowledge of Arctic climate and landscape variation over time, are the foundations of wisdom upon which subsequent explorers would rely for survival.

Spectacular advancements in global literacy were accelerated by the invention of the printing press by Johann Gutenberg in 1452 and the Fall of Constantinople on May 29, 1453. As a result of the Treaty of Tordesillas, signed on June 7, 1494, Western Europe lost access to lucrative Asian markets, a turn of events that ushered in a new scramble for alternative trading routes. The subsequent formation of new networks of exchange corresponded with increasing knowledge of the world. The synthesis of accumulated wisdom regarding the earth's terrain is reflected in the increasing sophistication and detail of global cartographic representations, evolving out of a tripartite Mediterranean cosmos to the inclusion of the Americas and finally Oceania, the Arctic, and Antarctica. Printing presses enhanced the momentum of global exploration, creating a mass audience whose imaginations to the present day thrive on the tales of incredible voyages to the limits of the known world.

The search for Thule, the land of the frozen north described by the Greek explorer Pytheas during the third century BC, inspired generations of talented mariners who risked lives and fortunes to find a profitable maritime route across the Arctic Ocean, one that would cut the distance between Europe and Asia by thousands of miles. Attempts to navigate and settle the lands of the Arctic include the ventures of early Norwegian Vikings during the early AD 800s, the settlement of Greenland by Erik "the Red" Thorwoldson in 981, and a succession of European ventures including the expeditions of Hernán Cortés, Cristóbol Colón, John Cabot, Sir Martin Frobisher, John Davis, Henry Hudson, William Baffin, Samuel Hearne, James Cook, Sir Alexander Mackenzie, Sir John Ross, Sir William Edward Parry, Sir John Franklin, Sir John Ross and Sir James Clark Ross, and Sir John Franklin.

The Northwest Passage lies within the Arctic Circle, an imaginary line drawn around the Arctic Ocean (66°33′N). The area includes the Bering Sea, the Canadian Archipelago, Iceland, Greenland, the length of the Eurasian coastline and its marginal seas. The circle is an important marker delineating the tree line above which frigid polar landscapes prevail. The innovative use of isothermal mapping and the vertical zonation of vegetation and climate during Alexander von Humboldt's exploration of the Americas in the early 1800s influenced the nineteenth-century mapping techniques to the present day. His interest in geomagnetism and his subsequent mappings and readings of declination, inclination, intensity, and isodynamic zones inspired early nineteenth-century voyages sponsored by the Royal Society to the Polar Regions to gather magnetic data, information vital to establishing accurate navigational coordinates at sea. On June 16, 1903, Norwegian native Roald Amundsen (1872–1928) set sail from Oslo, Norway, in the *Gjøa*, a 47-ton herring fishing vessel with a small petroleum motor, to relocate the North Magnetic Pole, a landmark originally investigated by James Clark Ross in 1831. During that trip, Amundsen successfully navigated a course through the Northwest Passage, sailing through Queen Maud Gulf to Herschel Island, where he and his team of six seamen were trapped by ice. Amundsen traveled by dog sledge to Eagle, Alaska, to announce the successful navigation of the passage on December 5, 1905.

Arctic voyages were capital intensive and represented close international scientific collaboration coordinated by increasing numbers of learned and professional societies, including the British Royal Navy, the Royal Society, the Royal Observatory, the British Association for Advancement of Science, the Royal Geographic Society, and the Royal Geological Society. These efforts anteceded a series of explorations known as the International Polar Year; the first international investigations were conducted from 1881 to 1884 and were followed by studies in

1932–1933, 1957–1958, and 2007–2008. The numerous expeditions to the Arctic demarcate the complexity and increasing sophistication of geographic representation and instrumentation required to enhance the success of a voyage. Meteorological registers and naval logs collected during the nineteenth century set an important baseline from which to understand current climate change. Key instruments used during the mapping of the Northwest Passage were standardized by the Meteorological Instruments Committee of the Royal Society of London and included marine and aneroid barometers, and various types of spirit and mercurial thermometers. Wind force and direction were measured by compass, wind vanes, gauges, and anemometers.

Similar innovations in shipbuilding that influenced the maritime mastery of the Arctic include the design of the Russian Pomorkoch; British naval architecture including armor plating, iron and steel hulls, and screw propellers; the steam engine; diesel-electric and nuclear systems; and the submarine. International disputes regarding the status of the waters internal to the Canadian Archipelago will continue to have important implications for future shipping ventures. Global warming and the subsequent opportunities to navigate previously impassable Arctic routes will have important repercussions in global market strategies.

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See also: Arctic Council; Arctic Ocean; Baffin Bay; Canadian Arctic Archipelago; Inuit; Northeast Passage; Northwest Passage; Ross Sea Party (1914–1917)

Further Reading

Charron, A. "The Northwest Passage: Is Canada's Sovereignty Floating Away?" *International Journal* 60, no. 3 (1906): 831–48.

Lambert, A. *The Gates of Hell: Sir John Franklin's Tragic Quest for the North West Passage.* New Haven, CT: Yale University Press, 2009.

Vastag, B. "Northwest Passage: Americas Populated via Alaska, Genetics Show." *Science News* 172, no. 22 (2007): 339–40.

Northwest Passage Claims and Disputes

Claims to and the jurisdiction over the Northwest Passage is presently disputed. The dispute is primarily between the United States and Canada. The United States along with most maritime nations acknowledges that Canada owns the Northwest Passage; however, the dispute is over whether the Northwest Passage is Canadian internal waters or an international strait that would allow for the free passage without Canadian consent for all international maritime vessels. Canada claims that the Northwest Passage is part of their internal waters and not international waters as specified under the United Nations Convention on the Law of the Sea (UNCLOS).

Thus, the Canadians claim that the Northwest Passage is under their sole jurisdiction, and they have the right to enforce their own navigable and shipping laws regarding fishing, vessel safety, and illegal transportation of goods or persons. The other maritime countries dispute the Canadian claim of jurisdictional authority. Another concern of wanting to maintain an international strait for the Northwest Passage is that Canadian environmental regulations over internal waters are stricter than the UNCLOS. The Canadian government does not claim to have the right to close the passage, just to have jurisdictional authority over enforcement and regulation.

Over the years, the Northwest Passage dispute has caused periodic controversy between United States and Canada. For example, in 1969, a U.S. company piloted an oil tanker, named *Manhattan*, through the Northwest Passage without the Canadian government's permission. Another incident occurred in 1985, when the U.S. Coast Guard icebreaker, named *Polar Sea*, went through the passage. These incidents infuriated the Canadians, causing a Canadian Arctic sovereignty crisis and straining Canada–U.S. relations. Mostly relations between Canada and United States are mutual, and they frequently set aside their differences, turn a blind eye, or agree that icebreakers and nuclear-powered submarines do not require permission to navigate in the Northwest Passage.

More recently, in 2006, the North Passage dispute was restarted. The Canadian Department of National Defense under the direction of the Department of Foreign Affairs started calling the Northwest Passage "the Canadian Internal Waters." This resulted in an internal struggle within Canada. In 1993, the Canadian government had signed the Nunavut Land Claims Agreement, which required the Canadian government to confer with the Inuit of Nunavut prior to altering names of any land area or feature in their territory. This incident was considered a diplomatic mistake because in the push to assert Canadian sovereignty over waters, the Canadian government disregarded Inuit sovereignty. In 2009, the Canadian parliament again proposed changing the name of the Northwest Passage to the "Canadian Northwest Passage." The United States along with most maritime nations did not see the name change as a solution or resolution to the Northwest Passage dispute over internal water or an international strait.

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See also: Northeast Passage; Northwest Passage

Further Reading

Charron, A. "The Northwest Passage in Context." *Canadian Military Journal* (2005). http://www.journal.forces.gc.ca/vo6/no4/north-nord-02-eng.asp.

Gray, D. "Canada's Unresolved Maritime Boundaries." *IBRU Boundary and Security Bulletin* 5, no. 3 (1997): 61–70.

McRae, D. "Arctic Sovereignty: Loss by Dereliction." *Northern Perspectives* 22, no. 4 (1994–1995). Canadian Arctic Resources Committee. http://www.carc.org/pubs/v22no4/loss.htm.

Norwegian Polar Institute (NPI)

The Norwegian Polar Institute (69° 38′N 18° 56′W) is Norway's main center for international cooperation securing environmental regulation for polar research and natural resource management in Antarctica and the Norwegian Arctic, a region that includes the Svalbard Archipelago and Jan Mayen island, pristine lands that are home to one of the world's last polar wilderness areas. The NPI provides essential services supporting polar research, including the use of the research vessel *Lance* and its research stations in Longyearbyen in Svalbard, Sverdrup, and the Zeppelin station in Ny-Ålesund. It also oversees research conducted on-site at Troll Station in Queen Maud Land, Antarctica, and the summer-only research station Tor. Troll is Norway's main station for meteorological studies in Antarctica.

The institute preserves a cultural legacy of Norse polar exploration that dates into antiquity. Its modern foundations reflect the leadership of Prince Albert of Monaco, who financed the first mapping and exploration of the Svalbard Archipelago in 1906. Subsequent field trips were organized under the auspices of the *Norges Svalbard-ogIshavsundersøkelser* (NSIU; Norwegian Svalbard and Polar Sea Studies), founded in 1928 by the noted Norwegian geologist and explorer Adolph Hoel. The organization was reincorporated in 1948, at which time it was given authority over the mapping and place-names of the Norwegian territories in Antarctica.

The institute's main offices are housed in the esteemed Fram Centre (*Framsenteret*) based in the capital city of Tromsø in northern Norway. The center (High North Research Centre for Climate and the Environment) supports a consortium of 20 institutions supporting the interdisciplinary research of more than 500 scholars, connecting and unifying foundations of knowledge in the fields of natural science, technology, and the social sciences. The center and its affiliates operate under the auspices of the Committee of Institutional Directors, whose meetings are attended by representatives of the Norwegian Ministry of the Environment.

As a directorate under the Ministry of the Environment, the institute operates as an adviser to the state on questions regarding Norwegian interests on the Svalbard Archipelago and Jan Mayen, and the Norwegian Arctic. It provides key topographic and geologic mapping systems resources as well as time-honored logistics support for polar research under extreme meteorological conditions. Many research initiatives in climate, pollutants, biodiversity, marine ecosystems, and geological systems are coordinated through the Centre for Ice, Climate and Ecosystems, operated by the NPI.

The NPI serves an advisory role in conjunction with the Directorate for Nature Management, the Norwegian Pollution Control Authority, and the Directorate for Cultural Heritage and the Governor on Svalbard. It also works in collaboration with the Secretariat for the Climate and Cryosphere (Clic) International Project Office. On April 26, 2013, Harald V of Norway signed into law the Antarctic Environment Protection Decree (No. 412 of 2013, with Norwegian title FOR 2013–04–26 nr 412: *Forskriftommiljøvernogsikkerheti Antarktis*). This legislation supersedes the Antarctic Environment Protection Decree No. 408 of 1995, revising statutes to ensure the preservation of the region's environment and ecosystems. The NPI is authorized to enforce all applicable Norwegian statutes in reference to research activities in Antarctica.

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See also: Antarctic Programs and Research Stations/Bases

Further Reading

Norwegian Polar Institute. http://www.npolar.no/en/. Accessed January 13, 2014.

Novaya Zemlya, Nuclear Tests

The Novaya Zemlya Archipelago (74° N 56° E) is approximately 22,400,000 acres (9,064,958 hectares) and consists of two main islands: Severny in the north and Yuzhny in the south. These islands are separated by the Matochkin Strait and a handful of small islands. To the west of the Novaya Zemlya Archipelago is the Barents Sea and the east is the Kara Sea. During the Cold War, Novaya Zemlya was a strategic airbase and nuclear testing site for the Union of Soviet Socialist Republics (USSR) or the Soviet Union.

In 1954, the USSR designated the Novaya Zemlya Archipelago for nuclear weapons experiments and tests. After designation, approximately 500 Nenets, the indigenous population of the Novaya Zemlya, were relocated. Construction of the nuclear test site took place over the winter of 1954–1955. Around 10,000 Soviet soldiers were brought in to construct the nuclear test sites. These soldiers lived on the frozen tundra in military tents.

The USSR after created the first nuclear testing site or zone then created two more zones. The nuclear testing zones were Chyornaya Guba (70° 42′N 54° 36′E), referred to as "Zone A" operational from 1955 to 1962 and from 1972 to 1975; Matochkin Shar (73° 23′ 19″N 55° 12′ 56″E), "Zone B" (used for underground tests), was operational from 1964 to 1990; and Sukhoy Nos (73° 42′N 54° E), "Zone C," operated from 1958 to 1961. Nuclear tests were not confined to the official zones with some tests occurring outside the zones and just off the islands.

From 1955 to 1990, there were 130 nuclear tests and the detonations of 224 nuclear devices with nuclear weapon yield of 265 megatons of TNT. Eighty-eight of these atomic tests were detonated in the atmosphere, thirty-nine were underground, and three were underwater atomic tests that took place in 1955, 1957, and 1961 in Chernaya Bay, on the southern tip of Novaya Zemlya. In 1963, after signing the Partial Test Ban Treaty, the atmospheric tests were officially suspended, and the first underground test at Novaya Zemlya occurred on September 15, 1964. From

1964 until 1990, there were 32 underground nuclear tests involving 128 separate nuclear devices at Novaya Zemlya.

On October 30, 1961, Sukhoy Nos (Zone C) was the site for the world's largest thermonuclear weapon detonation, nicknamed Tsar Bomba. Tsar Bomba was initially designed with a nuclear weapon yield of 100 megatons of TNT, but was reduced to 50 megatons over concerns about nuclear fallout and destroying the delivery aircraft. The largest underground detonation at Novaya Zemlya occurred on September 12, 1973. This test involved four nuclear devices with a nuclear weapon yield of 4.2 megatons of TNT resulting in an earthquake that measured 6.97 on the Richter Scale. The blast and the seismic activity caused an 80-million-ton rock slide and avalanche that dammed two glacial streams resulting in the creation of a 1.2-mile (2-km) lake. In September 1961, Novaya Zemlya was targeted and struck by two thermonuclear warheads launched from Vorkuta Sovetsky (around 400 miles away) and Salekhard (more than 400 miles away).

Collectively, the nuclear test sites represent 25 percent of the area designated by the Soviet Union for nuclear tests, but the total nuclear weapon yield of 265 megatons of TNT on or near the Novaya Zemlya Archipelago accounts for over 90 percent of the total nuclear weapon yield of the USSR. By 1990, the Novaya Zemlya Archipelago being used for nuclear weapons tests was shut down. There

TSAR BOMBA

On October 30, 1961, an AN602 hydrogen bomb with a nuclear weapon yield of 50 megatons of TNT was detonated over the Novaya Zemlya Archipelago at Sukhoy Nos, Soviet Union (modern-day Russia). This was the world's largest and most powerful thermonuclear weapon detonation ever. This detonation has several nicknames, such as Big Ivan, Kuz'kina Mat, Izdeliye 202, and Tsar Bomba in the former Soviet Union. The U.S. Central Intelligence Agency called the AN602 hydrogen bomb blast "Joe 111." Most commonly, the AN602 hydrogen bomb is called "Tsar Bomba." Tsar Bomba was initially designed with a nuclear weapon yield of 100 megatons of TNT, but was reduced to 50 megatons over concerns about nuclear fallout and destroying the delivery aircraft. The flash could be seen at around 600 miles (1,000 km) away, and the blast was hot enough to cause third-degree burns at a distance of 60 miles (100 km). The designers of Tsar Bomba were Julii Khariton, Andrei Sakharov, Victor Adamsky, Yuri Babayev, Yuri Smirnov, and Yuri Trutnev. Tsar Bomba caused significant environmental damage, such as melting rocks, leveling the land, and vaporizing the flora and fauna at the ground surface at Sukhoy Nos.

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have been small tests since 1990. Since 1998, there have been several underwater subcritical nuclear tests near Matochkin Shar. These are conducted by the Russian Ministry of Atomic Energy. The subcritical tests use about 3.5 ounces (100 g) of weapons-grade plutonium. Other areas of the Novaya Zemlya Archipelago are used for Russian nonexplosive nuclear experiments consistent with the Comprehensive Nuclear-Test-Ban Treaty of 1996.

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See also: Novaya Zemlya, Nuclear Tests, Environmental Legacy of; Nuclear Power in the Arctic; Nuclear Waste in the Arctic; Operation Chrome Dome; Sunken Soviet/Russian Nuclear Submarines in Arctic

Further Reading

Matzko, J. "Underground Nuclear Testing on Novaya Zemlya: The Physical Background." *Post-Soviet Geography* 35, no. 3 (1994): 123–41.

Shipko, Y., and N. Filonov. "Northern Test Site" (in Russian). *Information Bulletin of the Center of Public Information of Atomic Energy* (Moscow), (June 4, 1990), 22 pp.

Novaya Zemlya, Nuclear Tests, Environmental Legacy of

Nuclear weapon detonations on the Novaya Zemlya Archipelago (74° N 56° E) are one of the greatest sources of man-made radioactive contamination in the Arctic. The atmospheric nuclear test from 1958 to 1962 resulted in significant radioactive contamination of Russia, Northern Canada, Alaska, Finland, Sweden, and Norway. There were 130 nuclear tests in and around the Novaya Zemlya Archipelago. A total of 224 nuclear devices were detonated during the 130 nuclear tests. Early in the program, the Soviet Union detonated 15 atmospheric devices over the Novaya Zemlya Archipelago over 35 days in 1958 (e.g., September 20–October 25, 1958). The lingering effects of the atmospheric weapons testing on the Novaya Zemlya Archipelago remain a major source of radioactive contamination in the Barents, Kara, and other Arctic seas.

In 1963, after signing the Partial Test Ban Treaty, the atmospheric tests were officially suspended, and the first underground test at Novaya Zemlya occurred on September 15, 1964. From 1964 until 1990, there were 32 underground nuclear tests involving 128 separate nuclear devices at Novaya Zemlya. The largest underground detonation at Novaya Zemlya occurred on September 12, 1973, which had a nuclear weapon yield of 4.2 megatons of TNT. This blast triggered an earthquake measuring 6.97 on Richter scale and caused an 80-million-ton rock slide and avalanche that dammed two glacial streams resulting in the creation of a 1.2-mile (2-km) lake. Collectively, the nuclear test sites represent 25 percent of the area designated by the Soviet Union for nuclear tests, but the total nuclear weapon yield of 265 megatons of TNT on or near the Novaya Zemlya Archipelago accounts for more than 90 percent of the total nuclear weapon yield.

Beyond the nuclear detonations, the seafloor around the Novaya Zemlya Archipelago has been a graveyard for the Soviet/Russian nuclear reactors, weapons, and submarines for many years. These reactors and vessels were not disposed of correctly. Many reactors and vessels still have radioactive material and are emitting radiation. Scientific assessments by the International Atomic Energy Agency claimed that the radioactive contamination per individual of the Kara and Barents Seas ranges from 1 to 20 microsieverts annually. Over time, the seawater rusts and corrodes the containers and submarines resulting in radioactive leaks that pollute the marine environment and the ocean ecosystem. The ocean currents can carry radioactive contaminants into fishing areas as well as sea mammal and bird feeding areas of the Barents and Kara Seas. The lingering effects of dumping nuclear weapons, reactors, and vessels are that the seas around the Novaya Zemlya Archipelago will continue to be a significant source of radioactive contamination for the Arctic seas.

Andrew J. Hund

See also: Novaya Zemlya, Nuclear Tests; Nuclear Power in the Arctic; Nuclear Waste in the Arctic; Sunken Soviet/Russian Nuclear Submarines in Arctic

Further Reading

Khalturin, V., T. Rautian, and P. Richards. "Absolute Locations for Under-Ground Nuclear Tests at Novaya Zemlya." Manuscript in preparation for the *Bulletin of the Seismological Society of America*, 2005.

Matzko, J. "Underground Nuclear Testing on Novaya Zemlya: The Physical Background." *Post-Soviet Geography* 35, no. 3 (1994): 123–41.

Shipko, Y., and N. Filonov. "Northern Test Site" (in Russian). *Information Bulletin of the Center of Public Information of Atomic Energy* (Moscow) (June 4, 1990), 22 pp.

Nuclear Power in the Arctic

There are several operational and nonoperational nuclear power plants (NPPs) in Russia, Alaska, and Greenland. In the Russian Arctic, there are two NPPs, which are the Kola and Bilibino NPP. The Kola NPP (67° 28′N 32° 28′E) is also known as the Kolskaya NPP and is located in the Murmansk Oblast in Northwest Russia. Kola NPP consists of four units, all of which have a net capacity of 411 megawatts (MWe). Kola 1 and 2 reactors were the first generation of pressurized water reactors and went online in 1973 and 1975. Kola 3 and 4 reactors are the improved pressurized water reactors and went online in 1981 and 1984. Kola 1 and 2 were scheduled to shut down in 2003, but have been extended until 2018/2019 after safety and equipment upgrades. The Bilibino NPP (68° 3′N 166° 32′E) is also known as the Bilibinskaya NPP and is located in the Bilibino, Chukotka Autonomous Okrug, Russia. Bilibino NPP consists of four EGP-6 reactors. An EGP-6 is a scaled-down version of a graphite-moderated nuclear power reactor (RBMK). The unique feature of the RBMK model of reactors is that the core is cooled with graphite, not water like modern reactors. At low temperatures, RBMK reactors are potentially explosive. A full-scale version of the Russian RMBK NPP is the Chernobyl NPP (e.g., an RBMK 1000 reactor). Bilibino NPP is the northernmost NPP and the smallest in the world.

In the 1960s, the U.S. Army Nuclear Power Program built a number of small nuclear power reactors. For example, from 1962 to 1972, an experimental SM-1A (2 MWe) nuclear reactor was operational at Fort Greely, Alaska, which is about 100 miles (160 km) southeast of Fairbanks, Alaska. Officially, this SM-1A reactor was designed to test a nuclear reactor's ability to operate in cold climatic conditions. It has also been noted that the Fort Greely reactor had the capacity to produce superfissile material, which could possibly be used as small nuclear yield weapons on the battlefield. Another example is the Camp Century, Greenland, portable nuclear reactor (PM-2A). From 1960 to 1963, the PM-2A was operational at Camp Century, Greenland, which is below the ice-surface facility. Camp Century reactor was operational from 1959 to 1966 and was under the direction of the Army Polar Research and Development Center. This experimental nuclear reactor was built by the U.S. Army Corps of Engineers. The PM-2A (2 MWe) nuclear reactor demonstrated that a nuclear plant could be portable and thus brought in pieces, assembled, and made operational, then dissembled. The Fort Greely, Alaska, and the Camp Century, Greenland, reactors operated at a uranium-235 enrichment of 93 percent.

The United States, United Kingdom, France, and China all have nuclear-powered military vessels that travel Arctic waters. The Russian Murmansk Shipping Company has eight nuclear-powered ships used as icebreakers in the tourist trade and for scientific research. In 2010, the first non-self-propelled floating nuclear vessel, called "Academik Lomonosov" was put into use in Russia. It will operate in the Kamchatka Peninsula region of the Russia Far East. There are plans to build a number of self-contained and self-propelled floating nuclear power stations for the Arctic. It is called a "nuclear power station barge" and will be mobile. These floating nuclear power station barges are combined heat and electricity units. The floating nuclear vessels will be 98 ft. wide (30 m), 33 ft. tall (10 m), and 475 ft. long (145 m). The hull will be 18 ft. (5.6 m). The vessel will require a crew of 70 people. The reactors of these vessels are two modified nuclear fission reactors (KLT-40S), which are slight variant of the Taymyr-class icebreaker reactors. These reactors are capable of producing up to 300 MW of heat or 70 MW of electricity, which is enough energy for a population of 200,000. These floating nuclear vessels could be modified to produce more electricity and work as a desalination plant capable of producing around 63,401,292 gallons of water a day.

There are three nuclear fuel reprocessing plants, which are Mayak, Krasnoyarsk, and Tomsk, located south of the Arctic Circle. The spent fuel for nuclear production is sent to these plants for reprocessing (recycling), where the nuclear and non-nuclear products are separated from the spent fuel. The by-products can either be reused or disposed of via chemical or mechanical processes. The discharge of liquid waste (effluents) from the Mayak and Tomsk nuclear fuel reprocessing plants is released into the Ob River and those from Krasnoyarsk flow into the Yenisey River. Both these rivers flow into the Arctic Ocean.

There are several nuclear power reactors that are presently decommissioned, operational, or in the planning stages located near the Arctic Circle in Finland, Norway, Sweden (Forsmark NPP), and Russia. Presently, in Finland, there are four NPPs (e.g., Loviisa 1 and 2 and Olkiluoto 1 and 2), and in 2009, they provide 27.8 percent of the country's electricity. A fifth nuclear reactor is being completed at Olkiluoto and is expected to be operational in 2012/2013 and will cost more than $4 billion. Two additional nuclear plants are in the planning stage.

Andrew J. Hund

See also: Novaya Zemlya, Nuclear Tests; Novaya Zemlya, Nuclear Tests, Environmental Legacy of; Nuclear Waste in the Arctic; Sunken Soviet/Russian Nuclear Submarines in Arctic

Further Reading

Koudrik, I., and A. Nikitin. "Second Life: The Questionable Safety of Life Extensions for Russian Nuclear Power Plants." *Bulletin of the Atomic Scientists* (2011).

Stolyarova, G. "Nuclear Power Vessel Launched." *The St. Petersburg Times*, July 1, 2010.

Nuclear Waste in the Arctic

There is a significant amount of nuclear waste in the Arctic. Nuclear products have entered the environment through several different processes, which include the atmosphere, rivers, and the ocean. There have been 130 nuclear tests with a total of 224 nuclear device detonations with a nuclear weapon yield of 265 megatons of TNT at the Novaya Zemlya Archipelago, from 1955 to 1990. Eighty-eight of these atomic tests were detonated in the atmosphere, thirty-nine were underground, and three were underwater atomic tests that took place in 1955, 1957, and 1961 in Chernaya Bay, on the southern tip of Novaya Zemlya. From 1964 until 1990, there were 32 underground nuclear tests involving 128 separate nuclear devices at the Novaya Zemlya. In 1968, a U.S. B52 bomber carrying four 1.1-megaton nuclear weapons crashed near Thule Airbase in Greenland, releasing approximately 1 pound of plutonium into the atmosphere. All of these released significant amounts of radiation into the Arctic environment.

There are three nuclear fuel reprocessing plants that pollute the Arctic rivers and the Arctic Ocean. The reprocessing plants are Mayak, Krasnoyarsk, and Tomsk, which are located south of the Arctic Circle. The spent fuel for nuclear production is sent to these plants for reprocessing (recycling), where the nuclear and nonnuclear products are separated from the spent fuel. The by-products can either be reused or disposed of via chemical or mechanical processes. The discharge of liquid waste (effluents) from the Mayak and Tomsk nuclear fuel reprocessing plants is released into the Ob River and those from Krasnoyarsk flow into the Yenisey River. Both these rivers flow into the Arctic Ocean.

Disposing of nuclear plants' radioactive waste and storage practices has resulted in elevated exposure levels in certain communities in Russia. For example, due to the excessive dumping of radioactive waste into the Techa River, from 1949 to 1956, citizens received doses ranging from 350 to 3,500 millisieverts. From 1950 to 1951, the citizens of Muslimova village, who live along the Techa River, 20 miles (32 km) downriver from the Mayak Chemical Combine, received doses of 240 millisieverts.

The British Nuclear Fuels Limited reprocessing plant in Sellafield, England (formerly Windscale) is one of the chief sources of radionuclides into the Arctic marine environment, due to the magnitude of discharges. Ocean currents around Sellafield carry the contaminants, mostly cesium-137 north into the Barents Sea, and subsequently the Kara Sea, Laptev Sea, and central Arctic Ocean. Almost all of the plutonium and americium discharged from Sellafield is retained in the sediments of the northeast Irish Sea.

Nuclear waste was also dumped west and east of Novaya Zemlya, from 1960 to 1991, in the Barents Sea and Kara Sea, respectively. A significant amount of this high-level radioactive waste was dumped into the shallow fjords of the Kara Sea near the Novaya Zemlya Archipelago. The waste is dumped at a depth of about 33 ft. (10 m) to 440 ft. (135 m). Waste is also dumped in the Novaya Zemlya Trough that has depths up to 1,250 ft. (380 m). Low-level radioactive liquid waste has also been dumped in the open Barents and Kara Seas.

Sixteen nuclear reactors have been dumped in five different locations. These locations are Ambrosimov Inlet (eight submarine reactors), Novaya Zemlya Depression (one submarine reactor), Stepovoy Inlet (two submarine reactors), Techeniye Inlet (two submarine reactors), and the Tsivolka Inlet (three reactors from icebreaker named *Lenin*). The total radioactive waste products dumped by the Soviets at sea include 17,000 radioactive contaminated containers, 19 radioactive contaminated vessels, 14 nuclear reactors, 735 radioactive-contaminated heavy machinery, and the K-27 nuclear submarine. Collectively, the estimated radioactive waste dumped into the Arctic Sea is approximately 90 petabecquerel (PBq) (1 petabecquerel = 1.0×10^{15} Becquerels [Bq]). Some of the dumped radioactive items include equipment, reactors, weapons, and solid and liquid waste.

On the Kola Peninsula of Russia, there are three nuclear submarine naval facilities (Murmansk, Gremikha [Yokanga], and Severodvinsk [Sevmash]), and a cache of spent fuel rods and spent fuel of which a sizable amount of the fuel is highly enriched uranium and plutonium. There are two storage facilities on the Kola Peninsula: Andreeva Bay and Gremikha as well as 90 decommissioned nuclear submarines, and the Pacific Fleet also has 75 decommissioned nuclear submarines stranded in harbors in the Russian Far East. The U.S. military dumped a total of 47,078 gallons (556,750 liters) of liquid radioactive waste on to the Greenland ice cap after taking down the PM-2A reactor at Camp Century, Greenland.

Andrew J. Hund

See also: Novaya Zemlya, Nuclear Tests; Novaya Zemlya, Nuclear Tests, Environmental Legacy of; Nuclear Power in the Arctic; Sunken Soviet/Russian Nuclear Submarines in Arctic

Further Reading

International Atomic Energy Agency (IAEA). TECDOC-1105. "Inventory of Radioactive Waste Disposals at Sea." August 1999.

Nuuk (Godthaab)

Nuuk (64° 10′N 51° 45′W) is the capital of Greenland and is situated at the mouth of the large fjord system, Nuup Kangerlua, at the west coast of Greenland, toward the Davis Strait. The city is also the main town in Semersooq Kommune, which extends across the Greenland Ice Sheet, including the town Tasiilaq on the east coast. The town is partly surrounded by mountains with altitudes up to 4,000 ft. (1,200 m) (Sermitsiaq). Others are Lille Malene at 1,500 ft. (450 m) and Store Malene at 2,500 ft. (770 m). On the other side of the fjord, the land is relatively flat, Nordlandet (Akia). The climate is Low Arctic. Average temperature is 45°F (7°C) in July and 18°F (−8°C) in January. Annual precipitation is around 30 inches (752 mm).

Nuuk (Godthaab) was established in 1728 by the Danish Norwegian missionary Hans Egede. He left in 1736, and the Herrenhut missionaries took over the area. In the 1850s, the area was in crisis because of cultural clashes and imported diseases. In 1853, H. J. Rink arrived and promoted Greenlandic culture and identity. During World War II, Greenland was administered by the Danish ambassador in the United States, and later a local administration (Landsraadet) was established by Eske Brun. Landsraadet was closed down in 1979, when home rule was established. Since then, the administration of the country and the self rule is located in Nuuk. The town has

Icebergs floating past Nuuk harbor in summer. (Shutterstock.com)

16,181 inhabitants in 2012. Nuuk consists of three major parts, Midtbyen (Town Centre), the old part where culture and administration is located; Nuusuaq was established in the 1970s and expanded in the 1980s mainly to house the fast rising population. The modern quarter Qinngorput is established in 2003 and is the main area for new housing. Nuuk has a harbor that can handle oceangoing ships and a regional airport inaugurated in 1979. The town has approximately 60 miles (100 km) of roads, but no road connection to other cities.

Nuuk has five public schools and the teachers' college (Ilinniarfissuaq) dating back to 1847. The University of Greenland was inaugurated in 2007 and offers education of bachelor and master candidates. Jern-og Metalskolen educates technicians within the fields of transportation, communication, and construction. Furthermore, there are schools for journalists, social workers, police, and health care. Other places located in Nuuk include the Greenland Institute for Natural Resources (Pinngortitaleriffite), which houses departments of marine animals, mammals, and birds; the Greenland Climate Research Center; and the Asiaq research group that carries out monitoring and data storing within mapping, geographic information, hydrology, and climate. A number of the cultural institutions are located in Nuuk, such as the Katuaq (House of Culture); the Greenland National Museum and Archives; and the Landsbiblioteket, the National Library.

Bent Hasholt

See also: Greenland; Nuuk Ecological Research Operations (NERO)

Further Reading

Hansen, B., et al. "Nuuk Basic—The GeoBasis Programme." In L.M. Jensen and M. Rasch, eds. Nuuk Ecological Research Operations, 4th Annual Report, 2010. Aarhus, Denmark: Aarhus University, DCE—Danish Centre for Environment and Energy, 2011, 80 pp.

Nuuk Ecological Research Operations (NERO)

The Nuuk Ecological Research Operations (NERO) station (64° 8′N 51° 23′W) is located near the coast of the inner part of Kobbefjord. The terrestrial part of the research program is carried out within the catchment of Kobbefjord located about 3 miles (5 km) southeast of the capital Nuuk. The marine research program also includes the larger Godthåbsfjord. The research hut was taken into use in August 2009. The hut is around 600 sq. ft. (55 sq. m) and is equipped with a kitchen and accommodation facilities for the research and monitoring activities.

Kobbefjord is carved by glaciers, and the surrounding relief is alpine with altitudes above 3,000 ft. (1,000 m) above sea level. The catchment contains several minor glaciers at high altitudes and minor lakes in the valley bottoms. The vegetation is subarctic fen and scrub. The monitoring was initiated in 2007, so longer time series are not yet available. The annual mean temperature in 2009 was 30°F (−1.3°C), the coldest month was March 10°F (−12.1°C), and the warmest month is July 50°F (9.9°C). Annual precipitation was 33 inches (84 cm) with approximately 50 percent of the precipitation being snow. The development of the research station is based on the experiences gained from the Zackenberg Station (ZERO). The overall purpose of Nuuk Basic is to collect long-term data quantifying seasonal and interannual variations and long-term changes in the biological and geophysical properties of the terrestrial, freshwater, and marine ecosystem compartments in relation to local, regional, and global climate variability and change. The aim is to establish a data platform that enables a thorough description and analysis of climatic effects on the structure, function, and feedback dynamics of a Low Arctic ecosystem. The monitoring is organized in separate modules, each covering part of the ecosystem: Climate Basis, GeoBasis, BioBasis, and MarineBasis program. Examples of research projects are as follows: Copepods feeding in a glacial marine environment—effects of suspended sediments and mercury (Hg) transport from the terrestrial to the marine environment. The research is coordinated with similar research at Zackenberg to cover regional variations in Greenland. The research is also coordinated with the Greenland Climate Research Centre in Nuuk and participates in international programs: SAON, SCANNET, and INTERACT.

Bent Hasholt

See also: Greenland; Nuuk (Godthaab)

Further Reading

Hansen, B., et al. "Nuuk Basic—The GeoBasis Programme." In L. M. Jensen and M. Rasch, eds. Nuuk Ecological Research Operations, 4th Annual Report, 2010. Aarhus, Denmark: Aarhus University, DCE—Danish Centre for Environment and Energy, 2011, 80 pp.

Juul-Pedersen, T., and S. Rysgaard, et al. "Greenland Climate Research Centre—Studying Climate Change Up Close." ESSAS Open Science Meeting, May, 22–26, 2011, Seattle, WA.

Rysgaard, S. "Arctic Marine Ecosystems: Investigations and Developments in Greenland. The Arctic as a Messenger for Global Processes—Climate Change and Pollution." May, 4–6, 2011, Copenhagen, Denmark.

O

Ob, Pechora, and Yenisey Rivers

The three major rivers flowing into the Kara Sea are the Ob, Pechora, and Yenisey Rivers.

Ob River

The Ob River is located in western Siberia with a length of 2,268 miles (3,650 km). About six months of the year, the Ob is navigable, while the other six months, it is frozen over. The confluences of the Ob are the Biya and Katun Rivers in the Altai Krai of Russia. The upper Ob flows northwest and then heads northeast past the cities of Barnaul (53° 17′N 83° 38′E) and Novosibirsk (55° 1′N 82° 56′E) flowing through the lowlands where it is joined by the Tom River. The Ob's course then flows northwest where it is joined by the Chulym, Ket, and Irtysh Rivers. The Irtysh River is a major river that originates in China and is the chief tributary of the Ob. The Irtysh is 2,640 miles (4,248 km) in length. In the lower section, the Ob flows north then turns east flowing between the Gydan and Yamal Peninsulas forming the 600-mile (1,000-km) long Ob Bay. The Ob Bay is the world's largest estuary. The Nadym and the Pur Rivers flow into the Ob Bay. The Taz River (871 miles [1,400 km]) flows into the Taz Estuary, which connects to Ob Bay.

Humans have been using the Ob River for thousands of years. Present uses include using the Ob for agriculture (irrigation), electricity (hydroelectric), drinking water, and fishing. Built in 1956, the hydroelectric dam is near Novosibirsk and creates a reservoir 100 miles (160 km) long and 12.5 miles (20 km) wide making the Novosibirsk Reservoir the largest man-made lake in Siberia. The Ob Basin has significant oil and gas deposits. Historically, the Ob River was traversed by steamboats. The steamboats were first used on the Ob in 1936, but it was not until 1857 when the transport of goods and services were used on steamboats. The utilization of steamboats on the Ob River dimensioned when the Trans-Siberian Railway was completed. The discharge of liquid waste (effluents) from the Mayak and Tomsk nuclear fuel reprocessing plants has polluted the Ob River via its tributaries. In the lower part of the Ob, the pollution has significantly damaged the once famous fishery. The Ob has more than 50 species, such as whitefish (sheefish, Board, whitefish, and muksun), carp, sturgeon, burbot, and pike. An Arctic city along the Ob

River is the Labytnangi (66° 39′N 66° 25′E) and a near-Arctic city is Salekhard (66° 32′N 66° 36′E).

Pechora River

The Pechora River is located in Northwest Russia in the Komi Republic with the northern portion intersecting the Nenets Autonomous Okrug. The length of the Pechora River is just more than 1,100 miles (1,800 km) and empties into Pechora Bay, on the Barents Sea. The discharge of the Pechora River is 44,800 ft^3/s (4,100 m^3/s). The Pechora originates in a small spring around 3,000 ft. (900 m) above sea level called the Pechor-Ya-Talyakh-Sekhal in the Ural Mountains. The opposite side of the Ural Mountains is the headwaters of Northern Sosva River, which drains into the Ob River. The Pechora basin is 124,000 square miles (322,000 sq. km) and has more than 62,000 lakes.

In the summer, the Pechora is considered navigable to almost 500 miles (760 km) and just more than 1,000 miles (1,670 km) during the spring and autumn. During breakup, the Pechora is prone to flooding partly due to ice jams. From October to November, the Pechora freezes over.

The Pechora River first flows south then turns west and finally heads north around the town of Yaksha (61° 49′N 56° 50′E). Navigating to the Yaksha is possible when the water level is high during late spring and early summer. There are hundreds of tributaries flowing into the Pechora, with the main tributaries being the Ilych, Izhma, Kozhva, Severnaya Mylva, Shugor, Sula, Tsylma, Unya, and Usa. The Pechora River originates in the Ural Mountains and flows past the towns of Komsomolsk-na-Pechore (62° 7′N 56° 36′E) and Ust-Ilych, where the major tributary, the Ilych River, joins the Pechora. The Pechora then heads northwest toward the town of Troisko-Pechorsk (62° 42′N 56° 12′E) then north passing by the towns of Vuktyl (63° 51′N 57° 18′E) and Ust-Shchugor (64° 15′N 57° 45′E) and then is joined by the Shchugor River. The Pechora River flows north to the town of Pechora (65° 8′N 57° 13′E) then north to the town of Ust-Usa. At Ust-Usa, the Usa River enters the Pechora, then the Izhma River and later the Tsilma River flow into Pechora before it crosses the Arctic Circle and then flows into the Pechora delta, Pechora Bay, the Pechora Sea, and finally empties into the Barents Sea.

The Pechora River has been occupied by the Komi, Khanty, and Mansi people, prior to Russians settling in the area in the seventeenth century. The upriver portion of the Pechora remained unstudied until the late nineteenth century. The Pechora has around 30 fish species, such as Arctic char, taimen, whitefish (Siberian, European cisco, and Board), Arctic grayling, salmon, perch, sturgeon, burbot, and pike. The Pechora Delta is a significant breeding area for birds and waterfowl, such as goldeneyes, swans (Bewick and whooper), eiders (common, king, and steller), and guillemot (Brünnich’s and black).

Yenisey River

At 2,167 miles (3,487 km), the Yenisey is the largest river flowing to the Arctic Ocean. The Yenisey River starts in Mongolia, travels north across the Russian Federation to the Yenisey Gulf, then emptying into the Kara Sea. The Yenisey drains a large portion of Siberia. The Yenisey is the large river with an average depth of 45 ft. (14 m) and a maximum depth of 80 ft. (24 m). The water discharge is 692,200 cubic feet per sec (ft^3/s) (19,600 cubic meters per second [m^3/s]). The Yenisey Basin covers around 1,003,865 square miles (2.6 million sq. km). It is the fifth largest drainage in the world.

The Yenisey rises out of the East Sayan Mountains and travels west along the Mongolian and Russian borders. At the capital of the Kyzyl, in the Tuva Republic, the Yenisey River is joined by the Bii-Khem River. The Yenisey then flows north past the cities of Minusinsk (53° 42′N 91° 41′E), Krasnoyarsk (56° 1′N 93° 4′E), and Yeniseisk (58° 28′N 92° 08′E); crosses the Arctic Circle; and then passes the town of Igarka (67° 28′N 86° 35′E) traveling through a long estuary of the Yenisei Bay and Gulf before emptying into the Kara Sea. The upper part of the Yenisey has fast-moving water and is prone to flooding, the middle section is controlled by a chain of power-generating hydroelectric dams at Krasnoyarsk (the Krasnoyarsk Dam) and at Sayanogorsk (the Sayano–Shushenskaya Dam), and the lower section is characterized by many tributaries entering the Yenisey River, such as the Angara, Stony-, and Lower-Tunguska as it crosses the tundra forest and then empties into the Kara Sea. The Yenisey freezes up for half the year, and during breakup, the upper section (in or near Mongolia) melts early while the lower section is still frozen, resulting in ice dams and significant flooding.

The Yenisey river area has been used by the Ket and Yugh people for thousands of years. The first Russians traveled to the Yenisey in the early 1600s. In the seventeenth century, Russia fur traders and Cossacks migrated and settled into the Yenisey River area. The first explorer in the region was the Finnish-Swedish explorer Adolf Erik Nordenskjold (1832–1901) in 1875. The entire length of the Yenisey River was not traversed until 2001. The first team to travel the length was the Australian Canadian made up to Colin Angus, Tim Cope, Ben Kozel, and Remy Quinter. Common fish species of the Yenisey include Arctic cisco, sturgeon (Siberian and starlet), doctor fish, Arctic flounder, stone sculpin, peled, inconnu, northern pike, Prussian carp, Arctic grayling, and the East Siberian grayling.

Andrew J. Hund

See also: Colville River; Indigirka and Kolyma Rivers; Khatanga, Lena, and Yana Rivers; Mackenzie River; Yukon River

Further Reading

von Bunge, A., and B-E. Von Toll. *The Expedition to the New Siberian Islands and the Jana Country, Equipped by the Imperial Academy of Sciences.* 1887. n.p.

von Merhart, G. *The Palaeolithic Period in Siberia: Contributions to the Prehistory of the Yenisei Region.* Lancaster, PA: American Anthropological Association, 1923.

Operation Chrome Dome

During the Cold War, Operation Chrome Dome was started under the direction of Strategic Air Command (SAC) General Thomas S. Power (1905–1970). From 1961 to 1968, Operation Chrome Dome was one of the United States Air Forces' airborne global alert programs. The operation was billed as a nuclear deterrent program. Under the deterrence theory, the goal was to let the enemy know (at the time, the Soviet Union) that if they launched nuclear weapons first, there would be a significant retaliatory or second strike response. Thus, the nuclear deterrence threat was meant to prevent the enemy from striking first. The other code names for Operation Chrome Dome were "Head Start," "Hard Head," "Round Robin," and "Operation Giant Lance."

Chrome Dome missions used a number of B52 Stratofortress strategic bomber aircrafts flying up to 24-hour missions. The B52 bombers were all equipped with thermonuclear weapons for a retaliatory strike on specific targets in the Soviet Union. The bombers' flight path was designed to loiter near the Soviet Union airspace border. Initially, there were two flight paths a southern and a northern route. The southern route started from Homestead Air Force Base, Florida (25° 29′N 80° 23′W), flew across the Atlantic Ocean, refueled over the Mediterranean Sea, flew over Italy, and then headed return to Homestead Air Force Base. The return route was roughly the same.

One northern route took off from Sheppard Air Force Base, Texas (33° 59′N 98° 29′W), headed toward the New England area of the United States, then flew out across the Atlantic Ocean. The B52 bombers were met up with KC-135 aircraft for midair refueling, near Newfoundland. After refueling, the B52 bombers changed course and headed between Canada and Greenland over Baffin Bay (73° N 67° W) toward Thule Air Base. The B52 bombers changed course and headed west over Queen Elizabeth Islands and then toward Alaska. Near Alaska, the B52 bombers were met up with another KC-135 for the second midair refueling. After the refueling, the B52 bombers headed over the Pacific Ocean, then back to Sheppard Air Force Base across the continental United States. The northern route took approximately 24 hours to complete. Upon returning, another set of B52 bombers took off on the same route. By 1966, there were three missions being operated. The first was an eastern route that flew over the Atlantic and the Mediterranean, the second over Baffin Bay, and the third over the state of Alaska.

The SAC military units involved in Operation Chrome Dome were the 306th Bombardment Wing (based out of the United States Air Force Academy, Colorado); 494th Bombardment Wing (based out of Sheppard Air Force Base, Texas);

821st Strategic Aerospace Division (based out of Ellsworth AFB, South Dakota), and the 822d Air Division (based out of Turner Air Force Base, Georgia). Main bases of operation were Sheppard Air Force Base, Homestead Air Force Base, and the various SAC bases in the United Kingdom.

General Power started the alert program in 1958 with a few missions. The program came online in 1961, and by 1964, there had been more than 6,000 alert missions. The program was not secret and was widely known and promoted. For example, in 1961, Operation Chrome Dome was featured in *Time* magazine. General Power publicly announced the program in 1961 and promised to have SAC's fleet, airborne at all times. It is estimated that approximately 12 nuclear-armed B52 bombers were aloft each day. Thus, the B52 bombers of SAC were airborne and on alert 24 hours a day as a nuclear deterrence during Cold War. During the Cuban missile crisis, there were 75 airborne global alert SAC nuclear flights each day.

There were five B52 bomber crashes involving nuclear weapons. Two occurred in 1961 (e.g., one in Goldsboro, North Carolina, on January 24, 1961, and the other on March 14, 1961, an aircraft accident occurred near Yuba City, California). In 1964, another crash occurred on January 13, 1964, near Meyersdale, Pennsylvania. The next B52 bomber crash occurred in 1966 and was a midair refueling crash over the Mediterranean Sea. The last crash occurred in the Arctic. On January 21, 1968, a U.S. Air Force B52G Stratofortress, operating under the call sign "HOBO 28" originating out of Plattsburgh, New York Airbase, 380th Strategic Bomb Wing, as part of Operation Chrome Dome crashed near Thule Airbase in Greenland and nearby Baffin Bay (76° 31′N 69° 16′W). The B52 bomber carried four 1.1-megaton nuclear weapons, and upon impact, the high-explosive charges of the nuclear warheads went off, and a nuclear explosion was averted. The radioactive material of the B28FI nuclear weapons, however, was strewn across a large area. The burn off of the B52's remaining fuel of 225,000 pounds lasted more than five hours melting the ice and sending most of the wreckage and munitions to the ocean floor. The Thule accident marked the end of Operation Chrome Dome.

Operation Chrome Dome was memorialized in the satirical film *Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb*, directed by Stanley Kubrick in 1964. The theme of the film was on the deterrence theory and a doomsday machine. General Power was depicted as General Jack D. Ripper in the film. General Ripper, in the film, is characterized as being delusional and orders a first strike resulting in both the United States and the Soviet Union attempting to stop the doomsday machine. The film ends with the complete destruction of the planet.

Andrew J. Hund

See also: Operation Deep Freeze; Operation Highjump; Operation Nanook; Operation Tabarin; Operation Windmill

Further Reading

Maydew, R. *America's Lost H-Bomb: Palomares, Spain, 1966.* Manhattan, KS: Sunflower University Press, 1997.

Operation Deep Freeze

Initially organized to provide logistical support for U.S. activities during the International Geophysical Year, Operation Deep Freeze was to continue until the late

Rear Admiral George J. Dufek, right, relinquishing command of the U.S. naval support forces in Antarctica, turns over a stuffed penguin, symbol of "Operation Deep Freeze," to his successor, Rear Admiral David M. Tyree in New York Harbor, April 14, 1959. A bearded crew member, veteran of the "Operation Deep Freeze," stands at attention during ceremony aboard icebreaker *Glacier*. Admiral Dufek said jets would fly commercial routes over the South Pole within 10 years. He made his first trip to Antarctica under Rear Admiral Richard E. Byrd in 1939. (Anthony Camerano/AP Photo)

1990s. For more than 40 years, scientists of the U.S. Antarctic Program were transported to Antarctica on ships and airplanes of the U.S. Navy, whose Seabees were also responsible for building the stations, including those deep in the interior at Byrd and the South Pole.

Deep Freeze 1, 1955–1956

Although Admiral Richard Byrd was given the essentially symbolic title of officer in charge, executive authority was assigned to Admiral George Dufek as commander of Task Force 43. Dufek was a veteran of two previous expeditions to Antarctica: the United States Antarctic Service Expedition (1939–1941) and Operation Highjump (1946–1947). Deep Freeze was to continue the work of both. In particular, it was to establish permanent U.S. bases on the continent, something first attempted by the Antarctic Service Expedition but thwarted by the outbreak of World War II. Highjump had obtained air photographs of 60 percent of the coastline, indicating several promising sites for stations. Ground surveys of these sites had been completed by Operation Windmill (1947–1948). Thus, by the time preparations were begun for the International Geophysical Year (IGY, 1957–1958), the United States had a clear idea of where it wanted to locate its IGY stations. Just to make sure, the icebreaker USS *Atka* was sent to make a final inspection in 1954–1955. The windswept sea ice of McMurdo Sound was confirmed as the best location for air operations. At the Bay of Whales, however, where Little America V was to be erected close to its four predecessors, *Atka*'s captain, Glen Jacobsen, found that a major calving event had left the bay surrounded by steep cliffs, which would prevent cargo ships from unloading. Another location would have to be found, and Jacobsen suggested Kainan Bay, also on the Ross Ice Shelf.

Deep Freeze 1 was a major operation involving 1,800 men, three icebreakers (USS *Glacier*, USS *Edisto*, and USCGC *Eastwind*), three cargo ships (USS *Arneb*, USS *Wyandot*, and USNS *Greenville Victory*), one tanker (USS *Nespelen*), and 19 airplanes. At 8,640 tons and with 21,000-horsepower engines, *Glacier* was the newest and most powerful icebreaker in the Atlantic Fleet. *Glacier* and *Edisto* sailed from Boston on October 30, 1955; *Eastwind* followed a month later, having shortly before returned from the Arctic. *Nespelen* left Norfolk on 6 November; the three cargo ships departed a week later. The first planes flew from New Zealand to McMurdo on December 20. The task force itself arrived on December 26.

Dufek's immediate aim was to establish beachheads for the major assault to be mounted by Deep Freeze 2 the following year. Little America V was opened in Kainan Bay on January 4, 1956. Farther west, fast ice extending 40 miles (64 km) offshore impeded unloading in McMurdo Sound. The first fatality occurred when tractor driver Dick Williams plunged through the ice while attempting to cross a tidal crack. To avoid risking further deaths, the tractor operations were halted, and the cargo transferred instead to the icebreakers for transporting closer inshore, where the tractors could again take over. Meanwhile, flights were made south over the pole to inspect conditions there, as well as west to Wilkes Land, where another station was to be constructed the following year. Meanwhile, Commander Jack Bursey, a veteran of many expeditions dating back to 1928, led two Sno-Cats and a weasel across the ice from Little America with the aim of establishing a safe trail to the planned location for Byrd Station at 80°S, 120°W. Bursey got about 380 miles (611 km) or halfway before being forced to abandon the attempt. With the bay ice threatening to break up, Dufek decided to risk three last flights, including one on January 13 to the Weddell Sea when the Pensacola Mountains were discovered. Five days later, the two Skymasters and two Neptunes took off on their 11-hour flight back to New Zealand.

Preparations were being made for the task force's own departure, when a Twin Otter was reported missing on February 3. Sent to bring back Bursey's trail party, Lieutenant Commander Glen Lathrop had five men on board when contact was lost during his return flight to Little America. The long-range airplanes were now sorely missed as a desperate search effort was mounted in deteriorating conditions; the missing men were found six days later. Through February, the ships left one by one, the last to go being *Glacier* after cutting a path through to Discovery Inlet, where two gasoline supply vessels were moored through the winter. At the suggestion of the chaplain, the McMurdo base was now named the Williams Air Operating Facility in honor of the tractor driver who had perished. Ninety-three men were left behind to winter. Seventy-three more remained at Little America V. Before finally heading north on March 30, *Glacier* circumnavigated the continent to inspect planned sites for stations at Cape Adare, the Budd Coast, and on the Filchner Ice Shelf south of the Weddell Sea.

Deep Freeze 2, 1956–1957

The major objectives for Deep Freeze 2 were to establish five more stations for U.S. IGY scientists. This second phase, involving 3,400 men and 12 ships, was to be even larger than its predecessor. Dufek continued in overall command, with Captain Gerald Ketchum leading the Ross Sea Task Group and Captain Edwin MacDonald the Weddell Sea Task Group. Consisting of six supply vessels and three icebreakers—*Glacier*, *Atka*, and USCGC *Northwind*—the Ross Sea Task Group was to relieve the two existing stations and establish four more: two on the coast at Cape Adare and in the Windmill Hills region of the Budd Coast, and two deep in the interior on the Rockefeller Plateau and at the South Pole. The Weddell Sea Task Group, consisting of *Wyandot* and the icebreaker USS *Staten Island*, was to establish Ellsworth station as far west on the Filchner-Ronne Ice Shelf as possible, preferably on the east coast of the Antarctic Peninsula.

Although none of the stations would be easy to construct, the stiffest challenges would be presented by the two inland stations. More than 500 tons of equipment would have to be transported by tractor some 700 miles (1,100 km) over a winding trail across numerous crevasses to Byrd. An even greater load would have to be flown 780 miles (1,250 km) from McMurdo Sound to the South Pole. Flights made during Deep Freeze 1 suggested that the snow at the pole was too soft to support a wheeled landing, meaning it had to be made instead on skis. Once the first planes had begun to fly in from New Zealand on October 17, the first task was to erect a support base on Beardmore Glacier. There, planes would refuel on their way to the South Pole. It would also serve as a relief base should anything go wrong with the polar flight. On October 28, *Glacier* arrived. The same day, Beardmore Base was established by two Skytrains. Three days later, a Grasshopper weather station dropped at the pole indicated promising conditions, and all was in place for three planes to take off from McMurdo: a Skymaster to act as pathfinder, a Douglas R-4D Skytrain to make the landing, and a Globemaster to carry emergency supplies, including a weasel, fuel, and sleds. Shortly after reaching the polar plateau, the Skymaster developed engine trouble and had to return. Once over the pole, the pilot, Lieutenant Commander Conrad Shinn, made three passes at 43, 21, and 11 ft. (140, 70, and 35 m) to assess surface conditions before setting the Skytrain down on hard snow at 8:34 P.M. While Shinn kept the engines running, Dufek and five colleagues spent 49 minutes inspecting conditions in temperatures of −90°F (−68°C). With the skis firmly frozen to the surface, it took all their 15 jet-assisted takeoff bottles to get back into the air.

The building of South Pole Station began one month later. Eighty-four flights would be required to drop 760 tons of building materials and equipment. At McMurdo, Dufek was still reliant on the bay ice landing strip, which would probably begin to break up later in the year, so it was essential that the airlift be accomplished as rapidly as possible. Ten tons of supplies were dropped from each plane, with up to three flights a day being completed when the weather held. Some problems were experienced early on, with lines sometimes becoming entangled during drops. Sergeant Richard Patton volunteered to investigate by making the first parachute jump at the pole on November 26. The station was completed in February 1957 and operating by March. Lieutenant John Tuck Jr. was left in charge of the nine-man naval support unit, which would remain through the winter along with nine scientists led by Dr. Paul Siple.

Meanwhile, arrangements for establishing Byrd Station were coordinated by Commander Paul Frazier. Crevasses were systematically hunted down using helicopters and electronic crevasse detectors fitted to a weasel. Once found, the deceptive snow bridges were dynamited and the crevasses filled in. Laying the trail proved difficult, but by December 5, all was ready for the first tractor train to leave Little America. Good progress was also made elsewhere, though Ellsworth Station had to be established on the Filchner Ice Shelf rather than farther west when MacDonald found the heavy ice of the southwest Weddell Sea impenetrable. Thus, by the conclusion of Deep Freeze 2, seven American stations were operating on the Antarctic continent, five of them new: South Pole, Byrd, and Ellsworth; Cape Hallett on the coast of Victoria Land; and Wilkes on the Budd Coast.

Initially planned for the few years on either side of the IGY, Operation Deep Freeze continued until 1998 when logistics support for the U.S. Antarctic Program was transferred to private contractors. Later operations were primarily concerned with relief and resupply, though they also erected additional facilities at existing bases and built several new stations in the 1960s. Of the IGY stations, Ellsworth and Wilkes were kept open only during the IGY, being transferred in 1959 to Argentina and Australia, respectively. Little America V was closed the same year. Cape Hallett was operated jointly with New Zealand before closing in 1964. The large scientific and logistics center at McMurdo replaced the more limited Williams Air Operating Facility in 1961. Eights (formerly Sky-Hi) operated between 1962 and 1965 in Ellsworth Land. Two new stations were established in 1965: Palmer on Anvers Island west of the Antarctic Peninsula, and Plateau deep in the interior of Queen Maud Land at 79° 15′S, 40° 30′E. Although Palmer remains open and is the main center for the U.S. Antarctic Program's marine biological program, Plateau was closed in 1969, as was Byrd in 1972. Between 1969 and 1991, Siple Station operated in Ellsworth Land. Stations in the continental interior are enormously expensive to run and are generally kept open for limited periods only. The one exception has been Amundsen–Scott (formerly South Pole Station), for its political significance as well as its unique advantages for scientific research, particularly astronomy and upper atmospheric physics.

William James Mills

See also: Antarctic Programs and Research Stations/Bases; East Antarctica; Ice Shelves of Antarctica; International Geophysical Year (IGY); Operation Highjump; Operation Windmill; Ross Island; South Pole; Transantarctic Mountains

Further Reading

Dufek, G. *Operation Deepfreeze.* New York: Harcourt, Brace, 1947.

Frazier, P. *Antarctic Assault.* New York: Dodd, Mead, 1958.

Siple, P. 1959. *9° South: The Story of the American South Pole Conquest.* New York: G. P. Putnam's Sons, 1959.

Operation Highjump

Operation Highjump was by far the largest expedition ever to visit Antarctica. Indeed, it was bigger than all previous expeditions put together. Although primarily a U.S. naval exercise, many significant discoveries were made, and knowledge of the continent was greatly extended, by the massive air photographic campaign.

Wartime Technology Is Employed in an Assault on Antarctica, 1946–1947

Admiral of the Fleet Chester W. Nimitz, shown here in 1944, commanded the U.S. Pacific Fleet in World War II. Although the defeat of Germany was the top Allied priority, Nimitz early on pursued an aggressive strategy vis-à-vis Japan. (Naval Historical Society)

On August 26, 1946, Fleet Admiral Chester W. Nimitz, chief of naval operations, gave orders for the establishment of the U.S. Navy Antarctic Developments Project, soon to be known by the code name "Operation Highjump." In an exercise primarily designed to train personnel and test equipment in the most rigorous conditions on earth—though also to strengthen the basis for U.S. territorial claims should they ever be made—there was great confidence that the same technical know-how that had enabled the Allies to win the war should now be sufficient to conquer the intractable Antarctic continent. For the first time, icebreakers, helicopters, and submarines would be used in a fleet of 13 vessels carrying 4,700 men and equipped with 33 aircraft and assorted land vehicles, including 8 weasels, 10 D-6 Caterpillar tractors, Cletrac tractors, Jeeps, and tracked landing vehicles. It was anticipated that radar, among other innovations, could be used to assist pilots to find their way back through fog and overcast weather, and a magnetic airborne submarine detector would provide useful indications of the nature of geology flown over, even when buried under ice.

Just seven weeks after its establishment, Task Force 68 was ready to depart with eight ships sailing on December 2 from four different ports on the Atlantic and Pacific Coasts of the United States, with the remainder following soon after or already at sea. Rear Admiral Richard Cruzen, a veteran of the United States Antarctic Service Expedition (1939–1941), was appointed task force commanding officer, with Rear Admiral Richard Byrd officer in charge of the expedition as a whole.

The plan was to attack Antarctica on three fronts. While two naval task groups—each consisting of a seaplane tender, tanker, and destroyer—would encircle the continent, the Central Group would operate from the Bay of Whales with ski-equipped airplanes. Consisting of an icebreaker (USCGC *Northwind*), two supply ships (USS *Merrick* and USS *Yancey*), a communications ship (USS *Mount Olympus*), and a submarine (USS *Sennett*), Central Group reached its appointed rendezvous off Scott Island on December 30. In what was clearly a bad ice year, *Northwind* took more than two weeks to smash a passage through 300 miles (480 km) of pack ice surrounding the Ross Sea, with all of the vessels apart from the icebreaker experiencing damage as their thin-skinned steel hulls struck projecting ice. The submarine *Sennett* was the worst affected, as ice threatened to pile up on its deck, slowing its progress so that it could not keep up with the rest of the convoy. Eventually, *Northwind* had to return to tow *Sennett* back through 65 miles of ice to open water near Scott Island, where it was released to serve as a weather station. Not until January 15, 1947, was the Bay of Whales reached; it was found to be filled by ice 6.5–9.8 ft. (2–3 m) thick, taking *Northwind* three days to break it up before the other ships could begin unloading.

Selecting a site just more than 2 miles (3.2 km) north of Little America III, the base used by the U.S. Antarctic Service Expedition in 1940, Central Group spent the next seven weeks setting up Little America IV. There, for the first time on Antarctica, an airstrip was constructed for the six twin-engine Douglas R4D transport planes brought south with Byrd in the aircraft carrier USS *Philippine Sea.* With the aid of four jet-assisted takeoff bottles strapped to their sides, these large aircraft managed to get into the air using only 393 ft. (120 m) of the carrier's flight deck in a previously untested operation. They were the largest planes to date to take off from a carrier, their wingspan being so great that they could only use that part of the flight deck forward of the superstructure. Byrd was on the first plane to leave on January 29, *Philippine Sea* then lying in an embayment in the pack ice some 700 miles (1,125 km) from Little America. During the next four weeks, these six planes flew a total of 22,700 miles (36,500 km), principally south over the Ross Ice Shelf to the Transantarctic Mountains and east over Marie Byrd Land, in the process discovering several major new mountain ranges and photographing about 100,000 square miles (259,000 sq. km) on each mission. On February 15, Byrd flew to the South Pole and 90 miles (145 km) beyond. Apart from lack of oxygen and extreme cold—the plane's heating system failed—this flight was uneventful in comparison with Byrd's first South Pole flight in 1929. The one significant land operation was the journey by a tractor party to the Rockefeller Mountains, where a weather station and an emergency fuel dump were established. With Admiral Cruzen on board, the icebreaker USS *Burton Island* arrived at the Bay of Whales on February 22 to evacuate Little America IV. The following day, Byrd was ready to depart, having first placed in safe storage the planes and other heavy equipment to be left behind for possible future use.

Meanwhile, the Western and Eastern Groups had been making their way around the continent in opposite directions. Led by Lieutenant Commander George Dufek, another veteran of the U.S. Antarctic Service Expedition, Eastern Group consisted of the seaplane tender USS *Pine Island*, the destroyer USS *Brownson*, and the tanker USS *Canisteo.* Aboard *Pine Island* were three PBM Martin Mariner seaplanes, a twin-engine seaplane, and two helicopters.

With operations beginning from the vicinity of Peter I Island, the first flights on December 29, 1946, were made in initially good weather. Detailed photographs of Thurston Island and the adjacent Eights Coast were taken in a region first explored by Byrd in 1940. With one PBM—*George 1*—still in the air, the weather became overcast. Radio contact was lost with *George 1*, whose copilot, Lieutenant William H. Kearns Jr., found himself flying in whiteout conditions and unable to distinguish between the snow below and the overcast sky above. Unsure of his elevation and believing himself near land, Kearns decided to turn back, colliding with the ice as he inclined his wings into the turn. The plane exploded; two died instantly and one soon after. The six survivors, including *Pine Island*'s commander, Captain Henry Howard Caldwell, were too shocked to make preparations for survival until a day and a half later. Two tents were then erected, where the men remained for 13 days in conditions preventing any possibility of search flights. The survivors were finally located on January 11, 1947, making their way with difficulty the next day to open water where *George 3* had managed to land. They returned safely to *Pine Island.*

For the next 10 days, conditions were impossible for flying as the Eastern Group headed farther west to investigate the coastline of the Amundsen Sea, a region previously seen only from a distance and not reliably charted. On January 19, Dufek was lucky to survive a helicopter crash when scouting for open water from which the seaplanes could take off. By January, the coastline had been photographed from 95° 30′ to 127° 30′W, and *Pine Island* was able to head once more eastward, first to Peter I Island, and then toward Charcot Island and Marguerite Bay, where further photographic flights were made along the west coast of Alexander Island. Orders were now received from Admiral Cruzen to proceed to the Weddell Sea, where heavy pack ice was again encountered with little possibility of undertaking further flights. Operations ceased on 3 March, when Eastern Group headed north for Brazil.

Western Group's composition was similar to Eastern Group, consisting of the seaplane tender USS *Currituck*, the destroyer USS *Henderson*, and the tanker USS *Cacapon.* Like *Pine Island*, *Currituck* carried three PBM Martin Mariner seaplanes, a twin-engine seaplane, and two helicopters. The task group was led by Lieutenant Commander Charles Bond, charged with working westward around the continent, starting from the vicinity of the Balleny Islands, with the intention of photographing as much of the coast as possible of the sector known to Americans as Wilkes Land, and to Australians and British as the Australian Antarctic Territory. Some

1,500 miles (2,400 km) of coastline had been controversially charted in 1840 by the U.S. Exploring Expedition led by Charles Wilkes. Since other expeditions had later found sea where Wilkes had charted land, his claim to priority in discovering this coast had been disputed, with opinion dividing largely along national lines. Had the United States decided to reverse its 1924 policy of not making or recognizing territorial claims in Antarctica, this clearly was one area of potential dispute, and Highjump's air photographs would strengthen any U.S. claim.

On February 11, Lieutenant Commander David E. Bunger, flying the PBM *Baker 1*, discovered at 66° 18′S 100° 45′E an ice-free area comparable with the Dry Valleys of Victoria Land. It covered about 20 square miles (52 sq. km) and included a number of lakes. Two days later, Bunger was able to land on one of the larger lakes to obtain a water sample. This episode was to arouse considerable popular interest when the phrase "Shangri-la" was ill-advisedly included in a U.S. Navy press release, which also mistakenly reported that vegetation had been found. Although the coastline had been extensively photographed from the air, it was not until February 17 that the crew aboard *Currituck* actually got to see land, when a close approach was made to Kemp Land. Reaching his farthest west on February 22 at 67° 42′S 34° 15′E off Queen Maud Land, Bond then headed back east, undertaking air survey flights whenever conditions permitted until March, when he received orders to make for Australia.

What were the achievements of this vast expedition? The fact that its objectives were primarily military rather than scientific is made clear by the presence of only 16 military and 24 civilian scientists and observers among the total 4,700 men involved. Nor was provision ever made to work up results for publication. And without ground control, astronomical fixes, or precise methods of air navigation, the 70,000 air photographs could not be used for mapping purposes. Regardless, the expedition undoubtedly resulted in an enormous extension of knowledge of Antarctica. Some 1.5 million square miles had been photographed, including 60 percent of Antarctica's coastline. Of the latter, it is estimated that 25 percent of the area photographed was of coastline never before seen and 40 percent of coastline seen but previously incorrectly charted. The need to establish ground control for the photographs led directly to the organization of Operation Windmill the following year.

Operation Highjump II was planned for 1949–1950 but ran afoul of Washington politics, President Harry Truman being then involved in an unrelated dispute with Byrd's brother, Senator Harry E. Byrd, chairman of the powerful Finance Committee. Truman memorably remarked, "One Byrd is enough in Washington," and Highjump II was canceled.

William James Mills

See also: Antarctic Programs and Research Stations/Bases; East Antarctica; Ice Shelves of Antarctica; International Geophysical Year (IGY); Operation Windmill; Ross Island; South Pole; Transantarctic Mountains

Further Reading

Bertrand, K. *Americans in Antarctica, 1775–1948.* New York: American Geographical Society, 1971.

Byrd, R. "Our Navy Explores Antarctica." *National Geographic* 92, no. 4 (1947): 429–522.

Menster, W. *Strong Men South.* Milwaukee: Bruce, 1949.

Operation Nanook

Despite its official classification, Operation Nanook was less an operation than a charting and building expedition. During the summer of 1946, an icebreaker, seaplane tender, submarine, gate ship (for laying nets and fixing buoys), and two cargo ships charted the coastline of Greenland, conducted scientific experiments, and supported the construction of a radio and weather station at Thule, which due to its strategic position in northwestern Greenland would be converted to a U.S. air base five years later. The project was supposed to be a joint American Danish venture, as Denmark was recognized as the nation with historical claims to the island. All told, the weather and radio stations lasted only five years, until newer and more modern installations were incorporated into the new air base.

Although the expedition and the installations that resulted were both short lived, Operation Nanook nevertheless enjoys a key role in post-World War II American history in that it served as a very early indicator as to the American brand of postwar imperialism that would quickly become manifest. Although the operation was more science based and exploratory in nature, there is no doubt that military applications were anticipated. Understanding weather patterns over the polar regions and the ability to communicate to and from there would play key roles in the 1950s and 1960s as the Cold War waxed and waned between the United States and Soviet Union.

Following the conclusion of World War II, Arctic locations such as the Aleutian Islands, Greenland, and Iceland became prime real estate for a U.S. military machine concerned with potential attacks by their new enemy, the Soviet Union. The immediately realized fruits of Operation Nanook were a weather station and listening post that helped feed a culture of rapidly evolving paranoia, where the U.S. government and citizens alike feared first Soviet bomber incursions and later missile attacks launched over the top of the globe. Operation Nanook was the first such attempt to shore up information gathering and defensive capabilities along the northern flank of the Western Hemisphere. Later, and more famous, examples would come in time, including the Distant Early Warning Line, radar installations, and listening posts built during the 1950s along the Arctic regions from the western Aleutian Islands the Faroe Islands east of Iceland. A more offensive outgrowth of this Arctic focus was Operation Chrome Dome, a 1960 aviation program memorialized in the satirical film *Dr. Strangelove*, which ensured that a given number of B52 Bombers armed with nuclear weapons were in the air at any given time and able to strike Moscow and other targets via the polar route.

Thus, Operation Nanook was key in that it was an early postwar example of the United States employing the Truman Doctrine and marshaling geographic and technological advantages to keep communism out of the Western Hemisphere. There is no relation between this operation and the annual preparedness exercises carried out by the Royal Canadian Navy and Canadian Coast Guard between 2007 and 2010.

Andrew J. Howe

See also: Operation Chrome Dome; Operation Deep Freeze; Operation Highjump; Operation Tabarin; Operation Windmill

Further Reading

Coast Guard Academy Alumni Association. "Operation Nanook 52." *The Bulletin* (1952): 174–77.

Operation Tabarin

The origins of the British Antarctic Survey lie in a covert military operation conducted during World War II. Because the operation was going to take place in the dark through the long Antarctic winter, it was thought appropriate to name it after the Parisian nightclub Bal Tabarin.

Establishment of British Bases Are Established at Deception and Port Lockroy, 1943–1944

During World War II, small number of Nazi German warships disguised as merchant vessels had created havoc in the Southern Ocean shipping channels. Thousands of tons of ships were sunk, and one raider—*Pinguin*—was responsible for capturing an entire Norwegian whaling fleet. These ships found secret anchorages on the subantarctic islands, where they also found stores of oil and coal in the abandoned whaling stations. The British government was especially concerned that Nazi German raiders should not make use of the excellent harbor at Deception Island, or of anchorages along the adjacent Antarctic Peninsula. From those locations, they might be able to prey on ships passing through Drake Passage, the vital strait connecting the Atlantic and Pacific Oceans south of Tierra del Fuego. This area was particularly sensitive because the Atlantic coastline immediately to the north of Drake Passage was controlled by Argentina, a neutral country that nevertheless maintained good relations with Germany. Furthermore, Argentina had used the opportunity of Britain's engagement in the war to dispute its claims to the

Antarctic Peninsula and offshore islands, a sector also claimed by Chile. There were thus several reasons compelling the British government to give high priority to sending an expedition to an area remote from the main zones of conflict.

This was to be a secret operation, and over a period of months, stores and equipment essential for a polar expedition were brought together. Suitably qualified civilians were identified and withdrawn from their wartime assignments. Lieutenant Commander James W. S. Marr was chosen to lead the expedition. He had considerable experience in the Antarctic, as a young man having been selected to represent the Boy Scouts during Sir Ernest Shackleton's last expedition and, more recently, having worked as a biologist for the Discovery Investigations. The 250-ton Norwegian sealer *Veslekari*, renamed *Bransfield* in honor of the British naval officer who had discovered the Antarctic Peninsula in 1820, was chartered to take the expedition south. Unfortunately, it proved unusable when an old leak was revealed as it lay heavily loaded in the water. Instead, men and stores had to be relocated to the troopship HMS *Highland Monarch*, which reached Port Stanley in the Falkland Islands on January 26, 1944. From there, the expedition was taken to Deception Island in two ships: RRS *William Scoresby*, one of two research vessels used by the Discovery Investigations during peacetime but now employed as a minesweeper in the South Atlantic, and *Fitzroy*, chartered from the Falkland Islands Company. So secret was the expedition that only after leaving the Falkland Islands did Marr disclose the destination and intended mission to his men.

The expedition was unarmed, and it was therefore with some trepidation that Deception was approached on February 3. There, if anywhere, a German raider might lurk, though the British warship HMS *Queen of Bermuda* had visited the island in March 1941 to destroy coal dumps and puncture oil tanks to prevent possible use by the enemy. Instead of German occupation, they found a flag and other symbols denoting claims to Argentine sovereignty left by *Primero de Mayo* in February 1943. Deception was to be the site of Base B. Dr. W. R. Flett was now left behind as base leader with four colleagues to establish themselves in accommodations provided by the abandoned whaling station. *William Scoresby* and *Fitzroy* next headed for Hope Bay, the preferred site for the main base on the Antarctic mainland. Although *William Scoresby* was able to make its way through the ice in Antarctic Sound to Hope Bay, *Fitzroy* was forced to withdraw; without its stores and components for the hut, the base could not be established. Another site for Base A would have to be found. Marr reluctantly selected Port Lockroy off Wiencke Island when *Fitzroy* began to run short of coal. Despite its excellent sheltered harbor and spectacular location, Port Lockroy was not ideal, sited as it was far down the Antarctic Peninsula and on an island; this would substantially restrict surveying and scientific work. Again, an Argentine flag and cylinder containing documents claiming sovereignty were discovered, also left by *Primero de Mayo* in 1943.

Since this was supposedly a covert mission, it came as something of a surprise when the BBC Overseas Service for North America carried news of Operation Tabarin on April 24, 1944. Despite this report, the expedition continued to work under conditions of strict secrecy, with all radio communications being encrypted. Two times each day, weather reports were submitted by both stations to the Naval Meteorological Station at Port Stanley, but in other respects, their duties differed. One of Base B's chief roles was to keep watch for enemy and neutral ships. Other tasks included daily observations of the sea ice in Bransfield Strait throughout the winter and the study of upper air currents through the use of balloons. Base A had been given the task of extending the survey work begun by John Rymill's British Graham Land Expedition. During the winter, a start was made on local mapping. As conditions improved in the spring, a four-man party consisting of Marr, "Taff" Davies, Captain Andrew Taylor, and Dr. Ivan Mackenzie Lamb man-hauled sledges over Thunder Glacier, where they survived an avalanche, to the east coast of Wiencke Island to conduct further surveying and to collect geological and botanical specimens.

Sledging Campaigns Begin from the New British Base at Hope Bay, 1944–1945

The primary objectives for the second year were to relieve the two existing bases, some of whose staff would remain another year (while others would be replaced by new recruits) and to build three new stations: at Hope Bay, where ice had thwarted the attempt the previous year; in Marguerite Bay, farther south on the peninsula; and on Coronation Island in the South Orkneys. Three ships were to be used, the third being the 550-ton wooden-hulled *Eagle.* On January 27, 1945, Base B at Deception was relieved by *Fitzroy* and *William Scoresby. Fitzroy* then sailed down the peninsula to relieve Base A on February 3, before heading 400 miles (km) east to leave building materials at Cape Geddes on Coronation Island, where Base C was to be constructed by the crew of *William Scoresby. Eagle* sailed from Deception through Antarctic Sound to Hope Bay, where construction of Base D began on February 13. Captain Andrew Taylor was left there with 12 men and 25 huskies and placed in overall command of Operation Tabarin when poor health forced Marr to return to England. Marr's withdrawal led to the abandonment of plans to build a fifth station in Marguerite Bay. *Eagle* was returning to Hope Bay with more cargo when a violent storm arose, during which it lost an anchor and collided with an iceberg. Water poured in, and it seemed that it could be saved from sinking only by being run aground on the rocky coast—a desperate measure indeed that few crew members might have survived. However, as conditions mitigated, the pumps gradually succeeded in reducing water levels, and *Eagle* managed to make its way back to the Falklands. This left Base D short of supplies, and food had to be carefully rationed until the sea ice was sufficiently firm for dog teams to be sent out to retrieve 30 tons of cargo landed some distance from the base.

Hope Bay was to become the great sledging center of the Falkland Island Dependencies Survey (the new name for Operation Tabarin following the end of World War II; see later). This tradition was established early, with a four-man party consisting of Taylor, Mackenzie Lamb, Lieutenant David P. James, and Captain Victor I. Russell sledging with 14 dogs down the east coast of the Antarctic Peninsula to the southern end of Prince Gustav Channel at Cape Longing, then eastward to Snow Hill Island and across to Seymour Island, before heading north past James Ross Island, a total distance of 270 miles (430 km). New islands were discovered, and significant improvements made to the mapping of an area that had not been systematically investigated since Nordenskjold, in 1902–1903.

With World War II now over, Operation Tabarin was officially renamed the Falkland Islands Dependencies Survey in July 1945. It was a civilian organization administered from Port Stanley in the Falkland Islands, though for some time basic supplies continued to come from naval stores, and the majority of recruits remained serving officers. Although the operation was mounted to serve a wartime need, the intention from the start had been to set up stations for continuous occupancy, particularly in light of the Argentine and Chilean claims to the same territory.

William James Mills

See also: Antarctic Peninsula; Operation Deep Freeze; Operation Highjump; Operation Windmill; Shackleton, Ernest (1874–1922)

Further Reading

Fuchs, V. *Of Ice and Men: The Story of the British Antarctic Survey, 1943–73.* Oswestry: Anthony Nelson, 1982.

Robertson, S. *Operation Tabarin.* Cambridge: British Antarctic Survey, 1993.

Squires, H. *S S* Eagle: *The Secret Mission 1944–45.* St. John's, Newfoundland: Jesperson Press, 1992.

Operation Windmill

This U.S. naval exercise was the successor of the massive Operation Highjump. It was a convincing demonstration of the effectiveness of helicopters for landing parties in Antarctica, and it returned with results that usefully supplemented those of its giant predecessor.

Helicopters Prove Indispensable to Operation Highjump's Successor, 1947–1948

The U.S. Navy Antarctic Developments Project (Operation Highjump, 1946–1947) had been a great success in meeting its major objectives. Yet because no attempt had been made to establish ground control for its 70,000 aerial photographs, the photos could not be used for mapping purposes. In addition to continuing Highjump's cold weather testing of personnel and equipment, the U.S. Navy Second Antarctic Developments Project was organized by the chief of Naval Operations in September 1947 precisely to provide the missing ground survey data for 30 designated major features, including Highjump's most newsworthy discovery, the Bunger Hills Oasis.

The expedition was to be carried out by Task Force 39, led by Commander Gerald L. Ketchum, who had captained the icebreaker USS *Burton Island* during Highjump. The task force consisted of two icebreakers, *Burton Island* and USS *Edisto*, both equipped with helicopters: a Sikorsky HO3S-1 and a Bell HTL-1 on *Burton Island*, and a Sikorsky HO3S-1 on *Edisto*. In addition, *Edisto* carried a Grumman J2F-6 amphibian airplane. The heavy use of helicopters during this expedition led to its afterward being nicknamed "Windmill." Four weasels were to provide land transport, with a total of 500 men participating.

On 1 November, *Edisto*, captained by Commander Edward C. Folger Jr., sailed from Boston. Nineteen days later, *Burton Island* left San Pedro, California, with Ketchum on board and captained by Commander Edwin A. MacDonald. The two ships met up at American Samoa on December 2, from where they proceeded south toward Scott Island. Encountering very heavy pack ice, they abandoned the attempt to reach that island on December 16, still some 40 miles (64 km) north. The two ships reversed course out of the ice and followed the northern ice limit westward to the Davis Sea, which was reached on December 25. The Davis Sea, between Shackleton and West Ice Shelves off Queen Mary and Wilhelm II Lands, is an area where open water is often found in a region where the pack is otherwise generally dense. Ketchum's task was to land survey parties at as many of the designated points as he could manage heading back eastward along that part of Antarctica known to Americans as Wilkes Land, and to British Commonwealth countries as the Australian Antarctic Territory. Ever since this region was first seen by the American Charles Wilkes, the United States had a potential claim to it, and compilation of the first accurate maps depicting it would greatly strengthen the U.S. claim should one ever be put forward.

Over a period of 23 days, survey parties were landed by helicopter at nine points along the 600-mile (965-km) coastline, including the Haswell Islands (discovered in 1912 by members of Douglas Mawson's Australasian Antarctic Expedition), Bunger Hills (discovered in 1947 during Operation Highjump), and the Windmill Hills (named after this expedition for its landing there on January 19, 1948). At all three locations, scientific stations were to be built during the International Geophysical Year (IGY, 1957–1958): the Soviet stations Mirnyy and Oazis (later the Polish station Dobrowolski) on the Haswell Islands and Bunger Hills, respectively, and the American (subsequently Australian) station Wilkes in the Windmill Hills.

Task Force 39 next headed east, north of the pack ice, and then south into the Ross Sea where a brief visit was made on January 29 to McMurdo Sound, soon also to be the site of IGY stations at McMurdo and Scott Base. Two days later, Ketchum was at the Bay of Whales to check the condition of Little America IV, which had been constructed by Highjump. He now transferred to *Edisto*, which was to investigate the possibility of penetrating the pack ice in the northeast region of the Ross Sea, something that no previous ship had achieved. Even this powerful icebreaker, however, could not break through the very heavy pack, and *Edisto* had to work its way north and northwest before managing to follow a northeasterly course. Rejoined by *Burton Island* on February 6, the two ships attempted to make a close approach to the towering Mount Siple at 73° 15′S, 126° 6′W but found the Amundsen Sea impenetrable. Peter I Island was the next objective, and there a landing was made—only the third ever—by men from *Edisto.* Learning that Finn Ronne's expedition was still cut off by ice and in danger of having to spend another winter in Marguerite Bay, the two icebreakers broke a path through to Stonington Island on February 20 and towed Ronne's *Port of Beaumont* to safety. RRS *John Biscoe*, the supply ship of the Falkland Islands Dependencies Survey, arrived at Marguerite Bay at the same time and was therefore able to resupply the British Base E on Stonington Island, which it would otherwise have been unable to do. Its work completed, Task Force 39 headed north along the west coast of South America to Callao, Peru, where the two ships separated, *Edisto* returning to Norfolk on March 28, 1948, and *Burton Island* to San Pedro in April.

William James Mills

See also: Amundsen Sea; International Geophysical Year (IGY); Operation Highjump

Further Reading

Bertrand, K. *Americans in Antarctica, 1775–1948.* New York: American Geographical Society, 1971.

Frazier, P. *Antarctic Assault.* New York: Dodd, Mead, 1958.

Orca

Killer whales or orcas (*Orcinus orca*) belong to a group of animals called Cetaceans: mammals that are exclusively aquatic, like whales and dolphins (most of them are marine, but some of them live in rivers and estuaries). Cetaceans are divided in two groups: Mysticetes and Odontocetes. Mysticetes are those that have baleen in their mouths, true whales like humpbacks, right, or the gigantic blue whales. Odontocetes have teeth, like dolphins, porpoises, and sperm whales. Orcas, the largest member of the dolphin family, are commonly known as "killer" whales. They earned this common name due to their hunting behavior: they feed on fish, birds, seals, and even other marine mammals that exceed them in size, like minke whales. They are fast and skillful predators, but it is just their feeding behavior and has nothing to do with an aggressive attitude. They are at the top of the marine's world food chain, with no known predators.

Orca whales are very large with males being a little more than 23–32 ft. (7–9.7 m) with females being slightly smaller, measuring up to 26 ft. (8 m) in length. Orcas can weigh up to 12,000 pounds or 6 tons (5,443 kg). Males and females are easily recognizable by their dorsal fins: adult males have a big dorsal fin shaped like an isosceles triangle that can reach 6.5 ft. (2 m) tall, while females (and juveniles) have smaller falcate dorsal fins. But what makes orcas so famous and probably the most universally recognizable animals in the sea is the striking black-and-white coloration, specially that prominent oval white patch above and behind their (very small) eyes. The life span of orcas in the wild is 50–80 years.

They are found in all the oceans of the world, but they are more likely to be found in cold waters. For some researchers, the world population of killer whales seems to consist of specialized subpopulations, each adapted to live off the resources available within its home range. Around the world, killer whale communities often comprise groups of different types or forms that can have different prey preferences, feeding habits, and acoustic behavior: fish-eating residents, mammal-eating transients, and the less commonly encountered (and therefore less known) offshores. In Antarctica, for example, there are killer whales that position themselves near the ice edge where they prey on penguins and seals exclusively, while others appear to target only fish. In the Arctic, on the other hand, they rarely move close along or

Orcas, also known as killer whales. (Captain Budd Christman, NOAA Corps) into the pack ice. Killer whales are amazing hunters, having intentional stranding hunting techniques in coastal areas of Patagonia and Crozet Islands to cooperative pack hunting where complex communication and echolocation is needed.

Orcas are a very social species, having complex and long-term social bonds. Even though groups vary in size from single animals (usually males) to hundreds of individuals, these large groups seem to be temporary associations of smaller and more stable groups called *pods.* In most areas where field studies have been conducted, *pods* are matrilineal (determining descent through the female line) and stable over long periods of time. Based on long-term field studies, it is known that females can live from 80 to 90 years and that they become sexually mature at the ages of 10–18. Newborn calves have been observed to be born year-round, with no particular breeding season.

Like many cetaceans, orcas depend on sound to orientate, feed, and communicate. They produce different clicks, pulses, and whistles that they use for different activities like navigation, finding prey, and socializing, which is a vital part of their lives. Studies in different regions of the world revealed that all members of a *pod* use similar calls or sounds, known collectively as a dialect. Dialects are composed of specific numbers and types of discrete, repetitive sounds, which are complex and stable over time.

Although orcas are widely distributed and are one of the most studied cetaceans, total world population and conservation status is truly unknown. They have no natural enemies and have not been hunted as much as other species during whaling activities in the eighteenth and nineteenth centuries. But nowadays, depending on the region, the threats they face are related to anthropogenic influences, mainly pollution with toxic chemicals and reduction of prey availability. Dedicated researchers all over the world work from land or small boats spending thousands of hours following killer whales, studying them aided by technologies such as satellite tagging, digital photography, and genetic analysis (among others) hoping to get a better understanding of these amazing animals' behavior and ecology.

Luciana M. Motta

See also: Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Northern Bottlenose Whale; Southern Bottlenose Whale; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Baird, R., P. Clapham, J. Christal, R. Connor, J. Mann, A. Read, and R. Wrangham. *Cetacean Societies: Field Studies of Dolphins and Whales.* Chicago: University of Chicago Press, 2000.

Falkens, P., R. Reeves, B. Stewart, P. J. Clapham, and J. Powell. *Guide to Marine Mammals of the World.* New York: Knopf, 2002.

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Pacific Sleeper Shark

The Pacific sleeper shark (*Somniosus pacificus*) is a deepwater sleeper shark and considered relatively common in the North Pacific Ocean continental shelves and slopes. They can be found between 22° N and 70° N inhabiting the northwest Pacific to northeast Pacific and the Bering and Chukchi Seas down to Baja California. They are also found along the Kuril Islands in the Sea of Japan and the Sea of Okhotsk. These sharks are a scavenger with a voracious appetite. In 2004, a shark caught from the water by Point Hope, Alaska, was the first definitive report of *S. pacificus* within the Arctic Circle.

The shark has a moderately long head, short, rounded snout, with two spineless equal-sized dorsal fins, and a long ventral caudal lobe with short keels at the base of the caudal fin. The body is torpedo shaped and colored black mottled with white giving way to sliver-gray on the abdomen. The average adult is about 12 ft. (3.7 m) from snout tail and weighing about 700–800 pounds (317–363 kg). The largest caught Pacific sleeper shark was 14 ft. (4.3 m) weighting 1,960 pounds (889 kg). Deepwater photographic evidence suggests that the Pacific sleeper shark can reach 23–25 ft. in length (7–7.62 m). The Pacific sleeper sharks have small mouths and long heads. Their upper teeth are spear-point shaped and their lower teeth are sharp oblique cusps that are close set, suggesting they are grasping and cutting and possibly a suction feeder. In the frigid waters of the high latitudes, these sharks can be found on the surface and in shallow littoral waters, inlets, and bays. In the lower latitudes with temperate water, it becomes strictly deep water found at depths to 6,500 ft. (2,000 m) in the southernmost extremes of its range. In its southern range, it never comes to surface.

S. pacificus is a versatile predator and opportunistic consumer feeding on diverse prey including cephalopods (octopus, squid), teleost fishes, crustaceans such as tanner and king crabs, marine mammals, other sharks, fish offal and carrion, and human waste. In Glacier Bay, sleeper sharks co-occur with harbor seals near a large pupping and breeding colony scavenging and preying on these marine mammals. Pacific sleepers enter shallow water to eat beached gray whale carcasses at Unimak Island, Alaska. In spite of concerns that sleeper sharks prey on Steller sea lion pups at four important rookeries in the northern Gulf of Alaska, a 2006 study showed no evidence of *Eumetopias jubatus* in the stomach contents of 198 sharks.

The majority of scientific research on the Pacific sleeper shark's diet, distribution, movement, and behavior has been conducted in the waters of Alaska and northeast Pacific. The research is focused on potential impact the shark has on commercial fishing and marine mammal populations, rather than the shark itself. With slow, sluggish movement and vision impairment due to the corneal parasite, *Ommatokoita elongata*, the Pacific sleeper shark is still adept at preying on fast-swimming fishes by employing stealth and ambush hunting tactics under the cover of darkness.

Pacific sleeper sharks give birth to live offspring (viviparous). The litter is around 10 pups that measure up to 1.4 ft. (42 cm) in length. Female sharks have been captured with ovaries containing more than 300 large unfertilized eggs. Neonates have been captured by midwater fishing trawls indicating early life occupancy of this habitat prior to moving into the bottom waters.

The Pacific sleeper shark population is not known definitely. They are bycatch in the Pacific cod, turbot, and sablefish longline fisheries. They are also taken as a bycatch in the Alaskan pollock and flatfish trawling equipment. When caught, it is usually discarded with the other bycatch species. The deepwater habitat of the adult Pacific sleeper shark provides some refuge. There are no conservation measures or actions for this species.

Joyce M. Shaw

See also: Greenland Shark; Salmon Shark

Further Reading

Hulbert, L., M. Sigler, and C. Lunsford. "Depth and Movement Behavior of the Pacific Sleeper Shark in the North-East Pacific Ocean." *Journal of Fish Biology* 69 (2006): 406–25.

Yang, Mei-Sun, and B. Page. "Diet of Pacific Sleeper Shark, *Somniosus pacificus*, in the Gulf of Mexico." *Fishery Bulletin* 97 (1999): 406–9.

Paleoecology of Antarctica

The lowest officially recorded temperature ever was −128.6°F (−89.2°C) at the Russian Vostok Station on July 21, 1983. In 2010, remote temperatures collected from high ridge in the East Antarctic Plateau were −136°F (−93°C). However, in a distant past, this was a continent of warm temperate climate where an abundant diversity of life flourished on land and seas. The current climatic characteristics of this region is a more recent development in its geological history, and its evolution profoundly affected the way that life evolved and how different organisms interact with each other in that region.

During the Cretaceous (between 145 and 65 mya), continental drift led Antarctica to, approximately, the same position it occupies today within the southern polar circle. At the beginning of the Cretaceous, Antarctica was connected to other large landmasses that formed the supercontinent of Gondwanaland, including Australia, New Zealand, South America, and India. The world was considerably warmer, and Antarctica had temperate climate conditions, with temperatures between 75ºF and 32ºF (24–0ºC). Antarctic vegetation was dominated by gymnosperms (flowerless seed plants), such as podocarps, araucarians, cycads, and ginkgos, as well as pteridophytes (ferns) and bryophytes (mosses). Fossils of animals from this time period are rare, possible due to the limited possibility of fieldwork. Since dinosaurs, pterosaurs, amphibians, turtles, and lizard-like reptiles have been found in once connected landmass Australia, they might be found in Antarctica as well. In the Middle Cretaceous (approx. 120 mya) angiosperms (flowering plants) arrived in Antarctica and became extremely diverse by the end of that geologic period. During the Late Cretaceous (70–65 mya), temperatures dropped in Antarctica, with surface waters in the surrounding ocean varying between 45ºF and 50ºF (7–10ºC). This led scientists to suggest the formation of polar ice sheets. Terrestrial life was abundant, including dinosaurs such as ankylosaurians, sauropods, theropods, and ornithopods, as well as birds (or avian dinosaurs), although their record in Antarctica is still quite rare. Marine fossils are particularly better known from this time frame, including bony fishes, sharks, and marine reptiles such as plesiosaurs, mosasaurs, and turtles, as well as invertebrates. The latter fauna was dominated by mollusks (bivalves, gastropods, and cephalopods), but crustaceans (especially decapods) became reasonably more represented at the very end of the Cretaceous.

The Cretaceous–Paleogene transition (65 mya) was marked by a mass extinction that decimated nonavian dinosaurs, marine reptiles, ammonites, and many other animal groups in the entire world. However, Keller has found the extinction patterns in Antarctica to be transitional for most species, and not being marked by an abrupt mass death as suggested for other parts of the world.

The beginning of the Cenozoic (65 mya to present) was marked by the return of warmer temperatures in Antarctica and by the appearance of the first fossil penguins, recorded in Seymour Island. These were large individuals about 4 ft. (1.20 m), indicating penguins did not evolve large size in cold conditions as originally thought. During the Eocene (55–33 mya), however, conditions started to cool down, and this led to one of the most dramatic changes in the faunal and floral composition of Antarctica. Sea-surface temperatures decreased progressively, from 66ºF (19ºC) in the early Eocene to 45ºF (7ºC) at the end of the Eocene, allowing the appearance of sea ice. The flora suffered a 47 percent decrease in diversity, but was still dominated by gymnosperms and angiosperms (especially by *Nothofagus*) some of them showing insect bite marks. In the seas, sharks disappeared from that continent, as well as most species of rays and crabs. Benthonic (living on or in the seafloor) organisms became markedly different from the ones observed in lower latitudes, and the disappearance of natural predators (e.g., rays and crabs) led to an increase in the diversity of echinoderms, such as sea lilies and brittle stars. This period also marks the first appearance of cetaceans.

During the Oligocene (33–23 mya), water temperatures became cold enough (45°F [7°C] on surface water/40°F [4°C] deep water) to allow the development of widespread marine ice. By mid-Oligocene, separation between Antarctica and Australia, which had begun during the Eocene, was completed. Later in this period, Antarctica became isolated from South America too. These continental movements contributed to the establishment of the circum-Antarctic current in the Austral Ocean, vital for the present climatic balance of the planet. At this time, most of the cool-temperate vegetation disappeared from Antarctica. Glacial erosion started to carry nutrients into the sea, which were further dispersed by the circum-Antarctic current, increasing primary productivity by phytoplankton, also boosting the population of zooplankton in the Austral Ocean. This is coincident with the increase in diversity of the record of fossil whales in Antarctica and has been proposed by Fordyce to be associated with the origin of the Mysticeti (currently widespread filter-feeding whales) in the southern oceans.

During the middle Miocene (14–11 mya), the permanent ice cap that covers present-day Antarctica was formed. By the Plio-Pleistocene (5 mya–10,000 years ago), the tundra-like vegetation that was still present was mostly gone, and only mosses and lichens are present in continental Antarctica today. Pinnipeds, including seals (Phocidae) and sea lions (Otarridae), are represented only by recent subfossils. However, they migrated from the Northern Hemisphere and were present since the Miocene in Australia and South Africa, migrating to the icy continent at some point still not well known. Paleontological studies have revealed significant facts about Antarctica's past, but considerable work is still needed to better understand how Antarctica influences life and climatic conditions in nearby continents.

Tiago Rodrigues Simões and Alexander W.A. Kellner

See also: Dinosaurs of Antarctica; Mesozoic Marine Reptiles of Antarctica; Pliocene Arctic Fossils

Further Reading

Crame, J., "Origins and Evolution of the Antarctic Biota." *Lethaia* 20 (2007): 106.

Fordyce, E. "The Development of the Circum-Antarctic Current and the Evolution of the Mysticeti (Mammalia: Cetacea)." *Palaeogeography, Palaeoclimatology, Palaeoecology* 21 (1977): 265–71.

Francis, Jane E., et al. "100 Million Years of Antarctic Climate Evolution: Evidence from Fossil Plants." In A.K. Cooper, et al., eds. *Antarctica: A Keystone in a Changing World.* Washington, DC: The National Academies Press, 2008.

Paulet Island

Paulet Island (63° 34′S 55° 45′W) is located at the tip of the Antarctic Peninsula in the northwestern portion of the Weddell Sea, southeast of Dundee Island. It is a circular volcanic island of about 1 mile (1.6 km) diameter, with rocky beaches and a lake, which is about 1,640 ft. (500 m) long. Paulet Island was discovered in 1842 by the British Antarctic Expedition led by James Clarke Ross (1800–1862) and was named by him after Captain Lord George Paulet (1803–1879), of the British Royal Navy.

In February 1903, the relief ship of Otto Nordenskjold's Swedish Antarctic Expedition *Antarctic* was crushed by the ice and sank, nearby Paulet Island. The ship's crew of 20 managed to get ashore and built a stone hut to survive the Antarctic winter. Months later, they were rescued by the Argentine corvette *Uruguay*. Together with the grave of a member of the expedition and a rock cairn built by the survivors at the highest point of the island to draw the attention of rescue expeditions, the remains of the building are still there and were designated as a historic site and monument since 1972 by the Antarctic Treaty.

Birdlife International identified Paulet Island as an important bird area because it supports a breeding colony of about 100,000 pairs of Adélie Penguin

Penguins congregate at Paulet Island in Antarctica. (Shutterstock.com)

(*Pygoscelis adeliae*), the second largest of this species in the area of the Antarctic Peninsula.

Luciana M. Motta

See also: Snow Hill Island

Further Reading

Antarctic Treaty Site Guidelines. 2013. http://www.ats.aq/siteguidelines/documents/Paulet_e.pdf. Accessed January 13, 2014.

Birdlife International. Important Bird Areas Fact Sheet: Paulet Island. 2013. http://www.birdlife.org. Accessed January 13, 2014.

Peary, Robert Edwin (1856–1920)

The quest for frozen Arctic by Robert Edwin Peary forms an inspiring saga in annals of geographical exploration. He was born on May 6, 1856, in Cresson, Pennsylvania, to Charles N. and Mary P. Peary. From his younger days, he was curious about the Arctic region and longed to become the first person to arrive in North Pole, the top of the world. He joined the U.S. Navy as a civil engineer in October 1881 with the rank of a lieutenant. His journey toward north began five years afterward. Arriving in ice-crusted region of northern Greenland, he could know that the North Pole was situated farther. It did not form a part of Greenland.

Explorer Robert Peary on a ship, wearing fur against the cold. Peary was under order to observe tides for the Coastal and Geodetic Survey during his 1900 North Pole Expedition. (National Oceanic and Atmospheric Administration)

In 1888, Peary married Josephine Diebitsch Peary, who accompanied her husband in some of the expeditions, and a daughter Marie Ahnighito Peary was born in the Arctic region itself. Josephine narrated the Arctic experiences in a book entitled, *My Arctic Journal* (1893). Expeditions to Greenland continued in 1891 and 1893.

Peary was ready in 1898 to tackle the ultimate aim of reaching North Pole.

He sailed in the steamship *Windward.* It was a hazardous expedition, and Peary reached only ice-capped top of Ellesmere Island situated approximately 5,000 ft. above sea level. For four years, Peary along with his companion Matthew Henson and a party of Eskimos undertook further forays into Arctic. Although he did not reach North Pole, Peary charted the northern coast of Greenland. He was determined to continue his polar voyage and the newly built 184-ft.-long ship *Roosevelt*, named after the then-president Theodore Roosevelt, sailed toward Arctic Ocean in July 1905. He could reach up to 87° 06′N only, 174 miles (280 km) from the pole amidst icy winter and depleting food supplies. The *Roosevelt* finally arrived at New York harbor on December 25, 1906.

Undaunted and determined, Peary made preparations for his final voyage, and once again the *Roosevelt* set forth on July 6, 1908, carrying Henson, Eskimos, and sufficient provisions. In February, the dog sleds started from Cape Columbia. On April 2, Peary, Matthew Henson, and four Eskimos, Ooqueah, Ootah, Egingwah, and Seegloo, were approaching toward the North Pole, and four days afterward, at 10 A.M., Peary exclaimed, "The Pole at last!!!" and hoisted the flag of the United States at North Pole. The team was within 30–60 miles of the pole. When the first person to set foot on the North Pole returned New York, his elation was short lived as another explorer Frederick A. Cook had claimed to have arrived in April 1908. Amidst considerable controversy, Peary's claim was endorsed by the National Geographic Society and the Congress. Cook's claim was proven false and was later jailed for seven years for an oil well swindle in 1923.

Promoted to a rear admiral, Peary retired from the navy in 1911. Although some persons were still in doubt about Peary's feat, the Navigation Foundation confirmed

HENSON, MATTHEW ALEXANDER (1866–1955)

Matthew Alexander Henson (1866–1955) was the first African American Arctic explorer. Henson was born in Nanjemoy, Maryland, the son of a sharecropper, whose father was a freed man prior to the Civil War. His life at sea started at age 12, when he became a cabin boy and sailed around the world. At 21, he met Commander Robert Edwin Peary Sr. (1856–1920). The two became friends, and Henson became his first man. Henson traveled on seven Arctic voyages with Peary over a span of almost 23 years. Together, they spent around 20 years in the Arctic on expeditions. Although disputed in 1909, after multiple attempts, Peary, Henson, and four Inuit reached the geographic North Pole (90° N). In 1912, Henson published a memoir of his Arctic travels titled "A Negro Explorer at the North Pole." In 1937, he became the first African American to be a member of the Explorers Club and, in 1948, an honorary member of the club. Henson has one son, named Anauakaq.

Andrew J. Hund

in 1990 that he had reached very near to the North Pole. Peary was the recipient of many awards such as Congressional Medal, French Legion of Honor, British Royal Geographic Society's Gold Medal, and honorary degrees from universities. He died on February 20, 1920, and was buried at Arlington National Cemetery in Washington, DC. He had published his polar experiences in *Northward over the "Great Ice"* (1898), *The North Pole* (1910), and *Secrets of Polar Travel* (1917). He had enlightened the scientific community about details of Arctic Circle and the culture of the Eskimos. The incorrigible Robert Peary is remembered as the first person to set foot on the North Pole.

Patit Paban Mishra

See also: Amundsen, Roald Engebrecht Gravning (1872–1928); Greenland; North Pole; Rasmussen, Knut (1879–1933)

Further Reading

Barber, Terry. *Matthew Henson and Robert Peary.* Edmonton, AB: Grass Roots Press, 2007.

Davies, Thomas D. *Robert E. Peary at the North Pole.* Seattle: Starpath Publications, 2009.

Henderson, Bruce. *True North: Peary, Cook, and the Race to the Pole.* New York: W. W. Norton and Company, 2005.

Pechora River. *See* Ob, Pechora, and Yenisey Rivers

Permafrost

Permafrost is a soil or rock that remains constantly at or below 32°F (0°C) for at least two years. Permafrost is typically overlain by an active layer that seasonally freezes and thaws and may be up to a meter or more in thickness. Permafrost may be less than 3 ft. (1 m) or more than a 0.6 of a mile (1 km) in thickness. Its depth depends on two factors. First, cold air temperatures are responsible for freezing the soil. The colder the outside air is and the longer it stays cold, the colder and deeper the permafrost will be. However, the interior of the earth is hot, and soil temperatures increase with depth. At a certain depth, which varies from place to place, the earth's heat will be strong enough to melt permafrost from below. Thick permafrost layers take long periods of time to develop. At Prudhoe Bay, Alaska, permafrost was found to be at least 500,000 years old.

Scientists generally classify permafrost as either continuous or discontinuous. Continuous permafrost exists where an area is entirely underlain by a thick layer of permafrost, with no areas of thawing in between. Continuous permafrost is typically more than 325 ft. (100 m) thick. Discontinuous permafrost, on the other hand, is found where permafrost underlies parts of an area, with areas of thawing in between. An example of discontinuous permafrost can be found in subarctic or alpine

Scientist melts permafrost in order to set a marker. (National Oceanic and Atmospheric Administration)

areas, where permafrost areas are spread out within sections of unfrozen ground, known as Taliks.

As Arctic air temperatures have been increasing over past decades, ground temperatures have also shown a warming trend. As a result, permafrost has been warming and even melting in some locations. While it will take centuries for permafrost

PINGO FORMATION

There are two processes responsible for the formation of pingos. Hydraulic (open-system) pingos are a result of the hydrostatic pressure of flowing groundwater, such as in an artesian spring. Hydrostatic (closed-system) pingos are the result of hydrostatic pressure exerted on water by permafrost around lake beds.

Natural springs exist far below subarctic permafrost. As the water seeks an outlet, permafrost blocks the way, increasing pressure on the water. The pressurized water pushes up on the soil until it finds a thinner layer of permafrost, where it seeps in and expands as it freezes. Water continues to feed into the crack and freeze, expanding into an ice core. As the core grows over time, it pushes upward on the soil, forming a bump on the land.

Pingos also form when lake beds dry out. Lakes are surrounded by a deep layer of permafrost, but the soil under the lake bed does not freeze. When a lake partially or completely drains, the insulating effect of the water is removed. Exposed to frigid temperatures, the waterlogged lake bed freezes and expands. With solid permafrost all around the lake bed, the easiest way for the ice to expand is upward through the thinnest layer of permafrost, eventually creating a bubble of soil-covered ice on the land. As the lake bed continues to freeze, the hill slowly grows, pushed up by the pressurized water underneath. Once all the water finally freezes, a process that may take hundreds of years, the pingo stops growing.

Jill M. Church

to melt even under high-end warming scenarios, the impact of thawing permafrost is already being felt in Arctic regions. Melting permafrost can cause the ground to become unstable, leading to soil collapse. Melting can produce thermokarst features, which are sinkholes or puddles at the surface of ground underlain by permafrost. This can have serious consequences for drainage and wildlife habitat as well as roads, pipelines, and structures.

Bruce Taterka

See also: Climate Change and Permafrost

Further Reading

Michael, C., and A. Heimsath. “Permafrost.” In Cutler J. Cleveland, ed. *Encyclopedia of Earth.* Washington, DC: Environmental Information Coalition, National Council for Science and the Environment, 2012.

Pink Snow

Pink snow (a.k.a. “watermelon snow”) is a natural phenomenon observed in alpine and coastal polar Arctic and Antarctic regions during summer. The freshwater algae species known as *Chlamydomonas nivalis* thrives in freezing water and snow that has persisted in these regions over time. The algae is genetically adapted for survival at high altitudes where it can be exposed to elevated levels of ultraviolet radiation and the production of astaxanthin, a bright crimson-colored chemical compound found in its cells. Astaxanthin is the same chemical compound that gives salmon and crabs its characteristic red and/or pink color and provides mammals that ingest them on a regular basis with the health benefits associated with protection against the harmful effects of ultraviolet radiation including skin cancer, visible signs of aging, and retinal/eye damage. Wild salmon obtains its red or pink color naturally during its life cycle by eating algae, shrimp, and krill that contain the astaxanthin compound. Farm-raised salmon obtains its coloring by having its diet supplemented with feed that has been enriched with synthetic astaxanthin and canthaxanthin pigments.

The pink-colored snow can be observed when snow that contains the *C. nivalis* algae is compressed and the red-colored astaxanthin compound is released from the cellular organelles (e.g., chloroplasts and chromoplasts) that have burst open onto snow, thus creating pink snow (red + white = pink). The chemical compound astaxanthin belongs to a larger family of molecules called "carotenoids" produced naturally in plants and some other photosynthetic organisms (e.g., algae, bacteria, and fungi). Astaxanthin is part of the class of carotenoids known as xanthophylls, which contain oxygen, and these compounds have the potential to serve as powerful antioxidants. The reason some carotenoid compounds appear orange or red in color is that they absorb blue light and transmit red light.

The frequency of light transmitted by the algae falls in the red region of the visible spectrum, thus the color observed by the human eye is red. Algae absorb light energy from the sun for its use in photosynthesis. Humans obtain carotenoids in their diets from eating plants (e.g., carrots and mushrooms) and fish (e.g., salmon and crab), which provide a number of necessary health benefits (e.g., healthy eyesight and protection from the harmful effects of ultraviolet radiation). Before the science of pink snow was understood, early explorers and naturalists believed that the pink color was caused by mineral deposits including iron deposits from a meteor. Pink snow has been observed in Arctic and Antarctic regions atop glaciers and polar ice caps. Some people have attempted to harvest red snow algae for their antiaging properties for use in the cosmetics industry. Pink snow is an amazing and natural phenomenon that can be observed only in Arctic and antarctic polar regions. Although eating pink snow may result in health benefits, walking on it will result in red-soled boots and pink-colored snow pants. It has been suggested that Inuit native peoples use the word "mentlana" for pink snow, but others have suggested that the idea that the Inuit people have several hundred names for snow was a hoax created by anthropologists. Later investigations have revealed that the Inuit really have multiple names for snow. Perhaps, pink snow whispers its sacred name to those who see its true nature with one.

Karen Knaus

See also: Ice Worms; Microbial Survival

Further Reading

Guerin, M., M. Huntley, and M. Olaizola. "Haematococcus astaxanthin: Applications for Human Health and Nutrition." *Trends in Biotechnology* 21, no. 5 (2003): 210–16.

Williams, W., H. Gorton, and T. Vogelmann. "Surface Gas-Exchange Processes of Snow Algae." *Proceedings of the National Academy of Sciences of the United States of America* 100, no. 2 (2003): 562–66.

Pliocene Arctic Fossils

Today the High Arctic is a polar desert, but the fossil record shows that in the past, the area had a temperate climate and was forested as recently as the Pliocene (5.332 million to 2.588 million years BP).

Pliocene deposits occur at multiple localities across the Canadian Arctic Archipelago and are characterized by the presence of unconsolidated sands, subfossil wood, and in rare cases, vertebrate fossils.

In the Strathcona Fiord region on Ellesmere Island, evidence of this surprising paleoenvironment is found in at least two adjacent sites: the Beaver Pond site and the Fyles Leaf Bed (FLB) site, both of which are in the eastern region of the Canadian Arctic Archipelago at 78° north latitude. These two sites are located near Strathcona Fiord and exhibit evidence of a diverse boreal-type ecosystem in the High Arctic.

Found at high elevations in the landscape, approximately 120 ft. (400 m) above sea level, these eastern deposits contain peat and are referred to as high-terrace deposits. In the western Canadian Arctic Archipelago, Pliocene deposits are thicker as a result of an extensive northwesterly flowing braided river system laying down extensive sediments along with weathered wood.

The significance of the Pliocene climate is that continental configuration and CO_2 levels at the time were similar to what exists today, yet global mean annual temperatures were 2–3°C warmer. For these reasons, the warmer Pliocene is considered an important historical analog for projected future warming brought on by climate change. More significantly, mean annual air temperature for the Strathcona Fiord area has been reconstructed to have been around 32°F (0°C), 57–72°F (14–22°C) warmer than the area is today. These findings show evidence of unexpectedly high temperature amplification for the High Arctic during this time, which could develop again and exacerbate the challenges of retreating multiyear sea ice, melting permafrost, and rapidly changing ecosystems. At present, the Arctic is currently warming faster than the rate of global warming.

The atmospheric temperature of the site was estimated using several approaches, including isotopes and tree ring thickness, the chemistry of the peat, and isotopes from mollusk shells found within the peat. These findings show evidence of unexpectedly high temperature amplification for the High Arctic during the Pliocene.

Of all the known Pliocene fossil sites, The Beaver Pond site at Strathcona Fiord has been most extensively researched. Discovered in 1961 by geologist Dr. John Fyles of the Geological Survey of Canada, the site was explored through a series of expeditions led by researchers from the Canadian Museum of Nature, including Richard Harington and Natalia Rybczynski. The Beaver Pond fossil site is remarkable in that it preserves thick deposits of peat. The peat is the remains of a fen, a nutrient rich, chemically neutral wetland sustained by a surface or groundwater source. Within the peat layer, the remains of macrofossil plants and subfossil wood, some fire-blackened, were discovered, including pollen, cones, leaves, and seeds that are indicative of a boreal-type forest. Mollusks, insects, microfossils (e.g., diatoms), and an assemblage of vertebrate fossils were also observed.

The fossil vertebrates include a frog, a percid fish (Percidae), an unusual rodent, a deerlet, a rabbit, a shrew, a near relative of black bear, a horse that seems most closely related to a three-toed horse lineage from China, and finally various small carnivores including a badger. Also preserved are the remains of numerous individuals of a small fossil beaver (*Dipoides*) along with hundreds of beaver-cut sticks and the possible remains of a beaver dam. The evidence of the cut sticks is significant because it suggests that the beaver lineage has been using trees for millions of years.

The Beaver Pond site is peculiar because it is the only Pliocene fossil site in the High Arctic to yield this extensive assemblage of vertebrates. Perhaps the animals were attracted to this area because at times it contained a beaver pond, and modern beaver ponds are known to create enhanced habitat and increased biodiversity. Because this was a fen peatland with near-neutral pH, fossil bones were preserved. Had the peat been created by a bog that is acidic, the bones would have dissolved.

South of the Beaver Pond site, there is a site called the "Fyles Leaf Bed" (FLB) site. The FLB site has yielded extensive plant remains, and to date, only one fossil vertebrate has been identified from this locality—a giant fossil camel, known as the High Arctic Camel.

The Pliocene paleoenvironment research suggests a boreal-type forest that was dominated by an extinct larch species. This forest is unlike the northern boreal-type forest found in North America today because it is dominated by Larch trees and includes a cedar tree—a taxon that today is associated with much more southern boreal forests. It is also important to remember that the same seasonal light regime was active during the Pliocene, so this forest was dark or near dark during the winter months.

The age of these sites was determined by terrestrial cosmogenic nuclide dating. This process dates the buried sands in the area where fossils are recovered. It is based on the scientific principle that the ratio of the abundance of rare radioactive isotopes produced in minerals previously exposed to cosmic rays provides a means to measure the duration of time that they have been buried and shielded from cosmic rays. Burial ages of 3.4 and 3.8 Ma (minimum age estimates) were determined for the peat layers of the Beaver Pond and FLB sites, respectively, and are consistent with vertebrate and floral biostratigraphic evidence.

Natalia Rybczynski and Martin Lipman

See also: Arctic Camel; Dinosaurs of Antarctica; Mesozoic Marine Reptiles of Antarctica; Paleoecology of Antarctica; Woolly Mammoths; Woolly Mammoths, Baby

Further Reading

Ashley, P. Y. Ballantyne, G. Miller, B. Otto-Bliesner, N. Rosenbloom, and J. White. "The Amplification of Arctic Terrestrial Surface Temperatures by Reduced Sea-Ice Extent during the Pliocene." *Palaeogeography, Palaeoclimatology, Palaeoecology* (2013): 59–67.

Polar Bear

The polar bear (*Ursus maritimus*) has long symbolized the Arctic. Living largely within the Arctic Circle, polar bears are the largest bear and the largest land carnivore. Inuit inhabitants of the Arctic both admired and feared the bear and called them "Nanuq." The polar bear was an integral part of Inuit myth and folklore in addition to being highly valued for their skins, which made the warm waterproof clothing. While related to the brown bear, polar bears have evolved to occupy a narrow ecological niche.

Polar bears range throughout the Arctic in areas where they can catch seals at open water spots as they wait on ice floes. If all the floes disappear, they are helpless. The five "polar bear nations" where the ice bears are found are the United States (Alaska), Canada, Russia, Denmark (Greenland), and Norway. Polar bears are highly adapted to their Arctic habitat. They are the world's largest land predators. They top the food chain in the Arctic and, because of the changes that are taking place, they are regarded by many as an endangered species. (Tersina/Dreamstime.com)

Population and Distribution

The polar bear can be found in much of its original range, within the Arctic Circle and its adjacent landmasses. They are often considered marine mammals, since the majority of their time is spent on sea ice. It is difficult to determine a global polar bear population count in such a remote and harsh climate, but it is estimated that there are between 20,000 and 25,000 polar bears worldwide. Nineteen discrete subpopulations have been tallied by their ranges, which are spread across territories controlled by five nations: Denmark (Greenland populations), Norway (Svalbard), Russia, Canada, and the United States (Alaska). These five countries have agreed to uphold the International Agreement on the Conservation of Polar Bears, which mandates cooperation in research and conservation efforts.

Physical Characteristics and Adaptations

Polar bears are massive solid animals with elongated bodies, stocky legs, and small ears and noses. All these features help them conserve body heat in their perpetually cold environment. The average adult male is more than 8 ft. long and weighs about 900 pounds (400 kg). Adult females are about half the size, measuring about 6.5 ft. long and 400–500 pounds (180–227 kg). Polar bears are immensely powerful and can run up to 35 mile per hour (56.3 km/h) in short distances. They have many adaptations conducive to moving about on ice. Their paws are very large, both to distribute their weight when walking on snow and thin ice, and to make them efficient swimmers. Polar bears have been spotted swimming in open water 50 miles away from the nearest ice floe or land. The pads of their paws are covered with bumpy skin and fur, both features that provide traction on ice. Their claws are also shorter and stockier than brown bears, again useful for digging into the snow and ice or gripping heavy prey.

The color of polar bear's fur ranges from very white to a creamy yellow, but their skin is actually black to absorb as much heat as possible from the sun. There is a dense layer of underfur for insulation, covered by an outer layer of guard hairs, which are hollow and appear white, but are transparent. Polar bears also have a 4- to 6-inch-thick layer of blubber under the skin for additional insulation. They retain heat so efficiently that they can remain active all winter and are actually in more danger of overheating from exertion than suffering from hypothermia. This is reflected in the bears' typically slow ambling gait of about 2.5 miles per hour. An increase to 4 miles per hour can raise a polar bear's body temperature from 98.6 to 102.2°F. They swim to cool down. A common pose in pictures is a bear lying on his back with all four paws in the air, which is also a cooling technique. Polar bears lose heat through their noses, muzzles, soles of their feet, and insides of their thighs. The pose maximizes the cooling surface exposed to the air.

Hunting and Diet

The polar bear is the most carnivorous member of the bear family, dining almost entirely on ringed and bearded seals. They will occasionally eat smaller mammals, beluga or narwhals opportunistically and, in summer months in the most southern territories, will eat vegetation and berries. Unlike brown or black bears, polar bears are capable of fasting through the summer months when the sea is not frozen. Some populations live solely on their fat reserves for months at a time.

Polar bears have an extraordinary sense of smell and can hunt by sniffing out dens of seal pups as well as locate seals nearly a mile away, buried under 3 ft. of snow. They also hunt at openings in the ice where seals surface to breathe or rest. Mature bears tend to eat only the skin and blubber of the seals, leaving the meat behind for younger bears and other scavengers. Their most common hunting method is called still-hunting. They crouch patiently near an opening in the sea ice. As the seal surfaces and exhales, the bear smells its breath, pounces, and drags it out onto the ice for the kill. When hunting for seal pup dens, they creep to the den located by smell, then suddenly launch upward, using their momentum to punch through the snow pack into the den to extract the seal.

Reproduction

Polar bears are generally solitary animals, with the exception of females with cubs. Mating occurs in the spring and early summer. After mating, the fertilized egg remains in a suspended state until the fall. While pregnant, the female consumes prodigious amounts of food, often doubling her body weight. In late fall, she digs a maternity den and remains inside until the birth of between one and four but typically has two cubs. The cubs are born blind, covered with fine fur, and weighing less than two pounds. The cubs nurse through the remainder of the winter and early spring. When the mother breaks open the den entrance for the cubs to emerge for the first time, they weigh about 30 pounds. They stay close to the den until the cubs adjust to walking and playing, then they make their first trip to the sea ice to break the mother's fast. Cubs stay with their mother for about 30 months, after which she is ready to mate again. Females generally mate and reproduce every three years. The average life span for polar bears in the wild is 25 years.

Jill M. Church

See also: Arctic Fox; Arctic Ground Squirrel; Arctic Hare; Arctic Seabirds; Arctic Wolf; Caribou; Dogs in the Arctic; Lemmings; Musk Oxen; Wolverine

POLAR BEAR, MATING WITH BROWN BEAR

Polar bears and brown bears have mated successfully many times over the past 100,000 years. As fluctuations in the climate occur, the bears' habitats occasionally overlap. Grizzly, Kodiak, and Alaskan brown bears, all subspecies of the brown bear, live and breed on land. Polar bears spend the majority of their time in the water and on pack ice, usually breeding on the ice. When the Arctic is in a colder period and ice is extensive, grizzlies and polar bears rarely interbreed even though their mating seasons overlap, because they are physically distant from one another. However, in warmer periods when ice recedes and open water becomes more prevalent in the Arctic, grizzlies and polar bears occasionally venture into each other's territory.

Hybrid bears have been bred in zoos for years, but the first documented case of a polar/brown bear hybrid found in the wild was in 2006. In 2010, a hybrid bear was found and genetic testing determined he had a grizzly–polar hybrid mother and a grizzly father. The media have assigned several names to these hybrid bears—pizzly bear and grolar bear being most common. Canadian officials suggest using *nanulak*, combining the Inuit names for polar bear (*nanuk*) and grizzly bear (*aklak*).

The current warming trend impacting the Arctic may increase the number of hybrid bears. Loss of habitat will drive polar bears further inland to hunt, and grizzlies will venture further into polar territory, escalating contact between the two species.

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Further Reading

Davids, R. *Lords of the Arctic: A Journey among the Polar Bears.* New York: MacMillan, 1982.

Gunderson, A. "Ursus Maritimus." *Animal Diversity Web.* University of Michigan Museum of Zoology, 2007.

Stirling, I. *Polar Bears: A Natural History of a Threatened Species.* Markham, ON: Fitzhenry and Whiteside, 2011.

Polar Research Institute of China (PRIC)

The Chinese national center for polar research, with headquarters in Shanghai, is responsible for coordinating the country's polar research and carrying out international cooperation and academic exchanges. It operates two permanent research stations in Antarctica: Great Wall (King George Island, west Antarctica) and Zhongshan

(Larsemann Hills, east Antarctica), plus a summer one: Kunlun (in Dome A, the highest place in Antarctica), in addition to an Arctic station: Yellow River (Ny-Alesund, Svalbard, Norway) and the icebreaker *XueLong* ("Snow Dragon"). It contains research divisions devoted to polar glaciology, polar upper atmosphere, and polar bio-ecology, in addition to a polar information center. Founded in 1989, the PRIC is under the Chinese Arctic and Antarctic Administration (CAA), amounting to its research body. The CAA is, in turn, under the State Oceanic Administration of China.

In 2012, the *XueLong* set sail on the Fifth Chinese National Arctic Research Expedition (CHINARE 5), with 70 scientists on board, reaching Iceland. In addition to scientific research, it carried out public diplomacy activities and could be visited by the public. Originally built in Ukraine in 1993 as an ice-strengthened cargo ship, it was modified one year later to serve a dual role as supply ship for China's research stations and floating laboratory, and is the largest nonnuclear-powered icebreaker in the world. In October 2012, the PRIC signed an agreement with Chinese ship builder MARIC for the design of her replacement, a stronger research icebreaker that could be launched in 2014.

The PRIC sponsors, together with the CAA, the peer-reviewed quarterly journal *Advances in Polar Science* (formerly the *Chinese Journal of Polar Science*) in both Chinese and English-language editions. In recent years, it has concluded a number of cooperation agreements with similar institutions in other countries, among them Australia, Germany, Iceland, Japan, Norway, and the United States. China's National Polar Archives are affiliated to the PRIC.

The current director of the PRIC is Dr. Huigen Yang, who got his PhD in magnetospheric physics from Wuhan University in 1991, joining the PRIC and spending 17 months at Japan's Antarctic Syowa Station and two years doing a postdoctorate at the Japanese National Institute of Polar Research, thanks to ongoing cooperation between the two institutions.

The research activities carried out by the PRIC, and its cooperation with fellow agencies abroad, support China's bid to become a permanent observer at the Arctic Council, the regional organization bringing together the eight Arctic states plus six indigenous organizations with permanent participant status. They are also important for Chinese efforts to portray the country as a peacefully rising power and to reinforce relations with resource-rich countries in the Arctic. PRIC researchers often refer to China as a "near-Arctic state," a novel concept of which the exact meaning is not completely clear yet.

Alex Calvo

See also: Antarctic Programs and Research Stations/Bases

Further Reading

Chinese Arctic and Antarctic Administration. http://www.chinare.gov.cn/en/index.html. Accessed January 13, 2014.

Polar Research Institute of China. http://www.pric.gov.cn/. Accessed January 13, 2014.

Polar Research Vessel *Grönland*

The *Grönland* was built in 1867 and is the oldest active sailing polar research vessel of the globe. Originally built as a Norwegian coaster by the Tolleff Toleffsen in Skånevik near Bergen, the ship was bought by Karl Coldewey for the First German North Polar Expedition. After retrofitting the vessel for the use as a research vessel in the ice-covered waters of the Arctic, the ship finally reached on September 13, 1868, north of Spitsbergen with 81° 4′ 30″N, the northernmost position ever recorded for a sailing vessel without an auxiliary engine.

Compared with modern standards, the research and living conditions on the open-deck single-masted sailing vessel without an auxiliary engine were extremely poor for the 12 crew members. With the hold used for storage of provisions and research equipment, 10 crew members needed to share the small forecastle that was also the only area aboard equipped with a coal/wood burning stove, while master and chief-mate shared a small aft-cabin that was at the same time the chart-room. Despite the ice-strengthened wooden hull, copper sheeting, and an additional layer of planking for operation in the ice, the vessel finally proved not to be able to maneuver in ice-covered waters due to the lack of an auxiliary engine. After the return from the First German North Polar Expedition, the *Grönland* was again considered to use for the Second German North Polar expedition, but these plans were finally given up, as the vessel with a total length of only 96 ft. (29.3 m) and 20 ft. (6.1 m) maximum width was considered too small for the new expedition.

After being laid up in Bremerhaven, the ship was finally sold back to Norway in September 1871 and served for the next 100 years as a commercial vessel under Norwegian flag. Although the ownership changed several times and the ship was substantially modernized, including installation of an auxiliary engine, construction of a wheelhouse, and so on, the name of the ship never changed and thus the memory that the ship wasn't an ordinary coaster, but the vessel of the First German North Polar Expedition. At the beginning of the 1970s, the commercial use of the *Grönland* finally reached its end, and various initiatives were interested in using the ship as a museum ship. After an episode at the 1972 Olympics, the newly established German Maritime Museum could buy the *Grönland* and decided to use the ship not as a stationary museum ship, but as an active sailing museum ship. The ship was rebuilt during the 1970s close to the conditions of 1868, means the actual conditions of the First German North Polar Expedition, and began operations under the flag of the museum all around the North Sea and the Baltic, including several trips to Norway.

During a major restoration project in 2004/2005, safety standards were brought up to the latest level required for active sailing traditional ships, and the rebuilding process to the conditions of 1868 was completed. Today the *Grönland* is not only one of the oldest original active sailing vessels on the globe, but a unique window into the history of polar research during the second half of the nineteenth century and an important tool for experimental historical research.

Ingo Heidbrink

See also: First German North Polar Expedition (1868)

Further Reading

Brouwer, N. *The International Register of Historic Ships.* London: Chatham Publications, 1999.

Deutsches Schiffahrts Museum Bremerhaven, UweSchnall, and DetlevEllmers. *Schwimmende Oldtimer der Seefahrt.* Bremerhaven, Germany: Stiftung Dt. Schiffahrts Museum, 1977.

Poles of Inaccessibility

The concept of Poles of Relative Inaccessibility (or the Poles of Inaccessibility) was introduced by Vilhjalmur Stefansson in 1920 to refer to those points in the Arctic and Antarctic that are most difficult to reach. In the Antarctic, it is the point farthest from the coast; in the Arctic, it is the point farthest from open water. The position of the Northern Pole of Inaccessibility was originally calculated by Stefansson at 83° 50′N, 160° W on the basis of "farthest norths" reached by ships in different sectors of the Arctic. Other writers give different figures, reflecting later voyages such as that of Konstantin Badigin in 1937–1940, whose farthest norths exceeded those achieved previously. By contrast, the Southern Pole of Inaccessibility (85° 50′S 65° 47′E) is fixed subject to major breakup of ice shelves surrounding the continent.

Walter William "Wally" Herbert—considered the first person to walk to the North Pole. (AP Photo)

Several expeditions have been organized with the intention of reaching the Poles of Inaccessibility. Hubert Wilkins intended to fly toward the Northern Pole in 1926 but was prevented by a series of accidents. On the basis of two exploratory flights undertaken with navigator V.I. Akkuratov in August 1939 and July 1940, Soviet pilot Ivan

Cherevichnyy succeeded in persuading the chief administration of the Northern Sea Route to back his plans for an expedition. Establishing his main base on the sea ice near the polar station on Wrangell Island, Cherevichnyy made three flights to the vicinity of the pole, where he landed for the first time on April 8, 1941. He was accompanied by scientists who conducted a series of observations at each landing. This marked the start of a program of high-latitude air expeditions, which was resumed by the Soviet Union after the end of World War II. Wally Herbert planned to establish his summer camp at the Pole of Inaccessibility to benefit from the Transpolar Current, anticipating that this would carry him toward the North Pole. Unfortunately, he was prevented from putting his theory to the test when forced to camp some way south at 81° 30′N 165° 29′W. First to reach the pole over the ice, though not from land, was Dmitriy Shparo in 1986, when he completed a 700-mile (1,125-km) journey on skis via the pole between the Soviet ice stations NP-26 and NP-27.

The Southern Pole has also proved suitably difficult to reach. Perhaps because obliged to compete with the Americans, who were establishing a station at the geographic South Pole, the Soviet Antarctic Program set itself the task of erecting a station at the Pole of Inaccessibility as part of its contribution to the International Geophysical Year (1957–1958). Whereas the Americans employed airplanes, the Soviets relied on tractors, which were unable to reach farther than 78° 24′S 87° 35′E, where Sovetskaya was constructed 450 miles (725 km) short of the pole. Another tractor team later succeeded in reaching the pole, where a temporary station was maintained between December 13 and 28, 1958. The location was 800 miles (1,280 km) from the coast and more than 12,000 ft. (3,720 m) above sea level.

William James Mills

See also: South Pole

Further Reading

Berton, P. *The Arctic Grail: The Quest for the Northwest Passage and the North Pole, 1818–1909.* Guilford, CT: The Lyons Press, 2000.

Fleming, F. *Ninety Degrees North: The Quest for the North Pole by Fergus Fleming.* New York: Grove Press, 2003.

MacPhee, R. *Race to the End: Amundsen, Scott, and the Attainment of the South Pole.* New York: Sterling Innovation, 2010.

Preston, D. *First Rate Tragedy: Robert Falcon Scott and the Race to the South Pole.* New York: Mariner Books, 1999.

Project Iceworm

In 1960, the United States gained approval from the Danish government for the construction of a military and research facility at Camp Century, Greenland. Camp

Century is located about 150 miles (240 km) northwest of Thule Air Base (76° 31′N 68° 42′W). The Camp Century facility would test the feasibility and construction techniques for a portable nuclear reactor (PM-2A) as well as have a place for conducting various scientific experiments. The Camp Century PM-2A reactor was operational from 1959 to 1966 and was under the direction of the Army Polar Research and Development Center. In conjunction with this official story, the U.S. Army established a top secret program to construct a network of ice tunnels, around 2,500 miles (4,000 km) in length, underneath the Greenland Ice Sheet. These tunnels would house 600 medium-range nuclear missiles (called the "Minuteman missile") in system of tunnels under the ice in Greenland that would be able to reach the Soviet Union in the event of a nuclear war. This secret program was code-named "Project Iceworm." Project Iceworm was allegedly secret to the Danish government and the public until 1997. However, it was noted in documents obtained in the 1990s that Danish Prime Minister H. C. Hansen in 1957 had given the tacit approval to the U.S. Ambassador for deploying nuclear weapons in Greenland.

The tunnel complex was anticipated to cover 52,000 square miles (134,000 sq. km) as outlined in the 1960 U.S. Army report titled the "Strategic Value of the Greenland Icecap." Within the tunnel infrastructure, the missile launch sites would be 4 miles apart. These would contain clusters of nuclear missiles, and the launch complex floors would be at a depth of 28 ft. below the surface. The missile launchers would be more than 60 ft. in depth to accommodate the Minuteman missile that was just 59 ft. in length and almost 6 ft. across. Each year the Project Iceworm was operational, a new tunnel was dug. The nuclear missile of choice for Project Iceworm was the U.S. Air Force's Minuteman missile, which was equipped with an American made thermonuclear warhead called "W62" with nuclear yield of 170 kilotons of TNT. The Minuteman missile had a range of 700 miles and a maximum speed of Mach 23 (around 15,000 mph). The Minuteman missiles were a modified version of the U.S. Army's Iceman missile. In all, 21 trenches were dug in the ice and covered with dome roofs, which included prefabricated buildings. These tunnels included a mini city complete with a hospital, a shop, a movie theater, and a church capable of supporting 200 people. From 1960 to 1963, the electricity for the under the ice complex was from the PM-2A nuclear reactor. Melted glaciers provided water for the complex, which was tested for unhealthy microbes.

During construction, geologist determined that the ice was moving faster than anticipated and would destroy the tunnel complex within about two years. The scientists also noted that the Greenland Icecap was constantly moving at a slow rate from the center out, and the ice had both viscous and elastic characteristics (viscoelasticity) when undergoing deformation depending on temperature and compactness. The determination was that the ice tunnel ceilings would collapse. In 1962, the reactor room ceiling had dropped and had to be lifted around 5 ft. (1.5 m).

In 1965, the tunnel complex was evacuated, and the PM-2A was removed. In 1966, Project Iceworm at Camp Century closed.

The details of Project Iceworm did not come to light until 1997, when the Danish Parliament, under the request of the Danish Foreign Policy Institute, was investigating violations of Denmark's nonnuclear policy, which forbid nuclear weapons from being on Danish soil (Denmark, Greenland, and Faroe Islands). The findings resulted in a political scandal called "Thulegate." The investigation uncovered that the U.S. B52 bombers loaded with nuclear weapons had flown daily over northwestern Greenland as part of Operation Chrome Dome. On January 21, 1968, a U.S. Air Force B52G Stratofortress, operating under the call sign "HOBO 28" crashed near Thule Airbase in Greenland. The crash was labeled an emergency landing of a crippled aircraft that crashed without disclosing the routine overflight nuclear missions. During Thulegate, the details of the Camp Century missile base were made public. Thulegate exposed the U.S. military and the Danish government's tacit approval of the housing nuclear surface-to-air nuclear weapons and other tactical warheads in Greenland, which was in violation to the Greenland Danish agreement of 1957 prohibiting nuclear weapons on the island.

Andrew J. Hund

See also: Greenland; Greenland, U.S. Bases in; Operation Chrome Dome

Further Reading

Danish Institute of International Affairs. *Greenland during the Cold War. Danish and American Security Policy 1945–1968.* Copenhagen, Denmark: Danish Institute of International Affairs, 1997.

Suid, L. *The Army's Nuclear Power Program: Evolution of a Support Agency.* Westport, CT: Greenwood Publishing Group, 1990.

Weiss, E. "Cold War under the Ice: The Army's Bid for a Long-Range Nuclear Role, 1959–1963." *Journal of Cold War Studies* 3 (2001): 31–58.

Protocol on Environmental Protection to the Antarctic Treaty

The Antarctic Continent is a very special place, not only for its extreme climate, wildlife, location in the globe, and all the features that make it such a unique environment, but also because of the way it is managed. Antarctica has no government like most countries we know. Instead, its status is regulated by an international document signed in 1959: the "Antarctic Treaty." The main provisions of the treaty state that Antarctica shall be used for peaceful purposes only, establishes freedom of scientific investigation and cooperation, and bans military activity on the continent. But the protection of the Antarctic environment was not the central objective of the Antarctic Treaty. Once it entered into force in 1961, several measures were taken in articles or in separate conventions, which addressed issues such as the protection of flora and fauna, conservation of Antarctic seals, conservation of all Antarctic marine living resources, and prohibition of mineral exploitation, among others. Such agreements and conventions paved the way to the creation of the most important instrument for the protection of the Antarctic environment: the Protocol on Environmental Protection to the Antarctic Treaty.

The Protocol on Environmental Protection to the Antarctic Treaty (also known as the Environmental Protocol, Madrid Protocol, or simply the Protocol), signed in Madrid in 1991, came into force in 1998 and is the main instrument concerned with conservation and management of biodiversity in Antarctica. It is an essential part of the Antarctic Treaty, reinforcing that the continent is used only for peaceful and scientific purposes. It designates Antarctica as a "natural reserve, devoted to peace and science." The environmental principles that support the Protocol set out the need to protect natural and scientific values of Antarctica, with particular emphasis on the obligation to conduct careful planning of any human activities, so as to avoid or mitigate any adverse impacts on the environment.

Detonation of nuclear explosives and waste storage of nuclear activities, exploration and exploitation of mineral resources not related to scientific research, and open burning of materials are examples of activities prohibited by the Protocol. Use of radioactive substances for scientific purposes, taking or harmful interference on Antarctic species, introduction of alien species to Antarctica, or entering Antarctic Specially Protected Areas, are examples of activities that are allowed only after issuing a permit.

The Protocol regulations are expressed in detail in six Annexes:

Annex I: Environmental Impact Assessments
Annex II: Flora and Fauna
Annex III: Waste Disposal
Annex IV: Marine Pollution
Annex V: Protected Areas
Annex VI: Liability Arising from Environmental Emergencies

To ensure the fulfillment of its objectives, The Environment Protocol established the Committee for Environmental Protection (CEP) as an expert advisory body, integrated by representatives of all the countries that are part of the Antarctic Treaty System. CEP functions are to provide advice and recommendations to the Antarctic Treaty Consultative Meeting (ATCM) in relation to the implementation of the Madrid Protocol. The CEP meets every year in conjunction with the ATCM. Until 2048, the Protocol can only be modified by unanimous agreement of all Consultative Parties to the Antarctic Treaty.

Luciana M. Motta

See also: Antarctic Territorial Claims; Antarctic Treaty System (ATS)

Further Reading

Antarctic Treaty Secretariat. Protocol on Environmental Protection to the Antarctic Treaty. 1991. www.ats.aq. Accessed January 13, 2014.

Putorana Plateau

A critically important cultural or physical space on the planet, if deemed significant, can be designated as a world heritage site under the United Nations Educational, Scientific, and Cultural Organization (UNESCO). To date, there have been 981 UNESCO world heritage sites, of which five are located in the Arctic. The Putorana Plateau is one of five Arctic UNESCO world heritage sites.

The Putorana Plateau (69° N 93° E) is located in the northern part of Central Siberia in the Russian Federation. It was declared a UNESCO world heritage site in 2010. The UNESCO heritage site of Putorana Plateau overlaps with a Russian Federation nature reserve called "Putoransky State Nature Reserve." The Putoransky State Nature Reserve was established in 1988 and covers an area almost 7,300 square miles (18,872 sq. km). The nature reserve was established to protect the large caribou and Siberian bighorn sheep herds. It was listed as a world heritage site because of its unique subarctic and Arctic ecosystems with a pristine cold

Rocky landscape on the Putorana Plateau, the origins of the Bucharama River, Russia, Taimyr Peninsula. (Shutterstock.com) water lake and river systems consisting of more than 25,000 lakes. These ecosystems are a unique collection of unsoiled below tree line and above tree line boreal forest, forest tundra, tundra, and Arctic deserts. The traditional group to inhabit the region is the Evenks. The Putorana Plateau is one of the few remaining caribou migration routes.

Andrew J. Hund

See also: Ilulissat Icefjord; Laponian Area; Natural System of Wrangel Island Reserve; Rock Art of Alta

Further Reading

"Putorana Plateau." National Geographic. http://science.nationalgeographic.com/science/earth/surface-of-the-earth/putorana-plateau-article/. Accessed January 13, 2014.

Pykrete

Pykrete is a composite material discovered during World War II in response to the need to find innovative new designs for warships operating in the Arctic regions. A British journalist named Geoffrey Pyke (1893–1948) proposed the ice/sawdust hybrid material to Admiral Louis Mountbatten in 1942. Pyke had been working on the problem of preventing the icing of ships operating in the frigid waters of the North Atlantic. This problem had become quite serious the previous summer with the Soviet Union's entry into the war. Icing made ships slow and vulnerable during the hazardous Archangel runs where allied shipping brought much needed supplies to the Russians via the Barents Sea. In some cases, these supplies constituted the difference between continued resistance and capitulation in such besieged Russian cities as Moscow and Leningrad. The Anglo-American allied command was thus highly invested in making such runs both quicker and safer.

Pykrete, as Pyke named it, would consist of ice and sawdust in a 6 to 1 ratio, could be formed into any desired shape, and would in its makeup be harder than concrete but with the ability to float. In his proposed Project Habakkuk, Pyke suggested that the material could be shaped to create massive aircraft carriers that could launch not only fighters but also bombers. The theory was to create a block of ice so huge that it would take quite a while to melt, at which point another one could be created. The pluses for such a scheme were manifest, including the fact that due to size and composition, such a ship would be impervious to sinking.

Although possibly apocryphal, Mountbatten claimed following the war that he demonstrated the resultant product as Churchill took his evening bath, amazing the prime minister with a material that seemed to defy the laws of physics. Despite

Churchill's green light and subsequent work in Canada to create a small ship, the project never came to fruition. It became clear that an aircraft carrier would be too massive to create, and Pyke could never figure out how the ship would be effectively propelled. Furthermore, 1943 witnessed a transition in the European theater to allied dominance on the water and in the air. Finally, with faster ships and aircraft with greater range rolling off of the assembly lines, such an extravagant and still theoretical undertaking was no longer deemed necessary.

Even though it was never used in warfare, the physics of Pyke's experimental material were allegedly born out when the sample ice ship built in Alberta, Canada, took an entire summer to melt, even without wood shavings added. On several occasions since, Pykrete has been seriously considered for various uses, mostly in Scandinavia. In 2009, the American television show *Mythbusters* tested pykrete, finding it to be as strong as claimed by Pyke, although a boat specially constructed by the show did not stand up to the tests through which they put it, melting far more quickly than expected.

Andrew J. Howe

See also: Ice Sheet; Pink Snow

Further Reading

The National Archives. *ADM 1/15677—Proposals and Inventions of Mr Geoffrey Pyke; Gravity Propelled Ball Bomb, Pykrete and Power Driven Rivers.* London: Royal Naval Museum Library, 2001.

Perutz, M. "A Description of the Iceberg Aircraft Carrier and the Bearing of the Mechanical Properties of Frozen Wood Pulp upon Some Problems of Glacier Flow." *The Journal of Glaciology* 1, no. 3 (1948): 95–104.

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Q

Qanruyutet. ***See* Inuit and Yup'ik Concepts of "Ihuma" and "Qanruyutet"**

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R

Radioactive Iodine (I-131) Human Experiments in Alaska

During the Cold War, the U.S. military was interested in understanding soldiers' physiological abilities to handle Arctic (extreme cold) conditions. In the late 1950s, the U.S. Air Force Arctic Aeromedical Laboratory undertook a thyroid functioning study for this reason. The study sought to determine whether the thyroid gland helped humans adapt to cold weather as found in the Arctic. Previously, studies conducted on animals had suggested that the thyroid played a role in their adaptation to extreme cold. From August 1955 to February 1957, the U.S. military conducted the thyroid study in the Inupiat villages of Wainwright, Point Lay, and Anaktuvik Pass as well as the Athabaskan Native villages of Fort Yukon and Arctic Village.

The sample consisted of around 20 military personnel and more than 100 Alaskan Natives (mostly Inupiat) men, women, and children. The ethnic distribution for the study was 84 Eskimos, 17 Alaskan Natives, and 19 Caucasians. The subjects were given capsules of radioactive iodine, also known as iodine-131 or I-131. The study administered 186 doses of I-131 with an approximate average of 50 microcuries (μCi) (1,850,000 Becquerel [Bq]) with a range of 9–65 μCi (333,000–2,405,000 Bq). During the 1950s, 50 μCi was standard for medical tracer studies. Sixty-eight participants received a single dose, forty-one received double doses (100 μCi [3,700,000 Bq]), and twelve received three doses (150 μCi [5,550,000 Bq]).

To evaluate the I-131 uptake, the subject's thyroid activity was measured using an instrument that detects and measures ionizing radiation (called a "scintillation counter"), and samples of their urine, blood, and saliva were collected and tested. The findings demonstrated that the thyroid was not significant for human adaptation to extreme cold. The results of the study were published in 1957 as an Air Force report titled "Thyroid Activity in Man Exposed to Cold." The principal investigator was the Norwegian scientist Dr. Kaare Rodahl, MD.

The ethical implications of the thyroid study were numerous. During the 1950s, the U.S. government had set protocols around study disclosure and consent of human subjects. In this study, these protocols were not followed. First, the military personnel or Alaskan Natives were not properly informed about the experiment or about the health risks of taking the I-131. The mostly subsistence-based Alaskan Native populations were not familiar with modern medicine and thus were unlikely to be fully aware of the purpose of the thyroid study. Many Alaska Native volunteers thought they were receiving medical care rather than being in a research study. Next, the sample included a woman who was believed to be pregnant as well as two women who were lactating. Third, parental consent for the minors was not achieved. Next, disclosure of the study was not translated into the language of the Alaskan Natives subjects. In addition, the term "radiation" was not provided to the English-speaking elder translators. Lastly, this I-131 experiment offered no medical benefit to the subjects.

Andrew J. Hund

See also: Inuit Arctic Relocation; Inuit Lawsuits over Climate Change

Further Reading

Rodahl, K., and G. Bang. "Thyroid Activity in Men Exposed to Cold." Technical Report 57–36 (Alaskan Air Command, Arctic Aeromedical Laboratory, Ladd Air Force Base: October 1957) (ACHRE No. CORP-071294-A), 81.

Setlow, L. Advisory Committee on Human Radiation Experiments, Transcript of Proceedings of March 16, 1995, 440.

Radioactivity

Radioactivity is the spontaneous decay of the nuclei of particular radioactive atoms (radioisotopes) with the emission of ionizing radiation. Nuclei exhibiting radioactivity are unstable and in a continual process of gradual breakdown (i.e., disintegration), which is referred to as radioactive decay. The effect of radioactivity is to produce a more stable state. The decay is most commonly of three main types, alpha and beta particles and gamma radiation, accompanied by the emission of ionizing radiation in the form of high-energy particles or rays. The rate of breakdown or decay is calculated by the half-life or the time it takes for a given number of atoms to decay by half, which can range from milliseconds for short-lived isotopes to billions of years. The amount of radioactivity exhibited is measured by the number of disintegrations per second (dps); 1 becquerel (Bq) = 1 dps, and 1 curie (Ci) = 3.7×10^{10} dps = 3.7×10^{10} Bq. As alpha and beta particles penetrate matter, they bump electrons out of atoms or molecules, thus ionizing them.

Alpha, Beta, and Gamma Radiations

Alpha particles are positively charged high-energy particles emitted from the nuclei of a radioactive atom. They are the largest in mass and the slowest traveling at less than one-tenth the speed of light. Alpha particles are produced following the decay of radioisotopes of heavy nuclei such as radium, plutonium, uranium, and radon. The process of alpha decay transforms one element into a different element that has a lighter nucleus than the original radioisotope by emitting an alpha particle, which consists of two protons and two neutrons. The total energy (including the masses of the new element and the alpha particle) is the same as before, but some of the nuclear binding energy is converted into kinetic energy of the alpha particle.

Beta particles are electrons emitted from the spontaneous decay of unstable nuclei when one of its neutrons turns into a proton and emits an electron and an electron antineutrino. Tritium, carbon-14, phosphorus-32, and strontium-90 all decay by beta emission. Beta particles travel at a high velocity, which can be as high as 98 percent of the speed of light. Beta particles are electrons and thus have only have about 1/2,000 the mass of a proton or neutron, and their emission does not affect the mass number, and no new element is created.

Gamma rays are produced following spontaneous decay of radioactive material, such as cobalt-60 and cesium-137. A gamma ray is an electromagnetic wave that is similar to ordinary visible light but differs in its wavelength. Gamma rays have a wavelength that is far shorter than visible light and thus higher in energy, greater than 100 keV. Gamma decay generally occurs simultaneously with an alpha or beta decay and does not affect the atomic number or the mass number of a nucleus, and no new element is created.

Alpha, beta, and gamma radiation each produces differing amounts of ionization. Alpha particles produce the most ionization because they are heavy, slow moving, and carry two positive charges. Gamma rays produce the least because they are photons that carry no charge, while beta particles have an ionizing potential in between alpha and gamma rays. The ionizing potential of alpha and beta particles and gamma radiation causes damage on contact or proximity with living cells and can result in radiation sickness.

Each of the particles has a differing penetration ability, which is based on the energy they carry. Alpha particles can travel only a few centimeters in air because of their large mass and slow speed; they lose energy quickly by many collisions with air molecules. A single sheet of paper can stop an alpha particle. Beta particles can travel different distances, depending on the kinetic energy of the particle, but they have slightly higher penetration ability than alpha particles and can be stopped by 2–3 mm of aluminum. However, gamma rays being high-energy electromagnetic waves penetrate matter more easily and ionize matter as it passes through and interacts with atoms. Gamma ray producers such as cobalt-60 are used for medical and research purposes including radiocarbon dating, measuring chemical reactions, dating rocks, X-rays, and cancer therapy.

Andrew J. Hund

See also: Novaya Zemlya, Nuclear Tests; Novaya Zemlya, Nuclear Tests, Environmental Legacy of; Nuclear Power in the Arctic; Nuclear Waste in the Arctic; Operation Chrome Dome; Radioactive Iodine (I-131) Human Experiments in Alaska; Radioactivity in the Arctic; Sunken Soviet/Russian Nuclear Submarines in Arctic

Further Reading

Krane, Kenneth S. *Introductory Nuclear Physics*. 3rd ed. Hoboken, NJ: Wiley, 1987.

Tuniz, C. *Radioactivity: A Very Short Introduction (Very Short Introductions)*. Oxford, England: Oxford University Press, 2012.

Radioactivity in the Arctic

Radioactivity can occur naturally or be artificially produced. Naturally occurring radioactive material (sometimes referred to as NORM) occurs from primarily two sources: terrestrial (e.g., earth surface and atmosphere) and cosmic radiation. The background level of natural radiation varies regionally and is dependent on the particular rock formations. The uranium parent (U-238) is present in small amounts in all rocks and soil on the earth's surface. Naturally occurring uranium decays in a long sequence with a smaller number of protons and neutrons resulting at each step. As an outcome of this sequential process, alpha and beta particles and gamma radiation are emitted until ultimately radon gas is produced.

Radon gas is the most common NORM that humans encounter, since it can accumulate in enclosed spaces and be inhaled. Radon gas has a half-life of 3.825 days, and radon itself decays via a series of decays to other radioactive substances, including polonium-218, -214, and -210; lead-214, -210, and -206; Bismuth-214 and 210, which can be deposited in the lungs and cause damage by alpha and beta particles and gamma ray emission.

Other natural sources of radiation are potassium-40 and thorium-223 from rocks and soils, and carbon-14, which is produced from the interaction between cosmic rays and the atmosphere. At present, an individual's average yearly external exposure to natural radiation (global average) is about 0.85 millisievert. There is considerable geographic variation, and living in the Arctic environment increases an individual's lifetime dose, on average, by approximately 0.6 millisievert per year, due to a combination of artificial (former weapons tests, dump sites, and Chernobyl) and natural radiation sources (radon, cosmic rays, and terrestrial). However, locally high concentrations of natural sources (e.g., high concentration of natural uranium) in the Arctic can further increase an individual's radiation dose by up to 10 millisieverts per year.

Artificial radiation was introduced into the Arctic environment (atmosphere, ocean, and land) by nuclear weapon detonations beginning in the 1950s, dumping/storage of nuclear waste and spent fuel in Arctic waters, and nuclear accidents (e.g., the nuclear-powered satellite Cosmos 954 that crashed in Canada in 1978 spreading debris across 1,000 km). Radionuclide emissions from aboveground atomic blasts peaked in the circumpolar region in the early 1960s, remained stable until 1980, and are presently believed to be in gradual decline.

Andrew J. Hund

OGOTORUK CREEK, ALASKA RADIOACTIVE TRACER EXPERIMENT

From August 20–25, 1962, the U.S. Geological Survey (USGS) designed an experimental radioactive tracer study. The purpose of the study was to investigate dispersal of radioactive particles from soils. The study took place at the Snowbank Creek and its confluence Ogotoruk Creek, located southeast of Cape Thompson, Alaska (68° 8´N 165° 58´W). The USGS set up soil plots, which ranged in size from 2 × 2 ft. (61 × 61 cm) to 5 × 7 ft. (1.5 × 2.1 m) and were filled with radioactive materials from the Nevada nuclear test sites. The soil plots consisted of 15 pounds (6.8 kg) of local soils that were mixed with 6 millicuries (mCi) (222,000,000 Becquerel [Bq]) of cesium-137, 5 mCi of strontium-85 (185,000,000 Bq), 5 mCi of iodine-131 (185,000,000 Bq), and 10 mCi of other radioactive isotopes (370,000,000 Bq). The plots were watered, and the subsequent runoff was analyzed to determine the dispersal of the radioactive particles. After the experiment, the radioactive contaminated soil was dug up and placed in a single mound at the confluence of Ogotoruk Creek. These projects were part of the program called “Project Chariot.” In 1962, the U.S. Atomic Energy Commission suspended Project Chariot and halted all the related environmental studies.

Andrew J. Hund

See also: Novaya Zemlya, Nuclear Tests; Novaya Zemlya, Nuclear Tests, Environmental Legacy of; Nuclear Power in the Arctic; Nuclear Waste in the Arctic; Operation Chrome Dome; Radioactive Iodine (I-131) Human Experiments in Alaska; Radioactivity; Sunken Soviet/Russian Nuclear Submarines in Arctic

Further Reading

Jaffe, D., A. Mahura, and R. Andres. “Atmospheric Transport Pathways to Alaska from Potential Radionuclide Sites in the Former Soviet Union.” *Research Report, UAF-ADEC Joint Project 96-001* 71 (1997): 71.

O’Neill, D. *The Firecracker Boys.* New York: St. Martin’s Press, 1994.

Rasmussen, Knud (1879–1933)

Knud Johan Victor Rasmussen was born on June 7, 1879, in the municipality of Ilulissat in the far western corner of Greenland, approximately 250 km north of the Arctic Circle. It is the location of the first Danish settlement in 1742. Earlier known as Jakobshavn, the town of Ilulissat (or ice mountains in Greenlandic Inuit) is the location of the Ilulissat Ice fjord, a 2004 UNESCO world heritage center found at the entrance to the Bay of Disko Bugt (bight). The bay is the sea mouth of the Sermeq Kujalleq, one of the most active glaciers in the world. This ice fjord is renowned for the production of 10 percent of all Greenland's calf ice, more than any glacier outside of Antarctica. Greenland and Antarctica are the only places on earth where glacial ice calving into deep fjords can be observed.

Rasmussen was born in what was originally the Catechist Training College of North Greenland. Built in 1848, it was repurposed to serve as a vicarage. Knud's father was a Danish Christian missionary serving as the vicar of Ilulissat at the time of Rasmussen's birth. Knud's mother, Lovise Fleischer Rasmussen, was of Eskimo and Danish heritage. As was the case throughout the Americas during the time of exploration and settlement of new territories, mixed marriages were not uncommon in Greenland, providing examples of rich and satisfying intercultural exchanges and adaptations that shaped the cultural legacies of the Americas and its northern neighbors to the present day. As a child, Knud spoke Kalaallisut, the language of

Danish explorer Knud Rasmussen (second from right) poses with members of his Arctic Expedition and two Eskimos who accompanied him to the United States on his return in 1924. (Library of Congress) the western Greenland Kalaallit Inuit and the descendants of ancient Thule and Dorset communities. When Knud was 12 years of age, his father was given the pasturage of Lynge in the district of Kronborg in North Seeland. There Knud and his brother attended public school at Birkeröd, where they learned to read and write in the Danish language. Later he would study ethnology, eventually receiving a University of Copenhagen honorary doctorate degree. During his youth, Rasmussen was immersed in Inuit language and customs throughout the Arctic Canada, and Siberia, among which he would spend a lifetime studying. In so doing, he himself became one of the great legendary heroes of the North that inspired him. Knud was particularly interested in the stories of the Thule tribes of the far northern corner of Greenland. Astonished that he could communicate with Eskimos throughout the Arctic, Rasmussen's familiarity with the language and customs of Greenland's natives gave him a level of warm familiarity and admiration never before experienced by other European explorers.

Perhaps no one can tell Rasmussen's story better than the Ilulissat people themselves, who have preserved his memory within an extensive archive at the Ilulissat Museum, housed in the former vicarage of his birth. It is written that at the age of seven, he helped to rescue a hunter on sledge and was subsequently given his own team of dogs and sledge. Two years afterward, he met the legendary Fridtjof Nansen (1861–1930), who stayed with the Rasmussen family, no doubt regaling the young Knud with stories of his polar adventures. He graduated in 1900 and, in 1903, landed a place as a participant in the Danish Literary Greenland Expedition headed by Ludvig Mylius Erichsen (1902–1904). The literary team, including Jørgen Brønlund (1877–1907) and Harald Moltke (1871–1960), was formed to learn more about the Polar Eskimos in Thule, an isolated community whose only contacts with Western cultures included the visits of Sir John Ross and Robert Peary. Setting out from Upernavik at the far northern reaches of Greenland to collect information about the Thule Inuit, the trip served as a valuable foundation, upon which Knud would organize his famous Fifth Thule Expedition into Canada, Alaska, and Siberia.

Following the literary expedition, Rasmussen published *Nye Mennesker*, in 1905, and translated into English as *The People of the Polar North* in 1908. Concerned for the future of commercial development among his beloved Inuit peoples, in 1910, Rasmussen and his collaborator, Peter Freuchen, established an Arctic station at Thule, a reasonably priced center of operation for future scientific studies and expeditions, and commercial trade. All subsequent exploratory ventures would be named "Thule Expeditions." They are seven in number. In sum, the trips represent a thorough canvassing of the Greenland coasts and interior. During the First Thule Expedition in 1912, Rasmussen and Freuchen traveled more than 600 miles (1,000 km) to disprove Robert Peary's claim that a channel separated Peary Land and Greenland. The Second Thule Expedition

(1916–1918) was organized to chart unknown coastal tracts along Greenland's north coast. During the Third Thule Expedition in 1919, Rasmussen provided support for Roald Amundsen's experimental polar drift aboard the *Maud.* Shortly afterward, the Fourth Thule Expedition commenced to collect ethnological data near Angmagssalik.

During the Fifth Thule Expedition (1921–1924), Rasmussen completed what is considered his lifetime achievement, a 10-volume collection of ethnological, archaeological, and biological data describing the Eskimo cultures across the Arctic extending from eastern Canada, across the North American coastline, into Alaska and onward to the Russian border. This trip included his masterful crossing of the Northwest Passage by dog sledge, a first success for European adventurers. Rasmussen recollected his trip in his book, *Across Arctic America* (1927); the book served as the inspiration for the 2006 Alliance Atlantis film, *The Journals of Knud Rasmussen.*

The Sixth Thule was organized in 1931 to Ammassalik on Greenland's east coast. The Eastern Greenland Case (1931–1933), involving Denmark and Norway's claims to sovereignty in Greenland, was the first territorial dispute in the polar regions that was eventually settled by the Permanent Court of International Justice. The Seventh Thule was also conducted on the east coast; it included collaboration with German and Austrian filmmakers featuring Greenlandic natives. The film, *Palupnuliarsamera* (*Palo's Wedding*), is still available as an ethnographical document. Shortly afterward, Knud suffered from ptomaine poisoning and died in Copenhagen on December 21, 1933, at the age of 54.

Today, Greenlanders honor Rasmussen's memory for his deep commitment to the Inuit and Danish communities of the North. This is best exemplified in his remarkable contributions toward establishing a common linguistic and cultural base for all the Inuit tribes of the world. His honors include an Honorary Fellowship from the American Geographical Society in 1912 and the Society's Daly Medal in 1924. His published works include *Greenland by the Polar Sea* (1921), *Eskimo Folk Tales* (1921), and *The Eagle's Gift* (1932).

Victoria M. Breting-Garcia

See also: Greenland; Greenland Ice Sheet; Ice Sheet; Inuit; Northeast Greenland National Park

Further Reading

Rasmussen, K. *Across Arctic America: Narrative of the Fifth Thule Expedition.* Classic Reprint Series. Fairbanks: University of Alaska Press, 1999.

Rasmussen, K. "A Danish Contribution towards the Comprehension of Eskimo Culture." *American Anthropologist* New Series 30, no. 3 (1928): 548–50.

Raven. *See* Common Raven

Red-Throated Loon

The red-throated loon (*Gavia stellata*) is a diving aquatic bird species that breeds in the Arctic and winters on the northern portion of the Atlantic and Pacific coasts (China, Japan, etc.). It also winters on major water bodies, such as the Aegean, Black, Caspian, and Mediterranean Seas, and the Great Lakes. It is also commonly called the "red-throated diver." The red-throated loon's preferred habitat is water areas, and they nest in low tundra wetlands, moors, bogs, and small freshwater pools. In winter, they prefer shallow protected or sheltered aquatic habitats that can be coastal or inland.

Red-throated loons are the smallest of all loons. The length of the red-throated loon ranges between 21 and 27 inches (53–69 cm). An adult's wingspan ranges from 39 to 47 inches (100–120 cm). It weighs between 35 and 95 ounces (1,000–2,700 g). Male red-throated loons are slightly larger than females. The red-throated loon differs from other loons in regard to its behavior, locomotion, and vocalizations. For example, the red-throated loon does not carry its young on its back like other loons. They differ also in that they are able to take off of water directly. Another difference is that the red-throated loon will travel considerable distances from the breeding area to forage for food and bring it back to the young. Both the male

Red-throated loon. (Shutterstock.com)

and female red-throated loons vocalize, whereas in other loons, only the males do so. The average life span is around 23 years.

In the summer, the red-throated loons are dark gray in color with the characteristic red throat. In the winter, they are pale gray and white. The bill of the red-throated loon is thin and tilted upward. During breeding season, its iris is distinctly red in color. They are an aquatic bird with a body built for swimming. For example, they have webbed feet, a short tail, and their legs are set far back on their body. The feet being set further back results in them being clumsy on land. Red-throated loons have the ability to alter their buoyancy and can sit high on the water or remain almost completely submerged so that only their eyes and bill are noticeable on the surface. Adults will shed their feathers twice a year rendering them unable to fly for a couple of weeks. The shedding occurs in the spring and autumn.

Red-throated loons migrate to the Arctic, subarctic, and boreal zones for breeding and raising a brood. They prefer undisturbed sites on freshwater lakes to nest. Breeding season generally starts in May but can be earlier or later depending on the timing of spring. They prefer still water, such as found in low tundra wetlands, moors, bogs, and small freshwater pools. These loons form long-term pair bonds and are monogamous. They reach sexual maturity in around two to three years. The courtship rituals of red-throated loons require a minimal amount of display. After pair bonding, the couple will start making a nest. The male selects the nesting location, and the nest is made of a collection of plant matter placed in a mound. The nest is close to the water since red-throated loons are awkward on land.

The couple mates on dry land a number of times and lays one to three eggs typically over several days. The incubation period of an egg is around 27 days. Both parents share egg sitting duties, but the female generally sits on the nest longer. Since the eggs are not laid at the same time, there is variation in the age and development of the chicks. If food is not available, the older and typically larger hatchling will get the food over the younger smaller ones. In two to three weeks, the hatchlings are able to swim and gather some food, but need their parents to get enough food. They learn to fly at about seven weeks.

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See also: Arctic Loon; Arctic Seabirds; Arctic Skua; Arctic Tern; Common Raven; Great Auk; Gyrfalcon; Lapland Longspur; Little Auk; Snow Bunting; Snow Goose; Snowy Owl; Sooty Albatross; Wandering Albatross

Further Reading

Barr, J., C. Eberl, and J. McIntyre. "Red-throated Loon (*Gavia stellata*)." In A. Poole and F. Gill, eds. *The Birds of North America.* No. 513. Philadelphia: The Birds of North America, Inc., 2000.

Reindeer Herding

Rangifer tarandus is the name of the reindeer in Latin—just like Rudolf the red-nosed reindeer from the famous Christmas song. In books, we read that this animal helps pull Santa's sleigh. An ancient legend recounts the story of two sisters, each of whom had reindeer that came freely to be milked. One sister was unkind to her reindeer that therefore left her and gave rise to the wild herds that the Sámi have to track through the Arctic vastness. The other sister's reindeer stayed out of affection for its kind mistress. These were the progenitors of the domesticated reindeer.

Today, reindeer herding is practiced by 100,000 people from about 20 ethnic minorities spread across the northern circumpolar region, including people who are not indigenous. Among the nonindigenous people to engage in reindeer herding are Finns, Jakuts, Komis, Norwegians, and Russians. This activity takes place in Alaska, Canada, China, Greenland, Mongolia, and Scotland as well as across

Engraving from 1833 of Sami people, in traditional clothing, milking reindeer in the dark of the northern winter. (iStockPhoto.com)

Sápmi (formerly known as Lapland), in northern Europe. Sápmi covers northern Finland, Norway and Sweden, and Russia's Kola Peninsula.

This reading will discuss this animal in the context of its traditional importance to the survival of Sámi people. In contrast to self-employed farmers who raise livestock on their privately owned land, taking care of reindeer is often a collective livelihood influenced by culture and society. Reindeer are individually owned, but herding takes place as a community and herding takes place on land jointly owned.

Once called Lapps, the Sámi people are the indigenous nation of Sápmi. There are more than 80,000 Sámi people, more than half of whom reside in Norway. Among the Sámi people, reindeer herding takes the form of community-based activity that often includes the extended family. Reindeer are individually owned, but herding remains a community effort; decisions are made when everybody agrees.

For self-employed Sámi reindeer herders, life traditionally revolved around reindeer, while the extended family was the work unit; there were long discussions during which parents transmitted expertise to their children. Sharing was important; there was no right of ownership as defined by modern Western society. When people had more food than they could consume, before it lost its freshness, a common practice was to share, without any money.

Until the middle of the twentieth century, a self-employed Sámi reindeer herder in Norway could subsist on 250 reindeer. These were owned individually but cared for collectively by means of flexible entrepreneurial networks. Human existence reflected the needs of herds, and rather than manage their reindeer, herders read their cues and followed the herds. Flexibility was the key to success. Nonbreeding male reindeer were useful in that they helped females find food in winter. When an animal was slaughtered, care was taken to minimize pain and avoid waste; every part of a reindeer was used.

As of the 1950s, the Sámi people became increasingly dependent on imported fuel, and the introduction of snowmobiles into reindeer herding in 1962 exacerbated the situation. Before 1963, the costs for equipment to work in reindeer herding were almost nothing.

Where the indigenous population's traditions and forms of production meet the institutions of the market economy, conflicts are on the rise. Although reindeer herding has traditionally been central to subsistence activities, recent changes have transformed this occupation.

Today, snowmobiles, GPS technology, helicopters, and increased regulation are causing massive changes. Reindeer herders have been adapting successfully to technological, regulatory, and other changes. Yet they are concerned that, if herding is reduced to an element of the food industry, the essence and efficiency of their community-based symbiotic entrepreneurship will be undermined. The reindeer remain a symbol for the Sámi. However, while reindeer herders are attracted or pulled toward traditional community entrepreneurship, many are forced or pushed into secondary money-driven enterprises, less close to their tradition.

Nevertheless, each spring, groups of reindeer owners participate in rounding up their herds. Every family of reindeer herders travels to round up its reindeer and to earmark the calves. A lasso is coiled by hand before throwing; this enhances its reach as well as its velocity. Although the reindeer gallop at 20 kilometers per hour, the herders seldom miss their target. A small group is separated from the herd and chased into a small enclosure. Calves are separated from adults, who are released into another enclosure. A number plate is placed around the neck of each calf. Calves and mothers are soon reunited, at which time herders observe which mother gives milk to which calf. Through consensus, people agree as to who is the owner of each mother and therefore the owner of the respective calf as well. Knives are sharpened to ensure a precise cut, and ownership of calves is then recorded by cutting notches into the ears of each calf.

When the land is covered with snow, the reindeer use their hooves to dig for food. The female reindeer are less good at digging, and males do some of the digging for them. A problem, however, is that policy makers are encouraging the culling of what the state considers to be excess males that are not needed for reproduction; although older males may not be required for breeding, they serve a purpose in the herd, especially during the winter when the ground is covered with snow. In the search for food below the snow cover, female reindeer are poor diggers when compared with the males. When there are an equal number of males and females in a herd, females can access food where males have dug through the snow. As the ratio of males to females decreases, the accessibility of food for females decreases.

Leo Paul Dana

See also: Sami

Further Reading

Dana, L., and T. Dana. "How Do Self-Employed Sámi People Perceive the Impact of the EU and Globalization?" *International Journal of Business and Globalization* 1, no. 1 (2007): 3–19.

Dana, L., and I. Light. "Two Forms of Community Entrepreneurship among Reindeer Herding Entrepreneurs in Finland." *Entrepreneurship and Regional Development* 5 (2011).

Ribbon Seal

The ribbon seal (*Histriophoca fasciata*) is a medium-sized seal from the family Phocidae, the only living species in the genus *Histriophoca.* Ribbon seals live in the Arctic and North Pacific, from Alaska to northern Hokkaido, Japan, and in the Bering, Chukchi, and Okhotsk seas. Ribbon seals are among the most strikingly colored and easily recognizable seals in the world. Its common and specific (*fasciata*) names come from the distinctive band or ribbon pattern characteristic for mature individuals. Adults are black-brown with broad whitish bands around neck, flippers, and hips.

Ribbon patterns vary among individuals in shape and width. Females have a less distinctive pattern, are grayish-yellow, with creamier and paler bands and less obvious contrast between bands. Pups are born with a thick, wooly white coat that is called "lanugo" and is shed after a few weeks. The characteristic ribbons do not appear until the seal is two to four years old. They have short pointed foreflippers with long, narrow, hooked claws, a small head with round face, and short-to-moderate and fairly prominent whitish whiskers. They can move rapidly on ice, using slashing side-to-side motions. There are three populations of ribbon seals: one in the Bering Sea, one in the southern, and one in the northern Okhotsk Sea, but their distribution is continuous, and there are no known morphological differences between them. The distribution of ribbon seals shifts northward as sea ice recedes in May and June. The current abundance and trend are unknown, but last estimates from 1990s suggest 240,000 seals. The IUCN Red List of Threatened Species gives an estimate of 300,000–600,000, but this species is data deficient.

Ribbon seals reach 5.5 ft. (1.7 m) (maximum 6.2 ft. [1.9 m]) with a weight of about 220 pounds (100 kg). They live on pack ice, which provides a platform

Ribbon seal with distinctive markings. (National Oceanic and Atmospheric Administration) for pupping, nursing, and molting, rarely use shore fast ice, and do not haul out on land. They prefer broken pack ice since they can locate and maintain access holes in ice up to approximately 6 in. (15 cm). Ribbon seals are solitary animals for much of their lives. Females become mature when they are two to four years old; males when they are three to five years. Ribbon seals produce one offspring per year. Pupping occurs between early April and early May. Pups are about 22 pounds (10 kg) when born on ice floes and triple their weight over three to four weeks when they are nursed. Ribbon seals molt each year between late March and July. They can live up to 30 years, but on average they live for about 20 years.

Ribbon seals feed on a variety of fish, squids, and octopuses, and their diet varies by area and age of the seal. Young ribbon seals mainly feed on small crustaceans such as euphausiids after weaning and switch to predominantly shrimp for a year when they are about one year old. Fish and cephalopods were found more often in adult stomachs. In Okhotsk Sea, they often feed on walleye pollock, Pacific cod, herring, and cephalopods. They can dive up to 2,000 ft. (600 m) deep. Ribbon seals are preyed on by killer whales and Greenland sharks, rarely polar bears. They show remarkable indifference to the approach of predators, including humans.

Ribbon seals have been hunted for generations. In the early 1950s, the Soviet Union started commercial harvest of ribbon seals in the Sea of Okhotsk, and sealing reached peak in the 1960s, with an average of about 13,000–20,000 seals harvested per year. They were also hunted in the Bering Sea since 1961, with an annual harvest of nearly 10,000 individuals. This caused a population decline and annual harvest drop to 3,500 in the Sea of Okhotsk and 3,000 in the Bering Sea in the 1980s, and large-scale commercial harvesting was stopped in 1994. Ribbon seals are still hunted today by Siberia and Alaska natives for subsistence, but the number of seals harvested is less than 100 in Alaska. Current shore-based harvests in the Russian Far East are also at very low levels and not likely to be a threat to the population. A petition for listing ribbon seals under the Endangered Species Act (ESA) is under consideration by the U.S. Department of Commerce, NOAA Marine Fisheries Service since March 2008. Currently, the conservation status of ribbon seal is a species of concern, which means that although there are some concerns regarding species status and threats, insufficient information is available to indicate a need to list the species under the ESA. Like all marine mammals, the ribbon seal is protected under the Marine Mammal Protection Act of 1972.

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See also: Antarctic Fur Seals; Bearded Seal; Crabeater Seal; Harp Seal; Hooded Seal; Leopard Seal; Polar Bear; Ringed Seal; Ross Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Spotted Seal, Weddell Seal

Further Reading

Boveng, P., et al. "Status Review of the Ribbon Seal (*Histriophoca fasciata*)." NOAA Technical Memorandum NMFS-AFSC-255, U.S. Department of Commerce, NOAA National Marine Fisheries Service Alaska Fisheries Science Center, 2013.

Fedoseev, G. "Ribbon Seal *Hisriophoca fasciata.*" In W.F. Perrin, B.G. Wursig, and J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals.* San Diego: Academic Press, 2002, pp. 1027–30.

Ringed Seal

Ringed seals (*Pusa hispida*) are a member of the family Phocidae. They are named ringed seals because of adults having light gray ring-shaped markings across their pelt. Other names of the ringed seal are the "jar seal," and the Inuit call them "nattiq" or "netsik." Ringed seals are a true or earless seals. They are the smallest and most common seal in the Arctic Ocean and the Baltic and Bering Seas. There are five recognized subspecies ringed seals, which are Arctic (*Pusa hispida hispida*), Baltic (*Pusa hispida botnica*), Ladoga (*Pusa hispida ladogensis*), Okhotsk (*Pusa hispida ochotensis*), and Saimaa (*Pusa hispida saimensis*).

Distribution

These seals are found throughout the circumpolar regions from 35° N to the North Pole (90° N). They live in all marginal seas of the Arctic Ocean, the Canadian Arctic Archipelago, Bristol Bay, Hudson Bay, and the Hudson and Davis Straits. Separate subspecies are found in the Seas of Japan and Okhotsk, the Baltic Sea, as well as freshwater species in the Lake Ladoga (Russia) and Lake Saimaa (Finland). There are vagrant populations in China and California. The five recognized subspecies are found in different regions. The Arctic ringed seals are found in the Arctic Ocean and Bering Sea; the Baltic ringed seals in the Gulf of Bothnia; the Lake Ladoga ringed seals in or near Lake Ladoga; the Okhotsk ringed seals are located in the Seas of Japan and Okhotsk, and the Lake Saimaa ringed seals in Lake Saimaa in Finland. The preferred habitat of ringed seals is large ice floes and pack ice, which is used for molting, hauling out (resting), and breeding.

Description

The ringed seal have a chubby body and small head. In the winter, they have a thick blubber layer that helps them live in the cold Arctic temperatures. Their muzzle is short and catlike. Adults have a silver belly and light gray ring-shaped markings on their back and sides. Due to the five subspecies, there is range of sizes for adults from 40 to 60 inches (100–152 cm) in length, weighing between 70 and 240 pounds (32–110 kg). Male ringed seals are slightly larger than females. The largest subspecies of ringed seals is the Baltic ringed seal. Ringed seal use their specialized inch-long (2.5 cm) claws on their fore flippers to maintain breathing holes in sea ice over 75 inches (2 m) thick. These claws are a unique feature not available to other ice seals. Close relatives of the ringed seals are the Caspian seal (*Pusa caspica*) and Baikal seal (*Pusa sibirica*). Ringed seals' life span ranges from 25 to 30, with the Baltic ringed seals reportedly living up to 40+ years of age. In early summer, mid-May to mid-July, ringed seals molt. During the molt, they haul out of ice and engage in minimal feeding. In the summer if ice is not available, the Baltic and Lakes Ladoga and Saimaa ringed seals haul out on the shore. The Ladoga ringed seals are smaller and have longer whiskers and a darker coat than the Baltic and Saimaa ringed seals.

Reproduction

Sexual maturity varies by gender, with females reaching sexual maturity around four years of age and males around seven years of age. During the mating season, a male searches for a mate, breeds with a female for a couple of days, and then moves on to another mate. The female builds a subnivean lair complex under the snow and ice. This lair provides a place for her to deliver her pup and affords some protection from the cold temperatures and predators. The female ringed seal is pregnant for nine months and gives birth to a single pup. The pup is nursed for just more than a month and then is weaned. She mates again at the end of the nursing period.

Diet

Ringed seals feed on a variety of amphipods, fish (polar, Arctic, and saffron cod and herring are common prey), cephalopods, krill, mysids, sculpins, and shrimp. Their diet varies by area and age of the seal. Freshwater ringed seals feed on burbot, perch, smelt, and so on. They can dive to depths of 35–150 ft (10–45 m) to acquire food. Ringed seals are preyed on primarily by polar bears. Pups are also preyed on by Arctic fox, orcas, glaucous gulls, and walrus. Indigenous groups have been eating ringed seals for 4,000 years.

Threats

The present population of ringed seals is incomplete. The International Union for Conservation of Nature lists the ringed seal as least concern. They presently do face a number of threats, including being caught in commercial trawlers' gear and climate change. Climate change is a serious concern because most ringed seals are dependent on large ice floes and pack ice. The present effect of climate change on ringed seals is being assessed.

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See also: Antarctic Fur Seals; Bearded Seal; Crabeater Seal; Harp Seal; Hooded Seal; Leopard Seal; Polar Bear; Ribbon Seal; Ross Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Spotted Seal, Weddell Seal

Further Reading

Fedoseev, G. "Population Biology of Ice-Associated Forms of Seals and Their Role in the Northern Pacific Ecosystems." Center for Russian Environmental Policy, Russian Marine Mammal Council, Moscow, Russia, 2000, 271.

Rock Art of Alta

A critically important cultural or physical space on the planet, if deemed significant, can be designated as a world heritage site under the United Nations Educational, Scientific, and Cultural Organization (UNESCO). To date, there have been 981 UNESCO world heritage sites, of which five are located in the Arctic. The Rock Art of Alta is one of five Arctic UNESCO world heritage sites.

Rock Art of Alta (69° 56′N 23° 11′E) was declared a UNESCO world heritage site in 1985. It was listed because of its large collection of prehistoric rock carvings. The Rock Art of Alta is a collection of more than 6,000 rock carvings dating back to 4,200 years ago. The most recent carvings are at least 500 years old. The rock carvings are located in and around the Alta Fjord in Sampi (Finnmark, Norway).

Ancient rock carvings (petroglyphs) in Alta, Norway. (Shutterstock.com)

About half of the rock carvings are in Jiepmaluokta Bay, and the other rock carvings are found in Storsteinen, Kåfjord, Amtmannsnes, and Transfarelv. Together, these sites are designated as the UNESCO world heritage site called "Rock Art of Alta." The first carving was found in Jiepmaluokta in 1972.

The carvings were made by rock chisels. The imagery of the rock carvings are mostly of hunter/gatherers, with many depictions of animals, such as moose, bears, birds, and fish. A dominate depiction in the rock carving is the caribou. Much of the imagery is characteristic of hunting activities, such as shooting arrows, throwing spears, fishing with lines and making hooks, and using boats. Researchers have noted that the bear depictions are suggestive of a culture that worshipped bears. The Sami were known to have worshipped bears. For example, Haldi was an animal spirit bear that protected Sami and bestowed hunters with good luck against bears. The depictions shows bear tracks leaving dens and crossing the path of other animal tracks. The bear tracks are commonly vertical, and the other animals' tracks are horizontal. There are several theories about the bear tracks none of which is conclusive. The bear imagery was discontinued around 1,700 BC. The rock carvings also have depictions of pregnant animals with a small baby animal inside. Other rock carvings include geometric symbols, food preparation, ceremonial dances, and possibly shamanistic and fertility rituals.

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See also: Ilulissat Icefjord; Laponian Area; Natural System of Wrangel Island Reserve; Putorana Plateau

Further Reading

"Rock Art of Alta." UNESCO. http://whc.unesco.org/en/list/352. Accessed January 13, 2014.

Rocket Ranges in the Arctic

There are three permanent rocket ranges in the Arctic. They are used for sounding rocket launches to study the atmosphere and near space. All three rocket ranges also host large observatories to support the science experiments. The three ranges are ESRANGE (European Space Range) in Kiruna, Sweden; Andy Rocket Range in Andenes, Norway; and PFRR (Poker Flat Research Range) near Fairbanks, Alaska. To support the rocket launches, the ranges have a number of radar and tracking antennas for communication with the scientific payload.

To avoid dropping burned-out rocket stages onto roads, pipelines, houses, or villages, rocket ranges have designated drop zones where no damage would be done by falling debris. This limits the flight path: the smaller the drop zone, the less altitude and range can the rockets have. None of these launches reach orbit; they all follow a parabola as a flight path and fall back to the ground after reaching

In this Saturday, February 18, 2012, photo provided by NASA Wallops, a rocket flies through the aurora borealis after lifting off from the University of Alaska's Poker Flat Research Range near Fairbanks, Alaska. The mission was launched by a NASA-funded group of 60 researchers studying electrical activity in the aurora borealis and the likelihood it's interfering with GPS and other signals. Cornell University says the 46-foot rocket sent back data as it flew through the aurora at an altitude of 217 miles. (NASA Wallops/Lee Wingfield/AP Photo)

their maximum altitude. Small rockets to study the atmosphere, like the ozone layer, go up to 30–60 miles (50–100 km), while larger rockets to study the aurora or other high altitude or space-related subjects can reach as high as 900 miles (1,500 km) or more.

ESRANGE is the smallest of the three ranges, located at 67.9° N, 21.1° E. The ESRANGE was officially inaugurated in September 1966, and the first rocket was launched there the following November. More than 400 rockets for scientific experiments have been launched there. Because of the relatively small landing zone, most rockets have been launched to altitudes below about 150 miles (250 km). The exception being several microgravity launch experiments. These were launched with guided rockets and reached altitudes of more than 350 miles (700 km). ESRANGE is also used to launch high-altitude balloons. The first balloon was launched in 1974, and more than 550 balloon launches have taken place since then.

Andøya Rocket Range is on the west coast of Norway, two degrees north of the Arctic Circle, at 69.3° N 16° E. Since 1962, more than 1,200 sounding rockets have been launched from here. The launch site is on the coast, and launches are directed toward the north and west, so that the flights are over water. Usually the science data from the rocket experiment are radioed to the ground in real time, and the payload is a one-use experiment. Sometimes the instruments on the rocket are so valuable that they are floating down on a parachute to be recovered by ship from the ocean. In 1997, a secondary launch site was established on Svalbard, near Ny-Alesund, one of the world's northernmost towns at 78° 55′ N 11° 56′ E. Rockets from here fly north toward the pole. Andøya also launches balloons, from the Norwegian mainland as well as from Svalbard. The rocket range

HOW TO LAUNCH A ROCKET

The very first thing you need is a really good idea for an experiment. As an example, we will look at the Horizontal E-region Experiment (HEX) launch. It is assumed that the heating from the aurora would set up convection in the upper atmosphere and ionosphere, but this is almost impossible to observe that from the ground. The HEX team proposed to fly a rocket on a nearly horizontal path at about 75–87 miles (120–140 km) altitude across an aurora arc and release a trail of tri-methyl-aluminate (TMA). This is a liquid that will ignite and burn slowly, leaving a glowing smoke trail. This should be distorted by any wind that the aurora would create. A second rocket would put two nearly vertical trails near the same aurora. NASA liked the idea and provided funds to conduct the experiment. While the payloads were built, the HEX team also built cameras that would observe the TMA trail from several ground stations. These cameras were located in Alaska and Yukon Territory to observe the trail from enough different places that would allow triangulation and thus precise location and altitude of the TMA trail. This process took about two years. Then, the rockets and payloads were assembled in Poker Flat, and the remote ground stations were set up in Ft Yukon, Toolik Lake, and Old Crow. When everything was ready, the wait for a suitable aurora began. Night after night, the scientists watched the sky with the rockets ready for launch. Since moonlight would be too bright, the launch window was limited to a two-week period when the moon would not rise at night. But either it was cloudy or the aurora was not at the right spot in the sky, and the two weeks went by without a launch. A second launch window was approved after the next full moon, and this time the weather and the aurora cooperated. The rockets were launched 5 minutes apart, and the TMA trails were observed for 20 minutes. The result from the analysis of this experiment showed that the wind pattern is much more complicated than simple convection by auroral heating.

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is complemented by the Alomar Observatory (Arctic Lidar Observatory for Middle Atmosphere Research). The observatory provides space for instruments that scientists bring there for their observations. There are also permanently installed instruments, notably lidars. A lidar shoots a powerful laser beam into the air and observes the light that is scattered back from various altitudes. They can measure a number of parameters like temperature, density, and wind at altitudes exceeding 60 miles (100 km).

Poker Flat Research Range (PFRR) is located approximately 30 miles (48 km) north of Fairbanks, Alaska, and is operated by the University of Alaska's Geophysical Institute (65.1° N, 147.5° W). This places the rocket range under the auroral oval and makes it a prime research site for aurora and space weather studies. The first launch from here occurred in March 1969. PFRR has a very large drop zone, which extends from the Trans-Alaska pipeline in the west to the Canadian border in the east, and north into the Arctic Ocean. This makes it the largest land-based rocket range in the world. More than 330 sounding rockets have been launched here. After a launch, the range makes an effort to locate and retrieve debris from the different rocket stages that have fallen into the Alaskan wilderness.

PFRR has five launch pads. This makes it possible to have more than one experiment waiting to be launched at a time or have experiments with multiple launches. For these experiments, rockets have been launched at less than five-minute intervals. To support rocket experiments, there are a number of observation sites throughout Alaska, where downrange instruments or observers can be positioned. Permanent sites are in Ft Yukon, Eagle, at the Toolik Lake Research Station, and on the north coast at Kaktovik.

PFRR also houses several ground-based observatories. There is the Davis Science Center, where mostly optical instruments like all-sky cameras, narrow-field auroral cameras, and spectrometers are based. There is a lidar facility with a number of lidars for different wavelengths and observation purposes. There is also a large incoherent scatter radar (PFISR) and other radio wave instruments. All these facilities can support rocket experiments, but they work mostly independent of the rocket program and have large science programs of their own. PFRR also has a large program for research and technology of unmanned aircraft. These unmanned aerial vehicles are used for many projects, including supporting firefighting of forest fires, counting seals or whales in the Arctic Ocean, or technology testing.

These planes are launched from mobile launchers on trucks or ships, and are controlled by a pilot on the ground. There are more rocket launch sites in the Arctic, but they are either not in use anymore or are temporary installations. NASA has the ability to launch rockets from mobile launchers, which have been deployed in Greenland and Svalbard. Fort Churchill in Canada on the coast of Hudson Bay had been an active launch site from 1954 to the mid-1980s.

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See also: Arctic Observatories; Aurora Australis; Aurora Borealis; Auroral Substorm

Further Reading

Andøya Rocket Range. http://www.rocketrange.no/. Accessed January 13, 2014.

ESRANGE Sweden. http://www.sscspace.com/esrange-space-center-3. Accessed January 13, 2014.

NASA Sounding Rocket Program. http://rscience.gsfc.nasa.gov/. Accessed January 13, 2014.

Poker Flat Research Range. http://www.pfrr.alaska.edu/. Accessed January 13, 2014.

Rockhopper Penguin

The rockhopper penguin (*Eudyptes chrysocome*) is one of the smaller penguins and nests on islands in the circumpolar region of the subantarctic. Like all other penguin species, it is flightless although with sturdy flippers designed for underwater dexterity. As a member of the *Eudyptes* genus, the rockhopper is black above and white below with a dull reddish bill and decorative yellow feathering that serves as a crest. There is no sexual dimorphism in plumage.

The taxonomy of this species is controversial, with some authorities recognizing a single species while others recognize two. A few scientists even promote the idea of third or fourth species. Recent DNA work, however, has suggested that there are two distinct species. The southern rockhopper is the predominant form, with more than a million pairs split among three different subspecies. The northern rockhopper was genetically isolated due to shifts in oceanographic currents during the Pleistocene. This much smaller group breeds on Tristan da Cunha and Gough Island. Beach-wrecked birds well north of their range, particularly in South Africa and Australia, are not that uncommon.

The rockhopper is the smallest of the crested penguins, ranging from 18 to 24 inches (45–60 cm) in height and 4.5–7.5 pounds (2–3.4 kg) due to sex and diet, although much larger individuals have been recorded. Rockhoppers feed largely on krill and crustaceans, although are quite cosmopolitan in their diet and also consume fish, squid, and mollusks. They are named for their tendency, shared with other *Eudyptes* penguins, of hopping over and around obstacles rather than tobogganing around them.

Although classified as vulnerable, the southern rockhopper is fairly common on its breeding islands, with perhaps as many as 1.5 million breeding pairs spread across the circumpolar region. The same cannot be said for the northern rockhopper, which although numbering in 100,000s on Gough Island has seen its population drop by 90 percent since World War II, recently achieving the status of endangered. As with most polar species, the primary culprits for such rapid population decline are pollution, commercial overfishing, and climate change. The grounding of the MS *Oliva* stands as an example of how increases in global shipping have served to harm this species. In this 2011 incident, a Maltese bulk freighter ran aground near Nightingale Island, releasing more than 800 tons of fuel that subsequently encircled the island and polluted the fishing waters of the northern rockhopper colony. Despite efforts to clean up both the spill and the penguins befouled by it, many of the 20,000 birds that were oiled ended up dying.

The rockhopper penguin is one of the better known penguins among the general public, in large part due to its crest and small size. In popular culture, the most well-known rockhopper is the character Lovelace from the 2006 animated film *Happy Feet.* Voiced brilliantly by Robin Williams, this character is funny as the film's self-styled love guru, but poignant in that he has a plastic six-pack ring holder caught around his neck, thus carrying a large part of the film's environmental message.

Andrew J. Howe

See also: Adélie Penguin; Chinstrap Penguin; Emperor Penguin; Gentoo Penguin; King Penguin; Macaroni Penguin

Further Reading

Banks J., A. Van Buren, Y. Cherel, and J. Whitfield. "Genetic Evidence for Three Species of Rockhopper Penguins, *Eudyptes Chrysocome*." *Polar Biology* 30 (2006): 61–67.

Woehler, E., and C. Gilbert. "Hybrid Rockhopper-Macaroni Penguins, Interbreeding and Mixed-Species Pairs at Heard and Marion Islands." *Emu* 90, no. 3 (1990): 198–210.

Rock Ptarmigan

The rock ptarmigan (*Lagopus muta*) is a sedentary Arctic game bird of the grouse family. Rock ptarmigan can be found across the Arctic Cordillera, with isolated populations being found in various northern subarctic European countries as well as Japan and the Franz Josef Land. The main predators of the rock ptarmigan include the Arctic fox, ermine, Arctic skua, glaucous gulls, and golden eagles. The rock ptarmigan is the official bird of Nunavut, Canada.

Rock ptarmigan male in winter plumage. (National Oceanic and Atmospheric Administration)

Rock ptarmigan are similar to the willow ptarmigan, but differs in size and habitat. The rock ptarmigan is slightly smaller in size with a smaller bill than the willow ptarmigan. Unlike the willow ptarmigan, the rock ptarmigan prefers to live in higher alpine elevations. The preferred summer habitat is the bare rocky slopes of the tundra. In the winter, they live in brush and forested areas. Males prefer the open barren landscapes, while females and juveniles prefer forest cover.

A main characteristic of the rock ptarmigan is that its feathers molt from brown to almost completely white. During the year, they molts at least two times. In the spring and summer, the rock ptarmigan's plumage is brown. In the winter, rock ptarmigans are almost completely white with the exception of a black tail. The type of plumage the rock ptarmigan is showing corresponds to the seasons and the habitat they occupy.

An adult rock ptarmigan is about 12–16 inches (31–41 cm) in length with a wingspan of 21–24 inches (54–60 cm). Their weight ranges between 15.5 and 22.6 ounces (440–640 g). Rock ptarmigan are adapted to year-round Arctic living with a thick coat of feathers including an outer layer to repel wind and snow and an inner layer (down) for warmth. Part of the cold weather adaptation is having feathers on their feet, which provide extra installation and work as snow shoes enabling them to walk on the snow.

During courtship, the male makes "kurr-kurr" vocalizations. Another display involves the male flying low to the ground then swooping upward, and diving down again. Some researchers have suggested that the red comb size is correlated to breeding success. Rock ptarmigan are not monogamous. During breeding season, males are almost completely white and are territorial and produce various vocalizations to maintain their territory. Females are brown during breeding season. Females build the nest on the ground commonly in a depression and lay about 8–10 eggs. The eggs are incubated for about 25 days. The brown plumage of the females makes them difficult to spot while nesting within 6 ft. (2 m). Male rock ptarmigan do not stay until the eggs hatch and do not assist with raising the young. Chicks are born with open eyes and covered in down. The chicks fledge about 10 days after hatching. Adult rock ptarmigans' diet commonly consists of willow and birch buds during the winter. Other food eaten are berries, flowers (catkins), leaves, seeds, and twigs. Young chicks supplement the sample diet with insects.

Andrew J. Hund

See also: Arctic Loon; Arctic Seabirds; Arctic Skua; Arctic Tern; Common Raven; Gyrfalcon; Lapland Longspur; Red-Throated Loon; Snow Bunting; Snow Goose; Snowy Owl; Sooty Albatross; Wandering Albatross

Further Reading

Holder, K., and R. Montgomerie. "Rock Ptarmigan (*Lagopus mutus*)." In A. Poole and F. Gill, eds. *The Birds of North America.* No. 51. Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists Union, 1993.

Ross, Sir James Clark (1800–1862)

James Clark Ross was born on April 15, 1800, in London, to George and Christian Ross. Just before turning 12 years, James entered the Royal Navy as a volunteer 1st class on the *Briseis*, commanded by his uncle, Commander John Ross (1777–1856). Together, they later served in the Baltic, White Sea, and the English Channel.

The Napoleonic Wars ended in 1815, and afterward, employment prospects for naval officers were very limited, but in 1817, John Ross was offered command of two ships to determine the existence of a Northwest Passage. In fact, the British Admiralty had decided to make a two-pronged assault on the Arctic, by sending out two other vessels to seek the North Pole. This boldness was the result of a report that year, by the noted whaler William Scoresby Jr., of a vast area of ice-free seas between the latitudes of 74º and 80º N.

In May 1818, the *Alexander* (Captain John Ross) and *Isabella* (Lieutenant William Edward Parry) sailed with Midshipman James Ross on board the latter, in company with the *Dorothea* (Captain David Buchan) and *Trent* (Lieutenant John Franklin). Captain Ross reached Melville Bay before becoming beset for some time by the ice; the movement of the pack ice put the ships in constant danger of colliding with one another. After escaping the ice, Ross rounded Cape York, and continuing northward came upon a group of Inuit who had never before seen white men—the captain named them "Arctic Highlanders." Sailing on, Ross named Cape Isabella and Cape Alexander for two cliffs marking the southern entrance of Smith Sound.

Ross now proceeded some 50 miles into Lancaster Sound, but during brief periods of clear weather, he believed he saw a chain of mountains stretching across his path in the distance and named them Croker's Mountains, after the first secretary of the Admiralty John Wilson Croker. This mirage caused John Ross to turn back and head for home. The *Dorothea* and *Trent* had sailed north and reached Spitzbergen at 78º N (the largest island of the Svalbard group). However, gales and the pack ice seriously damaged both vessels, forcing their return to England.

Over the following 14 years, James Clark Ross took part in five more Arctic expeditions; all except for one (a voyage toward the North Pole in 1827) had as their objectives the Northwest Passage: *Hecla* and *Griper* (1819–1820); *Fury* and *Hecla* (1821–1823); *Hecla* and *Fury* (1824–1825); *Hecla* (1827); *Victory* (1829–1833). During the last expedition, Ross reached the North Magnetic Pole on June 1, 1831. Promoted to captain in 1834, Ross became an expert on earth's magnetism and, in 1835, conducted a magnetic survey of Great Britain. The following year, he commanded the *Cove* during a winter expedition to search for some missing whalers in the Davis Strait and afterward continued his magnetic survey of the Britain's coast.

Between 1839 and 1843, Ross commanded the *Erebus* and *Terror*, making three voyages to Antarctic waters. These were some of the most successful polar voyages in history, attaining the highest southern latitude up until that time, astounding geographic discoveries like the Ross Sea, Ross Ice Shelf, Mount Erebus, and Mount Terror, sighting extensive sections of coastline and gathering a wealth of scientific data (including magnetic surveys) and natural history specimens.

Ross's achievements were rewarded with medals from the Royal Geographical Society and The Geographical Society (Paris), a knighthood in 1844, and he was elected a Fellow of the Royal Society in 1848. Within weeks of returning from Antarctica, Ross married his fiancée, Ann Coulman. Although the expedition's success did not capture the public's imagination as did earlier Arctic adventures, the discoveries pointed the way for exploration of the continent's interior 50 years later, at the beginning of the Heroic Era of Antarctic Exploration.

The British government's attention once again turned north, and it was decided to make another attempt at discovering the Northwest Passage. In May 1845, Captain Sir John Franklin set out in *Erebus* and *Terror*. By early 1847, with no news from Franklin, the Admiralty began laying plans to search for him. In the spring of 1848, Ross commanded a naval search expedition, composed of *Enterprise* and *Investigator*, to follow Franklin's trail. The next spring, Ross led the main sledge party, searching along the northern and western coasts of Somerset Island and down Peel Sound. Three other parties were sent out: one crossed Barrow Strait to Cape Hurd, Devon Island; one crossed Prince Regent Inlet, reaching near the northern end of Brodeur Peninsula; and the third examined the east coast of Somerset Island south to Cresswell Bay.

All the searching produced nothing, not a trace of Franklin and his men. With the health of his crews affected by scurvy and westerly winds bringing the ice pack down on his ships, frustrating of any more searching, Ross sailed for home in the fall of 1849. He never went to sea again.

James Clark Ross's retirement was an unhappy one. He was the victim of largely unjustified criticism for not finding Franklin and quarreled with the Admiralty. His wife died in 1857 at the age of 40, and he never recovered from the shock. Ross died on April 3, 1862, 12 days before his 62nd birthday.

Glenn M. Stein

See also: Heroic Age of Antarctica Exploration (ca. 1890s–1920s); Ross Island; Ross Sea

Further Reading

Dodge, E. *The Polar Rosses: John and James Clark Ross and Their Expeditions.* London: Faber and Faber Limited, 1973.

Ross, M. *Ross in the Antarctic: The Voyages of James Clark Ross in Her Majesty's Ships* Erebus *and* Terror *1839–1843.* Whitby: Caedmon of Whitby, 1982.

Ross Island

Ross Island is located between the ice-covered McMurdo Sound (77° 30′S 165° E) and the Ross Ice Shelf. The island is about 30 miles (50 km) from the coastline of Victoria Land. Ross Island has an area of 950 square miles (2,500 sq. km). It is the world's sixth highest island. Ross Island was a staging area to several historical events of Antarctic heroic exploration period. Robert Falcon Scott (1868–1912) used the island as staging area for his failed or second-place finish to reach the geographic South Pole. Scott was the leader of two British expeditions to the Ross Sea area. In these expeditions, he established two huts. One of the huts is located on Hut Point and is called "Discovery Hut" and was built in 1902, while the other is located at Cape Evans and is called "Scott's Hut" and was built in 1911.

There are two scientific bases on the southern part of Ross Island which are the U.S. McMurdo Station (77° 51′S 166° 40′E) and New Zealand's Scott Base (77° 51′S 166° 45′E). McMurdo Station was established in 1955 as a United States Antarctica Program support and logistics center. Presently, it has around 100 buildings and is capable of supporting more than 1,200 people. It is the largest community in Antarctica. In 2007, the documentary *Encounters at the End of the World* directed by Werner Herzog highlighted different perspectives of people working at McMurdo Station. Scott Base is named after Captain Robert Falcon

NUCLEAR POWER AT MCMURDO STATION, ANTARCTICA

From 1962 to 1972, there was a portable, medium-power, third-generation (PM-3A) nuclear reactor (1.75 MWe) at McMurdo Station, Antarctica. The nickname for this nuclear reactor was "Nukey Poo." This PM-3A was capable of producing steam heat and electrical power. It also had the capability of desalinization of saltwater. The PM-3A reactor was designed to provide power to the McMurdo Station. It was air cooled and the excess heat was used for distillation. The PM-3A was operated by the engineering command Naval Facilities Engineering Command (NAVFAC) of the U.S. Navy. This reactor was mostly run by the navy personnel, but also had officers (sergeants with the Army and Air Force) with the crew. Upon decommissioning in 1972, the plant was taken apart in 1979 and shipped back to the United States. The contaminated radioactive soil adjacent to the reactor was removed and sent to Port Hueneme Naval Base, California. The PM-3A operated at a uranium-235 enrichment of 93 percent.

Andrew J. Hund

Scott (1868–1912), who led two British expeditions (the Discovery Expedition of 1901–1904 and Terra Nova Expedition, 1910–1913) to the Ross Sea region. Scott died on the Terra Nova Expedition.

Ross Island is made up of four main volcanoes, which are Mounts Erebus, Bird, Terror, and Terra Nova. Mount Erebus (77° 31′S 167° 9′E) is a composite volcano and the largest on Ross Island. Its highest point is almost 12,500 ft. (3,800 km). During volcanic eruptions, crystallized rocks, called "Erebus crystals," are spewed from the Erebus volcano as glassy encased projectiles, called "volcano bombs." Mount Terror (77° 31′S 168° 32′E) is a dormant shield volcano about 20 miles (30 km) east of Mount Erebus. Its highest point is around 10,500 ft. (3,200 km). At the base of Mount Erebus, there is a glacier spit or tongue, called the "Erebus Ice Tongue," which stretches about 7 miles (11 km) out from the coast. Mount Bird is a dormant shield volcano, which is located about 7 miles (11 km) south of Cape Bird. Its highest point is around 5,800 ft. (1,700 km). Two glaciers are found on its slope, which are Shell and Endeavour Piedmont Glaciers. In between Mount Erebus and Mount Bird lies Abbott Peak (77° 26′S 167° E). Between Mount Erebus and Mount Terror is Mount Terra Nova (77° 31′S 167° 57′E) with an elevation of about 6,900 ft. (2,100 m). Mount Terra Nova is a dormant volcano. Located between Mount Erebus and Mount Terra Nova is the saddle glacier about 5 miles (8 km) long called "Terra Nova" (77° 27′S 167° 42′E). This glacier flows into Lewis Bay. Sir James Clark Ross (1800–1862), in 1841 named Mount Erebus and Terror after his expedition ships, the HMS *Erebus* and HMS *Terror*. Mount Terra Nova is named after the ship *Terra Nova* from the British Antarctic Expedition of 1910–1913.

Andrew J. Hund

See also: East Antarctica; McMurdo Dry Valleys of East Antarctica; McMurdo Dry Valleys of East Antarctica, Biology of; Nuclear Power in the Arctic; Ross Sea

Further Reading

Cochran, C. *Historic Sites: Ross Sea Region, Antarctica: Conservation Plan.* Christchurch, New Zealand: Antarctic Heritage Trust, 1990.

LeMasurier, W., and J. Thomson, eds. *Volcanoes of the Antarctic Plate and Southern Oceans.* Washington, DC: American Geophysical Union, 1990.

Ross Island, Historic Huts of

Ross Island, positioned about 30 miles (50 km) east of the shoreline of south Victoria Land, continental East Antarctica in the Ross Sea, is associated with some of the most significant events of Antarctica's heroic exploration history. Robert Falcon Scott used the island as a jumping-off point for his unsuccessful attempts to lead the first expedition to the geographic South Pole (all students of history will know that he was beaten by a matter of weeks in a race with the Norwegian explorer Roald Amundsen and perished with his team on the return journey). Nevertheless, in preparation for the fateful expedition, Scott led two ship-borne expeditions to Ross Island and established two huts, one on Hut Point in 1902 and the second at Cape Evans in 1911.

Discovery Hut was not a great success. Not only was it an extremely cold residence (having been acquired in Australia on the journey south and being a design better suited for the heat of the Aussie outback than the extreme cold of the deep Antarctic) but also the breakout of the sea ice that allowed Scott's vessel, the *Discovery*, to penetrate as far as Hut Point turned out to be a rare occurrence. Accordingly, the Terra Nova Expedition established the second hut at Cape Evans, some 20 km north, and it was from here that Scott's parties man-hauled south in their quests for the pole, and other parties departed for various scientific objectives.

Ernest Shackleton was Scott's contemporary and competitor, and in his quest for the pole established a hut at Cape Royds in 1906, some kilometers north of Cape Evans. The positioning of this beautifully designed hut is ideal in that it nestles in a sheltered nook a mere 200 m from Antarctica's southernmost Adélie penguin colony, a site that provided both protection from inclement weather and a reliable food supply. The hut and its historical contents have recently been carefully and extensively refurbished by skilled conservators from the New Zealand Antarctic Heritage Trust, and the hut is one of the most significant sites for East Antarctic ecotourism.

Don Cowan

See also: Adélie Penguin; East Antarctica; Ross Island; Ross Sea

Further Reading

Cochran, C. *Conservation of Historic Huts, Ross Island.* Report to Antarctic Heritage Trust, 1988.

Ritchie, N. *Ross Island Historic Huts: Report on Archaeological Work and Management Considerations.* Report to Antarctic Heritage Trust, Department of Conservation, Science and Research Internal Report, No. 15, 1988.

Ross Sea

The Ross Sea is a marginal sea of the Southern Ocean, located off of the Antarctic coast and lies from the Edward VII Peninsula (west) to Victoria Land (east). The southern border is the Ross Ice Shelf. On the western border is the ice-covered McMurdo Sound (77° 30′S 165° E), which is adjacent to Ross Island. The eastern border is Roosevelt Island (79° 25′S 162° W) and Bay of Whales (78° 30′S 164° 20′W). The Ross Sea was first explored by Captain Sir James Clark Ross (1800–1862), in 1841.

The dominant feature of the Ross Sea is the Ross Ice Shelf, which is the world's largest floating ice sheet covering an area of 182,000 square miles (472,000 sq. km). The Ross Ice Shelf is horseshoe shaped and about 500 miles (800 m) across and from the open sea inland is more than 350 miles (600 km) long. The cliff face above the water surface ranges from 50 to 150 ft. (15–50 m). The thickness of the Ross Ice Shelf ice ranges from 600 to 3,000 ft. (180–900 m). Captain Ross had first named the Ice Shelf "Victoria Barrier" in honor of Queen Victoria and then later the "Great Ice Barrier." The Ice shelf was later named in his honor.

Pancake ice adrift on the Ross Sea, Antarctica. (National Oceanic and Atmospheric Administration)

There are two scientific bases on the southern part of Ross Island, which are the U.S. McMurdo Station (77° 51′S 166° 40′E) and New Zealand's Scott Base (77° 51′S 166° 45′E). McMurdo Station was established in 1955 as a United States Antarctica Program support and logistics center. Presently, it has around 100 buildings and is capable of supporting more than 1,200 people. It is the largest community in Antarctica. In 2007, the documentary *Encounters at the End of the World* directed by Werner Herzog highlighted different perspectives of people working at McMurdo Station. Scott Base is named after Captain Robert Falcon Scott, who led two British expeditions (the Discovery Expedition of 1901–1904 and Terra Nova Expedition, 1910–1913) to the Ross Sea region. Scott died on the Terra Nova Expedition.

Neighboring the Ross Ice Shelf is Ross Island. Ross Island is made up of four main volcanoes, which are Mounts Erebus, Bird, Terror, and Terra Nova. Mount Erebus (77° 31′S 167° 9′E) is a composite volcano and the largest on Ross Island. Mount Terror (77° 31′S 168° 32′E) is a dormant shield volcano about 20 miles (30 km) east of Mount Erebus. Mount Bird is a dormant shield volcano, which is located about 7 miles (11 km) south of Cape Bird. In between Mount Erebus and Mount Bird lies Abbott Peak (77° 26′S 167° E). Between Mount Erebus and Mount Terror is Mount Terra Nova, which is a dormant volcano. Ross Island was a staging area to several historical events of Antarctic heroic exploration period. Robert Falcon Scott used the island as a staging area for his failed or second-place finish to reach the geographic South Pole. Scott was the leader of two British expeditions to the Ross Sea area. In these expeditions, he established two huts. One of the huts is located on Hut Point and is called "Discovery Hut" and was built in 1902, while the other is located at Cape Evans and is called "Scott's Hut" and was built in 1911.

The McMurdo Sound has a number of prominent features, which have been designated as Antarctic Specially Protected Areas (ASPA). Examples include the McMurdo Dry Valleys located on the western shores, such as ASPA-123 Barwick and Balham Valleys and ASPA-131 Taylor Valley. Other protected areas include ASPA-105 a penguin rookery at Beaufort Island (76° 56′S 166° 56′E) and ASPA-121 the southernmost Adélie penguin colony at Cape Royds (77° 33′S 166° 09′E). There are a few notable islands in the Ross Sea, such as Black (78° 7′S 166° 8′E) and White (78° 8′S 167° 24′E) Islands, and the stratovolcano Mount Discovery (78° 22′S 165° 1′E).

The Ross Sea has large ice holes called "polynya." A polynya is an unfrozen ice hole surrounded by frozen ice due to upwelling, currents, or winds. These polynyas make the Ross Sea productive for the entire food chain, such as phytoplankton, copepods, algae, fish, birds, and mammals. Seals are native to the Ross Sea. The Ross Sea has almost a dozen mammal species, about 100 fish species, and more than 1,000 invertebrate species. Some of these species are found only in this region. Crabeater, leopard, and Weddell seals as well as ecotype A, B, and C orca whales are found in the Ross Sea. Common Species of birds are penguins (Adélie and emperor), petrel (snow and Antarctica), and south polar skua.

Andrew J. Hund

See also: East Antarctica; McMurdo Dry Valleys of East Antarctica; McMurdo Dry Valleys of East Antarctica, Biology of; Nuclear Power in the Arctic; Ross Sea Party (1914–1917)

Further Reading

Garrison, D., A. Gibson, S. Coale, M. Gowing, Y. Okolodkov, C. Fritsen, and M. Jeffries. "Sea-Ice Microbial Communities in the Ross Sea: Autumn and Summer Biota." *Marine Ecology Progress Series* 300 (2006): 39–52.

Locarnini, R. "The Ross Sea." *Quarterdeck* 1, no. 3. College Station: Texas A&M University, 1995.

Ross Seal

The Ross seal (*Ommatophoca rossii*) is one of four phocid pinnipeds that lives exclusively in the Southern Hemisphere with breeding populations confined to the circumpolar pack ice of Antarctica. The species was named after Sir James Clark Ross (1800–1962), who collected two of these seals in 1840 during his voyage into the Ross Sea. The genus name is from the Greek *omma* meaning "eye," highlighting its large size. Ross seals grow to about 6.5–8 ft. (2–2.5 m) long and can weigh up to 475 pounds (216 kg). The estimated life span is

21 years. Sexual maturity occurs around three to four years of age for males and two to seven years of age for females. Although counting Ross seal numbers is fraught with problems, a continent-wide estimate ranges from 130,000 through 220,000.

Ross seals have relatively small but robust bodies with short broad heads. The eyes are noticeably large and forward pointing, reflecting adaptations to their deep diving and foraging habits. The teeth are all small, and the postcanines are simple without shearing or grinding structure. The canine teeth are very sharply conical, adaptations for catching squid, which seems to be the primary prey. The short pelage is dark brown dorsally and cream or tan ventrally, with several dark stripes radiating down the throat from the mouth and some spotting along the boundary between the countershaded dorsal–ventral pattern.

The little information on the reproductive biology of Ross seals suggests that pups are born from mid-October through November. Mating may occur just after that in December and early January. One definitive study showed the nursing period to be 13 days in mid-November, with mating occurring at the end, or shortly after the nursing period, evidently in the last week of November. However, exact timing is dependent on the region of the Antarctic, and the pupping season probably varies with location.

Ross seals molt from late December, but especially through late January to early February. Just after the molt in February, adults head north and stay pelagic in the area south of the Antarctic polar front, until October when they go south into the pack ice. Throughout the year, they make about 100 dives a day, most to a depth of 330 to almost 1,000 ft. (100–300 m), the deepest dive on record being more than 2,500 ft. (792 m). Most dives, outside the breeding and molting period, last for 5–15 min throughout the year. This diving behavior is consistent with feeding on midwater Antarctic silverfish, squid, and to some extent krill (*Euphausia superba*), when in the pack ice, and myctophid fish and several species of squid, when in the open ocean.

Although relatively little is known of the species' distribution, abundance, life history, and basic natural history, they may range all around the Antarctic continent though areas of higher density appear to be in the Ross Sea, the King Haakon VII Sea, and perhaps parts of the western Weddell Sea. Most sightings of Ross seals have been of solitary seals, but small groups and aggregations occasionally occur. Though Ross seal adults give birth and mate in remote and inaccessible areas of pack ice, and forage in open water far north from seasonal pack ice after they finish the molt, immature and nonbreeding seals may spend an entire year or more in pelagic habitats. Unsurprisingly, then vagrants occur at several subantarctic islands, New Zealand, and Australia.

Threats

There has been essentially no commercial harvest of the species, and none are planned or likely to be considered. The non-aggregating nature and remote breeding habitat of Ross seals shelter them from virtually all potential direct interactions with human activities. The apparent solitary behavior and broad distribution of nonbreeding seals may also reduce direct interactions with commercial fishing activities. Perhaps the most important threat is loss of breeding habitat accompanying ocean climate warming and constriction of seasonal pack ice. The effects of changes in sea ice on Ross seal foraging seem unlikely to be detrimental since they often forage at considerable distances from the continent, beyond the sea ice, and thus may be preying on species not particularly linked with the pack ice ecosystem. However, population size and distribution may be altered through changes in food web dynamics, and their nonbreeding season foraging habitats north of pack ice zones may overlap with southern elephant seals and other migratory subarctic marine vertebrates.

Conservation Status

The Ross seal is listed as lower risk, least concern on the IUCN Red List and is protected in its range as Specially Protected Species under Annex II to the Protocol on Environmental Protection of the Antarctic Treaty. It is also protected under the Convention for the Conservation of Antarctic Seals.

Marthán Bester

See also: Antarctic Fur Seals; Bearded Seal; Crabeater Seal; Harp Seal; Hooded Seal; Leopard Seal; Polar Bear; Ribbon Seal; Ringed Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Spotted Seal, Weddell Seal

Further Reading

Bester, M., and G. Hofmeyr. "Ross Seal." In B. Riffenburgh, ed. *Encyclopedia of the Antarctic.* New York: Taylor and Francis Books, Inc., 2007, pp. 815–16.

Reeves, R., (ed.). "Ross Seal." In *National Audubon Society Guide to Marine Mammals of the World.* New York: Alfred A. Knopf, Inc./Chanticleer Press, 2002, pp. 174–76.

Siniff, D., et al. "Projecting the Effects of Environmental Change on Antarctic Seals." *Antarctic Science* 20 (2008): 425–35.

Southwell, C., et al. "A Review of Data on Abundance, Trends in Abundance, Habitat Use and Diet of Ice-Breeding Seals in the Southern Ocean." *CCAMLR Science* 19 (2012): 49–74.

Ross Sea Party (1914–1917)

The Ross Sea Party was part of the failed Imperial Trans-Antarctic Expedition (1914–1917) led by Ernest Shackleton. With the original design of the expedition calling for a Trans-Antarctic journey from the Weddell Sea to the Ross Sea via the South Pole, the main task of the Ross Sea Party was laying out fuel and supply depots for the final leg of the transcontinental journey as the main journey party would not have been able to carry fuel and supply for the whole trip across Antarctica.

On December 20, 1914, the Ross Sea Party left Hobart (Australia) on board the steam yacht *Aurora* bound for Ross Island. Aeneas Mackintosh, who had served earlier as second officer during Shackleton's Nimrod Expedition, led the Ross Sea Party. While Mackintosh had a good deal of Antarctic experience, many of his men were comparably inexperienced. After a delayed arrival in Antarctica, the Ross Sea Party immediately began the depot-laying trips as they were not able to communicate with Shackleton's main party and needed to assume that the depots would be required in case Shackleton would attempt the transcontinental journey during the first season of the expedition. In fact the depots were never required due to the failure of the main expedition that resulted in the loss of the *Endurance* and Shackleton's famous trip to South Georgia on board the *James Caird.*

The first depot-laying trip in early 1915 became really discouraging for the Ross Sea Party as they lost 10 out of 18 dogs while managing to establish only one incomplete depot. In May 1915, the shore party lost access to the *Aurora* as the ship lost her moorings and was trapped by ice up to February 1916, when she finally could escape from the ice after an extensive drift. Despite having lost access to the ship and thus most provisions and supplies, the shore party continued establishing depots. Battered by scurvy and the death of several expedition members, including Mackintosh himself, the remaining seven members of the shore party had nothing else to do than waiting for her rescue sustaining largely on the remains of earlier expeditions to the Ross Sea region, most notably Scott's Terra Nova Expedition. The substantially damaged *Aurora* managed to sail to New Zealand, but refitting the vessel proved difficult as there were no remaining funds of the Imperial Trans-Antarctic Expedition, and more importantly, not a single word has been heard from Shackleton and the main expedition party.

Finally Australia, New Zealand, and Great Britain decided to fund the retrofitting of the *Aurora* but insisted that the relief expedition would be carried out under their control. Even after the rescue of the main party of the Imperial Trans-Antarctic Expedition and Shackleton's return to civilization, he was not given command of the relief expedition for the Ross Sea Party, but mustered only as a supernumerary. On January 10, 1917, the *Aurora* reached the stranded remaining seven members of the Ross Sea Party and learned from Shackleton about the complete failure of the Imperial Trans-Antarctic Expedition before heading north for New Zealand.

Ingo Heidbrink

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s); Ross Sea

Further Reading

Loewe, F. *The Scientific Observations of the Ross Sea Party of the Imperial Trans-Antarctic Expedition, 1914–1917.* Columbus: Institute of Polar Studies, Ohio State University, 1963.

McElrea, Richard, and David L. Harrowfield. *Polar Castaways: The Ross Sea Party (1914–17) of Sir Ernest Shackleton.* Montréal: McGill-Queen's University Press, 2004.

Tyler-Lewis, Kelly. *The Lost Men: The Harrowing Saga of Shackleton's Ross Sea Party.* New York: Viking, 2006.

Russian Antarctic Expedition (1819–1821)

In 1818, the Russian emperor, Alexander I (1777–1825), decided to send out two exploring expeditions, one to the North Pacific and the Bering Strait, and the other to the Antarctic. The northern expedition, commanded by Captain Lieutenant Mikhail Nikolayevich Vasil'ev (1770–1847), managed to sail a little further north into the Bering Strait than James Cook had done on his third and last voyage to the Pacific, but otherwise left little mark on history. The southern expedition was more significant.

The First Squadron, or Russian Antarctic Expedition as it is known today, comprised the two sloops-of-war HIMS *Vostok*, displacement about 980 tons, and HIMS *Mirnyi*, displacement about 814 tons, under the command of the 40-year-old Junior Captain Faddei Faddeyevich (Fabian) Bellingshausen (1778–1852). He was seconded on *Vostok* by the next senior officer in the squadron, Captain Lieutenant Ivan Ivanovich Zavodovskii, and the support ship *Mirnyi* was ably commanded by the 30-year-old Lieutenant Mikhail Petrovich Lazarev (1788–1851). Both Bellingshausen and Lazarev had taken part in previous circumnavigations on detachment to the state-sponsored Russian American Company, Bellingshausen as a navigating officer on the Krusenstern expedition of 1803–1806 and Lazarev as the commander of the *Suvorov* in 1813–1816.

Bellingshausen was an ethnic German from the Russian governorate of Livland, situated beside the Gulf of Riga in the eastern Baltic. The family was minor gentry with a small estate at the western end of the island of Ösel (nowadays Saaremaa), which they were obliged to sell during Bellingshausen's childhood. He was the fourth son, as yet unmarried, and unlike other German-Russian explorers, such as Otto Kotzebue or Ferdinand Wrangell, who were independently wealthy, he relied almost entirely on his naval salary. In true navy style, Bellingshausen's favorite motto was "fortune favors the brave." By 1819, he and Zavodovskii had been carrying out hydrographic surveys in the stormy waters of the Black Sea for six years.

The expedition set sail from the naval base of Kronstadt, which guarded the sea approaches to St. Petersburg, on July 15, 1819, with 190 people on board, six of whom, the astronomer Ivan Mikhailovich Simonov (1794–1855), the artist Pavel Nikolayevich Mikhailov (1786–1840), the chaplain, and three personal servants, were not naval personnel. A young medical student from Bremen, Karl Heinrich Mertens, had been invited to join them as a naturalist, but declined to do so at the last minute because he had been given too little time to prepare for the voyage.

After loading further provisions and scientific materials at Copenhagen, Portsmouth, Tenerife, and Rio de Janeiro, the squadron headed for the Southern Ocean in November 1819.

Their first destination was the island of South Georgia, which had been partly surveyed by James Cook in 1775. The Russians complemented Cook's work by making a running survey of the southwestern side of the island, not visited by Cook, from December 28 to 30, 1819. They then headed south toward Cook's only Antarctic discovery, a place that he had called "Sandwich Land" while pointing out that it could very well be a group of islands. During this passage, the Russian expedition made its own first discovery, a group of three small islands that Bellingshausen named after the Russian Minister of Marine, the Marquis de Traversay. They are now regarded as a northern subgroup of the South Sandwich Islands. Moving on, the Russians spent about two weeks at Sandwich Land, during which they confirmed Cook's hypothesis that his discovery might consist merely of islands and surveyed them as effectively as possible under difficult conditions of wind, ice, and heavy overcast, which often prevented the requisite observations of the sun and stars. By combining his own data with those obtained by Cook, however, Bellingshausen was able to produce the first satisfactory map of the group, which was published in the *Atlas* volume of his voyage in 1831.

Bellingshausen sailed on south for about 60 miles (100 km) below the South Sandwich Islands, but was turned back by continuous heavy ice. He also faced the problem that the prevailing winds in high latitudes were easterlies, favorable to ships westward-bound, whereas he was directed to make his circumnavigation in the opposite direction, eastward. From January 1820 onward, therefore, he began making repeated thrusts south into the ice fields, to see what he could discover, between which he retreated northward a little to make some easting with the prevailing westerlies of the Southern Ocean. During the first such probe, *Vostok* and *Mirnyi* became the third and fourth ships to cross the Antarctic Circle, on January 27, 1820, 47 years after Cook had done so for the first time with HMS *Resolution* and *Adventure.* On January 28, the Russian expedition reached their furthest south that year, 69º 17′ 26″S. During their next major probe, reaching 69º 7′ 30″S on February 17, 1820, the Russians sighted a massive, land-like ice formation of the type that would nowadays be regarded as an integral part of the ice-girt mainland of Antarctica. Since no one yet knew whether Antarctica existed, let alone what semipermanent ice features it might contain, such as ice barriers, ice shelves, and ice tongues, Bellingshausen was in no position to say that he had seen the mainland on that date, but nowadays most polar historians would agree that he had in fact done so.

The expedition continued probing south and progressing steadily eastward across the Southern Ocean until mid-March 1820, but without making any further discoveries. Then, at the end of the austral summer, they broke off their exploration and headed northeastward to the port of Sydney in the young British colony of New South Wales, for repairs and resupply. Although they had been heavily sheathed in pine and reinforced internally, *Vostok* and *Mirnyi* were small wooden ships that were in no sense ice-worthy, and both had sustained considerable damage during their daring passages inside the ice fields. The Russians received a warm welcome at Sydney, including free supplies of timber, coal, and water, and when necessary the services of Royal Navy artificers to supplement the skills of those carried with the expedition.

In May 1820, the expedition headed northeast into the Pacific Ocean, after an unscheduled visit to the South Island of New Zealand, to spend their time usefully while waiting for the next austral summer, when they could turn south again. During this phase, they discovered 15 tropical islands of various sizes that were previously unknown to Europeans. Bellingshausen thought he had found a few more, for the understandable reason that not all the achievements of previous voyages were available to him.

The expedition returned to Sydney in late September 1820 and spent another seven weeks there for further repairs and resupply. In November, they headed south again, calling first at Macquarie Island, where the ongoing slaughter of sea elephants had been temporarily suspended for lack of barrels in which to store the rendered oil. The Russians pushed on south to reach the ice fields in December and resumed the previous pattern of exploration, often in poor weather and bad visibility, at one point spending 11 days inside what Bellingshausen called "the labyrinth of ice." On January 21, 1821, their courage and persistence were rewarded with the discovery of Peter I Island, which Bellingshausen named after the founder of the Russian Navy and the modern Russian Empire. Seven days later, they made an even more substantial discovery, which Bellingshausen named the Alexander I Coast because they could only see it from a great distance, across an impassable ice field, and could not make out whether it had any southern termination. Several references to this discovery by members of the expedition and by contemporary geographers nevertheless described it as an island, and that hypothesis was finally confirmed, from the air, in 1929.

The last phase of exploration by the Russian expedition was a survey of the South Shetland Islands, a 280-mile (450-km) chain of islets and islands south of Cape Horn and running southwest to northeast, roughly parallel to and a short sailing distance from part of the mainland of Antarctica, namely, the Antarctic Peninsula. The group was discovered on February 19, 1819, by William Smith, master and part-owner of the English merchant brig *Williams*, and a year later, it was more thoroughly explored in an expedition for which the Royal Navy commissioned the *Williams*, placing Edward Bransfield, master, in command, with Smith remaining on board. Bellingshausen had received news of the discovery at Sydney in May 1820, but was of course unaware of the work of the Bransfield expedition. The

Russians surveyed the southeastern side of the chain, inside what is now known as the Bransfield Strait. After setting down that information, Bellingshausen was able to sketch in the missing parts of the northwestern coasts that he had obtained from other sources to produce a reasonably accurate map of the group, which appeared in his *Atlas* volume. Here too he believed he had made original discoveries, in the shape of the Elephant and Clarence subgroup at the northeastern end of the chain, but they had in fact been surveyed and claimed beforehand by the Royal Navy.

With the condition of *Vostok* steadily deteriorating, Bellingshausen was obliged to leave the Southern Ocean a month earlier in 1821 than he had done in 1820. He called at Rio in March for urgent repairs and then returned, via Lisbon, to St. Petersburg, which he reached on August 5, 1821, after a 65,000-mile (105,760-km) voyage, which had lasted two years and three weeks, or 751 days. The achievements of the Russian expedition included a furthest south of 69º 21′ 28″S 2º 14′ 50″W short of Cook's furthest south achieved in 1774, and the discovery of the first land south of the Antarctic Circle, both in January 1821. Bellingshausen warmly commended the courage, skill, and endurance of his officers and men to the emperor, and those qualities of the expedition have since been universally admired. Three seamen perished during the voyage.

Bellingshausen completed a narrative of the voyage in 1824. After extensive editing, which sometimes corrupted or confused the text, it was published in 1831 at a price, including the *Atlas*, of 20 silver rubles—equivalent to about £280 or $450 in 2012. A facsimile edition, published at St. Petersburg in 2011, costs RUB 250,000, about £5,000 or $8,000.

Robert Ion Pierson (Rip) Bulkeley

See also: Lazarev; Mikhail Petrovich (1788–1851)

Further Reading

Bellingshausen, F. *The Voyage of Captain Bellingshausen to the Antarctic Seas, 1819–1821.* Edited by F. Debenham. Reprint ed. Hakluyt Society, Second Series 91 and 92. Farnham: Ashgate, 2010.

Bulkeley, R. *Bellingshausen and the Russian Antarctic Expedition, 1819–21: Official Reports and First-Hand Narratives.* Basingstoke: Palgrave-Macmillan, 2013.

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Salmon Shark

The salmon shark (*Lamna ditropis*) is a large opportunistic predator found exclusively in the North Pacific Ocean. It is widely distributed in the coastal and oceanic waters of the western Pacific near Japan and in the Sea of Japan, off and along the Pacific coasts of North and South Korea, off the coast of Russia, and in the Bering Sea. To the east, the salmon shark ranges from Alaska and Canadian waters southward to Baja California, Mexico. It is considered an apex predator of the subarctic and temperate realm competing with marine mammals and seabirds for its prey.

Described as a new species by Hubbs and Follet in 1947, *L. ditropis* was previously thought to be a Pacific version of the porbeagle shark, *L. nasus*, a North Atlantic shark in the Northern Hemisphere. Its common name, salmon shark, is based on its favored prey, Pacific salmon (*Oncorhynchus* spp.), but it is a cosmopolitan consumer with a taste for many kinds of fish. In Japanese waters where it is abundant, it is called the "mackerel shark." Its scientific name means voracious fish (*Lamna*) and two keels (*di-tropis*).

Salmon sharks are large reaching a maximum of 10 ft. (3 m) and heavy weighing more than 450 kg (992 lbs). Its liver is used for buoyancy and may account for 25 percent of its body weight. The body is torpedo shaped and well designed for chasing and capturing fast-moving oceanic prey. It has a short, blunt conical snout with large, blade-like teeth. As its name implies, it has two keels on its wide tail. Coloring ranges from a dusky blue-gray to black on the dorsal and lateral surfaces with a dark dorsal fin. The ventral surface is white with dusky blotches. The dark blotches and secondary keels distinguish it from the white shark. There are differences in total length, growth rates, age of maturity, and weight between the western North Pacific (WNP) population and the eastern North Pacific (ENP) stock. The sharks of the ENP appear to have a faster growth rate and mature at an earlier age than the population in the WNP. The ENP females are larger and heavier than the western females. Salmon sharks from both geographic areas live up to 30 years. The two populations exhibit strong sexual segregation with the WNP stock being male dominated and the ENP female dominated.

Lamnid sharks are endothermic and have retia mirabilia, a vascular adaptation for retaining metabolic heat. This ability to regulate body temperature of 14–20°F above the ambient water temperatures allows them to exploit a wide range of oceanic and coastal environments. These sharks prefer cool waters, but can tolerate

Captured salmon shark. (Shutterstock.com)

temperatures from 2 to 24°C (36–75°F). Salmon sharks are powerful swimmers and divers and have been photographed at depths of 837 ft. (255 m).

L. ditropis is migratory. At the end of summer, salmon sharks leave their northern range and migrate south following the movement of the pelagic fish that constitute its primary food source. This correlates with its reproductive season, as well. In the Prince William Sound, Alaska, salmon sharks had the second highest consumption of all top predators including the seabirds, marine mammals, and teleost fishes with which they share the food web. Voracious and opportunistic eaters, they feed on a wide variety of fish, other sharks, squid, shrimp, and crab.

Salmon sharks have about a nine-month gestation following a late summer–autumn breeding season. Male sharks bite the female during mating. Litters contain two to five embryos. These sharks are ovoviviparous, giving birth to live young, which remain in the uterus with no placental attachment. These developing embryonic sharks have an oophagous stage consuming unfertilized but yoke-rich ova produced by the mother. The newborn pups measure about 2.8–3.1 ft. (84–96 cm). Salmon sharks show a fidelity to a particular region over multiple years for their annual southern birthing and feeding migration. Two separate birthing–nursery areas are used by the salmon sharks. For example, the highly productive California current is both a birthing site and foraging revisited by the western population. Neonates and young sharks are found in significant number beached along the Oregon and California coasts in the spring. A second birthing ground used by the WNP stock appears to exist in conjunction with the transitional boundary between the subarctic and central Pacific current. The major ecoregions used by the western population of salmon sharks are coastal Alaska downwelling, subarctic Alaska gyre, transitional zones, California current upwelling, and subtropical gyre.

The status and conservation of the salmon shark depend on actions that limit it being taken as bycatch in the purse seine and longline fisheries. Commercial and sports fishing for this species occur off Japan and Alaska. Its low fecundity and slow maturity make it vulnerable to climate change and man-made impacts to the oceans. The salmon shark is listed as the least concern on the IUCN Red List of Threatened Species.

Joyce M. Shaw

See also: Greenland Shark; Pacific Sleeper Shark

Further Reading

Goldman, K., and J. Musick. "Growth and Maturity of Salmon Sharks (*Lamnaditropis*) in the Eastern and Western North Pacific, and Comments on Back-Calculation Methods." *Fishery Bulletin* 104 (2006): 278–92.

Weng, K., D. Foley, J. Ganong, C. Perle, G. Shillinger, and B. Block. "Migration of an Upper Trophic Level Predator, the Salmon Shark *Lamnaditropis*, between Distant Ecoregions." *Marine Ecology Progress Series* 372 (2008): 253–64.

Sami

The Sami (also spelled Sámi or Saami), formerly called "Lapps," are an indigenous group inhabiting Sápmi or Northern Fennoscandia. Northern Fennoscandia is the northern regions of Norway, Sweden, Finland, and the Kola Peninsula of Russia. Sápmi covers an area of around 150,000 square miles (388,350 sq. km), which is roughly the size of Montana. The Sami are protected under international conventions and only recently recognized as an indigenous group in Norway, Sweden, Russia, and Finland. The total Sami population is estimated at about 80,000 people of which more than half live in Norway. About a quarter of Sami population live in Sweden, several thousands live in Finland, and only a couple of thousands live in Russia. Most Sami in Russia live in Lovozero, which is called "the Sami capital of Russia." The Sami are a minority population in all of these countries.

Commonly, the Sami are viewed as strictly a reindeer herding culture. Although the reindeer is important to their culture and reindeer husbandry is a significant activity across Sápmi, only about 10,000 Sami participate in reindeer herding. In several countries, the ability to herd reindeer is reserved only for certain Sami groups. Among the Sami that do herd reindeer, the reindeer are individually owned, but the herding activity is a community-based activity. Another misperception is that the

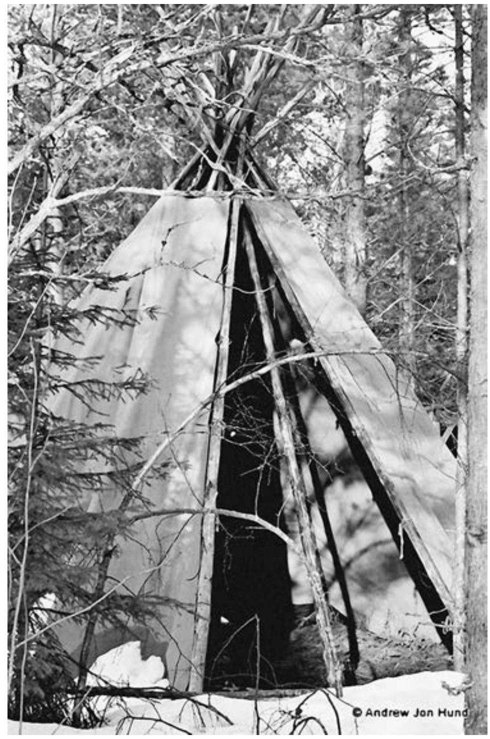
Reindeer breeder outside traditional Sami reindeer-skin tents (lappish yurts) in Tromso, Norway. (Shutterstock.com)

Sami are one people. There is considerable diversity between groups in regard to legal rights and status, subsistence and cultural practices, and settlement patterns. The Sami are also coastal people who use marine animals for subsistence, while other groups trap animals or herd other animals such as sheep.

Unique Genetics of the Sami

Genetic evidence suggests that the Sami are unique and descendants of old Asian and European populations. Scientists have discovered three specific genetic mutations in about one-third of the Sami, which is called a "Sámi motif." The Sami genetic uniqueness is the result of the Sami being isolated geographically for several thousands of years and an allelic drift. Mitochondrial DNA (mtDNA) haplogroups V and U5b are very common in the Sami with around 90 percent having these haplogroups. This is the highest of any group of people on the earth. The mtDNA haplogroups V sequences are estimated to have occurred in the Sami population around 7,600 BC and the U5b1b1 sequence took place around 5,500 BC. Among the Sami and Finn groups, the U5b1b1 sequence occurred later, around

6,600 BC. This genetic evidence suggests that the Sami have been occupying Northern Fennoscandia since the Late Glacial Maximum (ca. 13,000–10,000 years ago).



Sami forest camp. (Andrew J. Hund)

History

Sami were traditionally a hunting, gathering, and fishing culture that have been occupying Northern Fennoscandia since the last glacial period in Sápmi. The largest territory of the Sami was during the first millennium (1000 BC–1 BC), when their territory stretched from Lake Ladoga in the Republic of Karelia and the Leningrad Oblast of Russia to the Arctic Ocean (North), encompassed most of modern-day Finland, and went across the middle of Scandinavia to the White Sea. The Sami became a culturally distinct group when they developed a separate language from Finnish-Sami group about 2,000–2,500 year ago.

In the sixteenth century, the Sami were engaged in selling caribou skins, antlers, and other products to Europeans. During this time, the Forest-Sami had administrative units all across Northern Fennoscandia and was organized into Lapp villages. However, the intensive caribou hunting depleted the resource forcing the Sami to use their knowledge of caribou to develop reindeer herding. This had a considerable influence on the Sámi culture resulting in the Sami reindeer herders migrating with their herds. The Lapp villages became decentralized and nomadic, like the Sami people. The Sami culture became intertwined to the caribou and reindeer seasonal migration. The Sami migrated north like the caribou and reindeer. Aside from reindeer herding, the arrival of Finnish settlers pushed the Sami north or the Sami were assimilated into the Finnish culture. The Finns were significantly influenced by the Aryan race (Indo-Europeans). Shortly after this, the Sami were claimed as subjects under the Finland, Norway, and Sweden kingdoms. These kingdoms each established sovereignty over the northern regions by three approaches: (1) Christianization of the northern inhabitants, (2) encouraging northern settlements, and (3) replacing old Sami administrative system with each kingdom's administrative system.

The erosion of Sami sovereignty took place between other nations, and by the eighteenth century, the Sami no longer controlled their traditional lands. The Sami were not recognized as a sovereign nation and thus not participants in the border and land negotiations. The first treaty, called the "Treaty of Teusina" (1595), was between Sweden and Russia and clarified land and borders belonging to Sweden and Russia. The Sami were divided between the eastern and western nations and under the governance of Sweden and Russia. In 1751, the Strömstad Treaty was enacted and established the borders between Denmark–Norway and Sweden–Finland. Under the Strömstad Treaty, Denmark–Norway was granted ownership of the Kautokeino (69° 0′ 42″N 23° 2′ 36″E), Karasjok (69° 28′ 55″N 25° 6′ 18″E) in modern-day Finnmark country, and Utsjoki (69° 54′N 27° 1′E) in modern-day northern Finland. The Strömstad Treaty recognized the Sami, established the Lapp Codicil, and granted special rights to the Sami reindeer herders to cross international borders. These border rights were rescinded in 1852. The Russian and Swedish borders along the Torne River were closed in 1889. The Finnish and Russian borders in the Sápmi were drawn in 1944. Norway carried out the Norwegianization, which were designed to assimilate the Sami and other ethnic groups into the dominant Norwegian culture. For example, Norwegianization policies included provision that prohibited the instruction of the Sami language, Sami yoik singing was illegal from 1773 to 1958, and the Land Sales Act of 1902 allowed only Norwegian language speakers the right to purchase Finnmark land.

In response to the erosion of Sami rights, the Sami formed a series of Sami-based associations and newspapers in Norway and Sweden in the late 1800s. In 1875, the Isak Saba authored the Sami national anthem. The first Sami newspaper called the *Tales for Sámi Hungry for Education/Culture* was published from 1873 to 1875. On February 6, 1917, a general conference of all Sami groups was held in Trondheim, Norway. February 6 is now Sami national day. This cross-border association continued, and in 1953, in Jokkmokk, Sweden, the first Sami Conference addressing Sami rights to natural resources and to their language was held. During the 1960s, a Sami cultural renaissance came about that spawned new sociopolitical media and art.

In 1993, on the midsummer, a unique cultural and music festival occurred in Sápmi (in Karesuando, Sweden) known as the Davvi Suvvá festival. The festival was in conjunction with the United Nations International Year for the World's Indigenous People. The festival was a world cultural gathering as well as an affirmation of the progress that has been made toward Sami sovereignty and other indigenous people advancements from over the world. The Davvi Suvvá festival was an affirmation of the world's indigenous peoples' past triumphs and continued struggles.

Sami Belief System

The Sami belief system was based on the belief that all natural things (animate and inanimate) have a spirit (e.g., an animistic worldview) and must be respected. Under this worldview, it is taboo to disrespect nature. Traditionally, the Sami belief system emphasized the importance of individual spirituality, respect for nature, and a deep connection between the natural and spiritual worlds. The Sami were polytheistic pagans and viewed many animal spirits as helpers and guides. Some of the Sami beliefs have elements of Norse mythology suggesting that either the Vikings brought them to the Sami or the Sami brought them to the Vikings.

There is no uniform type of shamanism across Sápmi or the northern regions of Norway, Sweden, Finland, and the Kola Peninsula of Russia. Traditionally, Sami shamans (called "noaidi") were the protectors of the Sami from the harmful elements. The shamans were able communicate between worlds in the form of animals and/or ancestral spirits. The noaidi had the ability to cure illness by removing the evil spirit from the person, facilitate childbirth, ensure successful hunts, locate hidden or lost items, and see the future. They also guided the dead on their journey beyond. For rituals, the noaidi would sometimes take place at locations of spiritual significance, such as sieidi, hills, caves, and so on, and would use a drum, chant, and use sacred objects to enter the spirit world. The ritual and travels to the spirit world could last for several days. Protectors of the Sami also included animal spirits, such as "Haldi," a bear that was the protector of nature, and the "alder man" (Laib olmai), who lived in trees and bestowed hunters with good luck against bears.

The first Christians (Roman Catholics) arrived in Sápmi in the thirteenth century. During this time, the Sami practiced the pagan ways in the comfort of their home and went to church services on Sunday. By the seventeenth century, traditional Sami religious practitioners were accused of engaging in witchcraft or sorcery. Some Sami were convicted of witchcraft and sentenced to death (burned). By the early 1700s, the Norwegian government was actively attempting to convert the Sami. Norwegian Lutheran priest, Thomas von Westen (1682–1727) called the "Apostle of the Sami" engaged in burning Sami rune drums and sacred objects as well as destroying scared sites where offerings were made such as a sieidi, hills, caves, and so on. Sieidis were unusual stone formations for a geographic location where gifts were offered or sacrifices occurred. They could be natural or human-made. Westen was responsible for burning thousands of drums, and fewer than 100 were sent to museums. In 1840, Lars Levi Laestadius (1800–1861), a Lutheran Priest, learned the Sami language and culture and was able to establish a puritan movement together with the Sami. By the eighteenth century, the animistic/shamanistic belief system was replaced by Christianity. In modern times, some Sami have returned to their pagan roots, while other Sami are blending ancestral pagan activities with other pagan traditions from around the world. However, most Sami are members of the Lutheran churches Finland, Norway, and Sweden. Most Kola Peninsula Sami are members of the Russian Orthodox Church.

Language

The Sami languages are a branch of the Uralic language family. The Sami language is a group of 12 distinct languages of which 9 are still spoken. The nine spoken

Sami languages are the Inari, Kildin, Lule, Northern, Pite, Skolt, Southern, Ter, and Ume. These Sami languages are different enough that some Sami groups do not understand each other.

According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), all of the distinct Sami languages are endangered. There are about 34,000 fluent speakers of these Sami languages. Northern Sami has the largest fluent speakers at about 30,000. UNESCO classifies Northern Sami as definitely endangered, which means that young children are not learning the language as their native language. Several of the Sami languages are severely endangered according to the UNESCO. These are the Lule Sami (2,000 fluent speakers), Kildin Sami (800 fluent speakers), Ume Sami (500 fluent speakers), Inari Sami (400 fluent speakers), and Skolt Sami (300 fluent speakers). A UNESCO classification of severely endangered means that the grandparent generation and those older speak the language, but the parent generation do not speak the language, may have trouble understanding it, and do not speak it to others or their children. Three Sami languages are classified as critically endangered by UNESCO, which are the Pite Sami and Ume Sami (both with 20 fluent speakers) and the Ter Sami (10 fluent speakers). A UNESCO classification of critically endangered means the youngest speakers are the grandparent generation and those older speak the language infrequently. The three extinct languages are the Akkala Sami (extinct in 2003), Kemi Sami (extinct around 1900), and Kainun Sami (extinct in the 1700s).

SAMI JOIK SINGING

Joik (or yoik) is one of many different Sami traditional forms of song and is one of the most widely recognized genre of Sami music. Joik is one of the longest continuing music customs in Europe. Joik is most closely associated with the Northern Sami group. It sounds somewhat similar to Native American chatting styles. A joik is more than music because it is an expression of the Sami culture, philosophy, and traditional ways of life in Sami land. The lyrics and music created by the singer fosters an emotional response and is commonly improvisational. Yet, the joikers' message in a joik is indirect and requires the listener to decipher the joiked message. Many joiks express the various cultural elements of the Northern Sami. The joikers' messages are akin to a musical oral history of the past, present, and future. It is about the person and place. Modern joiks will sometimes use a drum, whereas this was not part of traditional joiking. Joiks were also used by Sami shamans during ceremonies. The most widely known Sami joiker is Wimme Saari.

Andrew J. Hund

The state of the Sami language is the direct result of historic policies of Sweden and Norway that forbid Sami languages from being taught in schools and at home. Like other Northern Arctic groups, the Sami were sent to boarding schools to assimilate them into the larger culture. An extreme example was found in Russia where Sami children were removed from the home at the age of one or two years. They remained in school until the ages of 15–17 years. The Sami that went to these boarding schools returned without the knowledge of their family, culture, or language.

Modern Politics

In Norway, Finland, Sweden, and Russia, the Sami are a minority and have limited legal rights and ancestral land ownership. They are marginal political participants under each these governments. Much of the legal status of the Sami originates from international bodies, rather than from within countries legislation.

Norway

In modern Norway, an elected body consisting of 39 members from seven constituencies forms the Samediggi. Located in Karasjok, Norway, the Samediggi group deliberates Sami social, cultural, economic, and political issues. Norway was the first country to ratify the Indigenous and Tribal Peoples Convention, 1989 (commonly referred to as the ILO-convention 169). A significant issue of the ILO-convention 169 and Norway and the Sami is land ownership. Norway views the ILO-convention 169 as recommending right to use land rather than actual ownership. In 2005, the Norwegian Government passed Finnmark Act and created the Finnmark Estate agency. This act transferred almost 18,000 square miles (46,000 sq. km) of Finnmark County to the local inhabitants. The Sami University College is located in Kautokeino, Norway, in Finnmark.

Finland

Finland in 1973 passed a law establishing a Finnish Sami Parliament. In 1966, the government of Finland ratified the UN Covenant on Civil and Political Rights. More than three dozen cases from Finland and Sweden have been brought under the UN Covenant. Since the 1970s, there has been Sami language instruction in select schools in Finland. The Inari, North, and Skolt Sami languages are found in Finland. In 1995, the government of Finland formally recognized the Sami as an indigenous group. The Sami were provided with the constitutional right to self-government as related to the Sami language and culture, in 1996. Like in Norway, the Sami are concerned with land rights (ownership and the rights to). The ILO-convention 169 has not been ratified by Finland. Finland also has a weak record of including Sami representation in the political process. The first Sami ever elected to the Finnish Parliament was Janne Antero Seurujärvi, in 2007. Finland has been continually criticized for failing to adequately address Sami rights.

Sweden

In 1989, the government of Sweden recognized the Sami as a nation. In 1993, Sweden passed the Sami Parliament Act (1992) as a representative body for the Sami people living within Sweden. The Sami Parliament offices in Sweden are located in Jokkmokk, Kiruna, and Östersund. The ILO-convention 169 has not been ratified by Sweden. The Sami language can be taught in school under the Compulsory School Ordinance providing a Native language speaker can be employed. The Swedish government in 2010 granted governing rights over the UNESCO World Heritage Site Laponia to the Sami group called the "Laponiatjuottjudus." Laponia is a 3,700-square-mile (9,400-sq.-km) almost untouched forest land that was established in 1996. The Sami were issued a formal apology for past mistreatment from the Swedish government in 1998.

Russia

In 1822, Statute of Administration of Non-Russians in Siberia was established. Under this statute, Russia claimed the land of Siberia and taxed indigenous groups to have monies to protect them from predatory traders and settlers. Under the Soviet Union, the Sami of the Kola Peninsula were forcibly put in collective farms called "Kolkhoz." In 1966, the Russian Federation ratified the UN Covenant on Civil and Political Rights. In 1985, in violation to the UN Covenant on Civil and Political Rights, the Russian government closed a 50-mile (80-km) stretch of the Ponoi River, which the Sami are dependent on for subsistence. The Russian government gave the fishing rights to a sporting fishing company that specializes in catch-and-release sports fishing. Russia has not ratified the Indigenous and Tribal Peoples Convention, 1989 (commonly referred to as the ILO-convention 169). In 1993, the rights of the Arctic indigenous minorities (Sami, Nenets, Evenks, and Chukchi) were guaranteed under the Russian Constitution (Article 69). Then, in 1999, the Russian government passed laws that protected and provided limited ownership of the indigenous minority's ancestral lands for subsistence activities, but did not convey the land title. The Russian government also maintained control over development rights of natural resources on the indigenous minority's lands.

The Russian government has failed to enforce existing laws to protect the Sami lands and rights. Sami and other Northern indigenous peoples have repeatedly been deprived of fishing and hunting rights on their ancestral lands. They have also been denied access to pastureland and the ability control natural resources on their ancestral lands. Even though there are limited local codes granting Sami access to traditional lands, to date, the Russia Federation has yet to enact any comprehensive legislation to resolve Sami land rights and ownership.

Andrew J. Hund

See also: Reindeer Herding; Rock Art of Alta

Further Reading

Broadbent, N. *Lapps and Labyrinths: Saami Prehistory, Colonization, and Cultural Resilience.* Washington, DC: Smithsonian Institution Scholarly Press, 2010.

Kuokkanen, R. "'Survivance' in Sami and First Nations Boarding School Narratives." *American Indian Quarterly* 27 (2003): 697–726.

SANAE IV (South African National Antarctic Expedition)

South Africa is one of the founding signatories of the Antarctic Treaty of 1959. In 1960, the first South African National Antarctic Expedition (SANAE) team overwintered at the Norwegian base on the Fimbul Ice Shelf. A new base, SANAE I, was constructed nearby (70° 18′S 2° 22′W) and opened in 1962. Later bases, SANAE II and SANAE III, were built on the same location (72° 40′ 22″S 2° 50′ 26″W) and commissioned in 1971 and 1979 respectively. SANAE I and II were simple wooden structures with a limited life span. SANAE III was more robust, housed in horizontal corrugated steel cylinders. However, as SANAE III disappeared beneath the accumulating snow, it was subjected to crushing pressure and ultimately abandoned in 1994. The current South African research station, SANAE IV (72° 40′ 22″S 2° 50′ 26″W), is located in the Norwegian territorial claim of Queen Maud Land, some 90 miles (150 km) from the edge of the ice shelf. In contrast to earlier bases, which were built on the ice shelf, SANAE IV is perched at an altitude of 2,800 ft. (850 m) above sea level on top of the sloping plateau of Vesleskarvet, an isolated nunatak on the edge of the Ahlmann mountain range.

SANAE IV was completed in 1997 with a designed life span of about 25 years. It was built to withstand temperatures as low as −67°F (−55°C) and wind speeds up to 155 mph (250 km/h). Most of SANAE IV was prefabricated in South Africa. The structure consists of a steel framework cladded with thick foam and fiberglass composite panels. The base is about 575 ft. (175 m) long with three linked modules, each of which is 144 ft. (44 m) long, 46 ft. (14 m) wide, and has two interior levels. The southern module, A-block, contains accommodation, ablution facilities, a laundry, radio room, hospital, and various offices, laboratories, and storerooms. B-block houses further accommodation and ablution facilities, another laundry, the kitchen and dining area, cold and dry stores, library, and entertainment areas. Finally, C-block contains the diesel generators, water storage and sewage processing plant, storerooms, engineering offices, gymnasium, sauna, and a helicopter hangar.

SANAE IV is elevated 13 ft. (4 m) above the surface on steel stilts, securely anchored into exposed rock. The elevated structure accelerates snow blowing through beneath the base. Since SANAE IV is located near the edge of a cliff, which is downwind of the prevailing wind direction, most of the snow that might have accumulated in the lee of the base has been blown over the cliff.

The base is powered by three 250 kW diesel generators. The internal temperature of the living areas is maintained using heat from the generators' exhausts. Potable water is produced by a snow smelter located a small distance from the base and which must be regularly filled with fresh snow. SANAE IV has a sophisticated communications infrastructure based on HF radio and satellite systems. The satellite connection provides telephone, fax, and Internet links. The operation of SANAE IV emphasizes environmental responsibility, and every effort is made to prevent contamination of the local environment. All waste material is sorted and then returned to South Africa for disposal or recycling.

SANAE IV can accommodate around 80 people during the summer relief period and up to 18 overwintering team members. The overwintering team typically consists of two or three scientists, a meteorologist, two diesel mechanics, electronic, electrical and mechanical engineers, and a doctor.

It is possible to fly from Cape Town to a blue ice runway near SANAE IV, but the costs are prohibitively high. Personnel, supplies, and equipment normally reach SANAE IV by sea. The annual relief voyage departs from Cape Town around the beginning of December every year and returns toward the end of February the following year. The SA *Agulhas*, the ship that has serviced SANAE bases since 1978, was replaced by the new SA *Agulhas II* in 2012. Once the supply ship reaches the ice shelf, personnel and sensitive equipment are airlifted to the base by helicopter, while the remaining cargo is transported over land by caterpillar train.

The base hosts a number of high-profile science projects. During the summer months, research is conducted in biology, renewable energy, geology, and geomorphology. Research in the physical sciences extends throughout the year, and a range of sophisticated experiments operate continuously in the vicinity of the base, such as the following: (1) the motion of ionospheric irregularities is measured by the Southern Hemisphere Auroral Radar Experiment (SHARE), a 16-element high-frequency coherent radar array. The radar can also detect the trails of ionization from meteors. The SHARE radar forms part of the Super Dual Auroral Radar Network, operating in conjunction with other radars on the continent. The field of view of the SHARE radar overlaps with those from the radars at Halley and Showa stations. The direction and velocity of ionospheric convection can be determined where the fields of view from two or more radars overlap; (2) properties of the magnetosphere are deduced from very-low-frequency (VLF) radio wave measurements made using a pair of orthogonal loop antennas. VLF waves originate from lightning activity and natural processes in the magnetosphere. The VLF system also contributes data to the World Wide Lightning Location Network; (3) the proportion of electromagnetic waves that are absorbed by the ionosphere is measured by a 64-beam imaging riometer, which monitors the radio noise originating from deep space; (4) the earth's absolute magnetic field strength, as well as fluctuations in the field, are measured using magnetometers; (5) a dual-frequency GPS receiver measures the total electron content of the ionosphere; (6) a scintillation monitor detects rapid fluctuations in GPS signals that are caused by small-scale irregularities in ionospheric density; (7) the flux of galactic and solar cosmic rays are studied using neutron monitors; and (8) a satellite telemetry station, which was installed for the Astrid 2 Swedish microsatellite, provides data downlink facilities. (9) A complete range of meteorological instruments supply weather data.

Andrew B. Collier

See also: Antarctic Programs and Research Stations/Bases

Further Reading

SANAE IV. http://www.sanap.ac.za/sanap_sanae/sanap_sanae.html. Accessed January 13, 2014.

Scottish National Antarctic Expedition (1902–1904)

The Scottish National Antarctic Expedition explored and performed scientific work in Antarctica between 1902 and 1904. This expedition was novel because it was organized and led by a natural scientist, and science was thus a priority. William Bruce (1867–1921) was a former medical student with an interest in the natural sciences, particularly oceanography. He had his first taste of the Antarctic on a whaling voyage in 1892 and subsequently went on several trips to the Arctic. Bruce had applied to join the Discovery Expedition and, after receiving no response, proposed a second ship for this expedition. This proposal was rejected. As a result, he set about obtaining private funding for an independent Scottish expedition.

Bruce secured a substantial donation from the Coats family, with which he purchased a Norwegian whaling vessel. This ship was extensively modified, with the addition of scientific laboratories and diverse experimental equipment. Its hull was reinforced, and auxiliary engines were added. Upon completion, she was renamed *Scotia.* The expedition scientists consisted of an oceanographer, zoologist, botanist, taxidermist, geologist, and physicist. These positions, as well as the captain, officers, and crew of the Scotia, were all filled by Scotsmen.

Scotia departed from Scotland on November 2, 1902, reaching the Falkland Islands on January 6, 1903. There she took on provisions and soon afterward left for the Southern Ocean. The first stop was at the South Orkney Islands, where botanical and geological samples were taken. Toward the end of February 1903, the Scotia had reached 70º S, but as the sea began to freeze over, she was forced to retreat northward, returning to overwinter at Laurie Island in the South Orkneys. During the winter, the scientific program commenced in earnest. A stone building, Ormond

House, was constructed on the island, to serve as accommodation for the meteorological station that was to be established there.

Toward the end of November 1903, the ice holding the *Scotia* broke up, and she departed again for the Falkland Islands and hence to Buenos Aires for provisions and repairs. A small party was left at Ormond House. Bruce persuaded the Argentinean government to support the observations being made on Laurie Island, handing Ormond House over to them. The building was renamed Orcadas Base. The Scotia returned to Laurie Island before once again sailing south to the Weddell Sea. After proceeding unimpeded for some time, she encountered heavy pack ice and shortly afterward the ice shelf. Sailing along the ice shelf they sighted land, which Bruce named *Coats Land.* The *Scotia* got to 74º S before gathering ice forced her to again turn northward. She then proceeded to Cape Town via Gough Island, where scientific specimens were collected. From Cape Town she sailed home, arriving on July 21, 1904.

Upon their return, Bruce and the captain of the *Scotia* were presented with medals from the Royal Scottish Geographical Society. However, unlike the members of the Discovery Expedition, none of the expedition members received Polar Medals. The expedition left a substantial scientific legacy. It returned with an extensive catalog of animal species, many of them previously unknown. The Scottish Oceanographical Laboratory was established by Bruce in Edinburgh to house these specimens. The Orcadas Base on Laurie Island is the oldest Antarctic base still in operation.

Andrew B. Collier and Claire M. Collier

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

Further Reading

Goodlad, J. “Scotland and the Antarctic, Section 5: Voyage of the ‘Scotia’—The Voyage South.” *Glasgow Digital Library.* Royal Scottish Geographical Society, 2003. http://sites.scran.ac.uk/voyage_of_the_scotia/scotia/vserm/vserm05.htm.

Speak, P. *William Speirs Bruce: Polar Explorer and Scottish Nationalist.* Edinburgh: NMS Publishing, 2003.

Sea Ice

Sea ice is frozen seawater. Due to its lower density compared with seawater, it floats on the sea surface. Sea ice grows and retreats seasonally in polar regions, covering the Arctic Ocean in the Northern Hemisphere and fringing the continent of Antarctica in the Southern Ocean. Salinity (dissolved salts and ions) decreases the freezing point of seawater below 32°F (0°C) so that at a salinity of 35, seawater freezes at 29°F (−1.91°C). Sea ice formation progresses through several stages. If temperatures are sufficiently low, elongated, needle-like ice crystals form frazil ice. In its early stage, the mixture of frazil ice and seawater produces an oil-like sheen on the ocean surface known as "grease ice." In calm conditions, ice crystals consolidate at the surface and grow downward, forming nilas. Turbulent conditions produce pancake ice, which is flat, somewhat round ice pieces with upturned edges. Eventually, consolidation leads to a cohesive blanket of sea ice, though pressure ridges in which prominent high points formed by sea ice slabs riding against each other of which common gaps (leads, polynyas, or permanently ice-free areas) can occur. Sea ice formation and growth causes most of the salt or brine to be ejected from the ice lattice, so that older sea ice possesses less salt than new sea ice. However, some brine is retained in pockets of varying sizes (sometimes forming a connected system) encapsulated by a framework of ice crystals. Sea ice is classified according to age and ability to drift. Some ice forms and subsequently melts within one year (first-year ice), while multiyear ice persists for more than one year. Some sea ice is mobile, drifting with ocean currents (drift ice) while landfast or fast ice is attached to land. Large mobile sea ice bodies are referred to as "ice floes."

The importance of sea ice cannot be overstated. It plays a crucial role in the physical and biological aspects of the Arctic and Antarctic. It occupies a key role in earth's climate through albedo, reflecting the sun's radiation, insulating the underlying water, and preventing evaporation and heat loss. It is furthermore crucial to global ocean circulation, as freezing and brine expulsion contribute to sinking of cool dense water in polar regions. In turn, this water sinks to the seabed and flows toward the equator, thus sustaining the ocean conveyor and distributing heat around the globe. Furthermore, sea ice shields coastlines from wind and wave action thus reducing coastal erosion, as well as protecting ice shelves. Biologically, sea ice occupies a key role in polar ecosystems and food webs, its melting releasing nutrients important in ocean productivity. Sea ice also provides living space for smaller organisms within the sea ice matrix and brine channels, including bacteria, algae, and zooplankton, and acts as a platform for hunting, breeding, and resting for a variety of animals such as polar bear, seals, walrus, and penguins. It also protects certain sea mammals, including bowhead whale, beluga, and narwhal, from predation. The seaward edges of sea ice (marginal ice zone) and permanently ice-free areas (polynyas) are particularly productive due to a combination of ice/water interface melt, increased light (for photosynthesis), and/or reduced water mixing.

Sea ice has been monitored and measured by satellites from the 1970s onward, though accounts by explorers and whalers may provide a historical perspective. A longer-term view on sea-ice variability is derived from geological records (seabed sediments) via indirect indicators such as fossil organisms or sediment characteristics. Sea ice has shown a prominent decline in extent and thickness during the past few decades, with 2007 and 2012 marking the lowest Arctic sea-ice years since scientific records began. It is estimated that Arctic sea ice will continue to decline significantly in duration and extent, with little or no summer sea ice left in the Arctic Ocean by 2080. Such loss is of great concern for polar regions and beyond, consequences including lowered albedo causing sea surface warming, heightened coastal erosion, and changes in ocean circulation. Diminishing sea ice also affects polar ecosystems, including loss of hunting platforms, most popularized by the high level of threat to the polar bear. However, not all organisms will suffer if sea ice declines; for example, some whale and fish species will benefit from increased primary production and habitat access. Sea-ice decline also presents an opportunity for oil and gas exploration and navigation, for example, the Northwest and Northeast Passages. However, this carries with it the potential for significant environmental impacts due to oil spills and accidents.

Anna J. Pieńkowski

See also: Ice Sheet; Ice Shelf

Further Reading

Polyak, L., et al. "History of Sea Ice in the Arctic." *Quaternary Science Reviews* 29 (2010): 1757–78.

Rothrock, D., and J. Zhang. "Arctic Ocean Sea Ice Volume: What Explains Its Recent Depletion?" *Journal Geophysical Research* 110 (C1) (2005): C01002.

Sealing and Antarctic Exploration

Unlike whaling, sealing is a land-based activity, as seals are generally killed on the land and not at sea. Thus, the search for new sealing grounds is the search for new land—especially for isolated islands such as those still to be found close to Antarctica in the late eighteenth and early nineteenth centuries. During that period, sealers were responsible for a number of important new discoveries, as well as for making the first detailed explorations of discoveries made by others.

James Cook may appear to be an unlikely founder of the South Sea sealing industry, but his widely read journals contained two observations that were to prove highly influential. The journal of his third voyage recorded the lucrative potential trade in sea otter pelts obtained in Northwest America and sold for vast profits in China; during his second voyage, he had noted observing many fur seals on South Georgia. The first sealers came to South Georgia in 1786, but it was not until after 1792 that they came in large numbers following the decimation of the larger and more accessible seal populations on the Falkland Islands and Juan Fernandez. By 1802, few fur seals were to be found on South Georgia. The same pattern of exploitation followed by exhaustion of the stocks was repeated on many other islands through the nineteenth century, most notably on the South Shetlands Islands following their discovery in 1819.

Two types of seal were of interest to sealers: elephant seals for oil, and the much more valuable fur seals for pelts. Being so valuable and so easily hunted, successive fur seal populations were wiped out, with the sealers showing no interest in conserving stocks to ensure future livelihoods. Indeed, competition was so intense that any measures to restrict killing would almost certainly have been ineffective. Once found, fur seals were easy to kill in large numbers on the beaches, where they hauled out to breed. Thousands of seals might be found on a single beach, and all would be killed, even the little pups, which had no chance of survival once their mothers were dead. A skilled sealer could kill and skin 60 fur seals in an hour. Being less valuable and tending not to aggregate in such numbers, elephant seal populations were less reduced than those of the fur seal. The elephant seal was very much second choice for the sealers. If the hold could not be filled with sealskins, then elephant seal oil could make up the difference. When fur seals became almost impossible to find, then the elephant seal became the main object of sealing on particular islands, especially Heard and Kerguelen during the mid-nineteenth century, that type of sealing being often conducted in combination with whaling.

Sealing vessels were typically small with shallow draft to better negotiate shoals and hidden rocks, and relatively broad in the beam to accommodate large holds. They frequently sailed in company for safety, and to pool resources, such fleets generally including smaller shallops, whose role was to ferry men, provisions, and sealskins between the beaches where shore parties were landed and the larger ships anchored in comparatively sheltered harbors. Shallops were also used to look for new seal rookeries and better harbors and were thus responsible for the majority of exploratory voyages undertaken by sealers: Nathaniel Palmer's *Hero* is a good example of such a vessel. Shore parties might be landed for extended periods depending on the numbers of seals on nearby beaches. In the South Shetlands, the season ran generally from November to early March, and sealers did not overwinter except by misfortune. On other islands, however, where the season was longer and winter conditions less harsh, sealers might remain on shore for years on end.

Put briefly, and more or less in chronological order, the contributions of the sealing industry to Antarctic discovery are these: discovery of the Auckland Islands (Abraham Bristow), as well as Campbell and Macquarie Islands (both by Frederick Hasselburg); thorough exploration, though not first discovery, of the coastal areas of all the subantarctic islands and the South Shetland Islands; further reconnaissance but not discovery of the Antarctic Peninsula (Nathaniel Palmer and others); the first continental landings (John Davis and Andrew McFarlane); discovery of the South Orkney Islands (George Powell and Nathaniel Palmer); the first deep penetration of the Weddell Sea (James Weddell); and a series of discoveries clearly indicating Antarctica's continental nature (John Biscoe, Peter Kemp, and John Balleny). A number of fine charts were compiled (by George Powell, James Weddell, and others), as well as useful sailing directions to the dangerous waters in which they sailed (Robert Fildes and George Powell). Finally, although one sealer, Benjamin Morrell, was unfortunately responsible for introducing a new mythical island (New South Greenland), through their exhaustive searches for islands—however doubtfully reported—the sealers did more than any other group to remove nonexistent islands from the maps.

There may appear to be some contradiction between this contribution to geographical discovery and the widely held view that sealers liked to keep discoveries secret (for obvious reasons, since a newly discovered island might yield a profit in many thousands of sealskins—as long as others did not hear about it). In practice, it appears that secrecy was more easily achieved within than between seasons; there was little to prevent news of a discovery spreading rapidly in ports where seamen from different vessels mixed freely. Although seamen were not allowed to know the latitudes and longitudes of where they had been, they had other means of knowing locations to some degree of accuracy, and once taken on by a new ship, their loyalties were clearly no longer to their previous captain. The same applied also to the ship's officers, who did have access to precise coordinates. Even when crew members remained with the ship, there were other obligations at play likely to result in leaks of information. The ship most probably had several proprietors. They naturally expected to be kept informed of significant developments, but as proprietors, they might also have stakes in other ships to which the information would then be passed. Whatever the means, it is undoubtedly the case that few sealing secrets remained well kept over a period of years. Of course, when a geographical discovery resulted in no discovery of seals, there was no reason not to announce it to governments and to bodies such as the Royal Geographical Society.

Much more remains to be learned about sealing discoveries in the Antarctic, in particular in the vicinity of the Antarctic Peninsula. Two logs found as recently as the 1950s document John Davis's landing on the continent, the first known. They also record a 22-day voyage in December 1820 and January 1821 by Robert Johnson to 66° S 70° W, where he found no land or seals but plenty of ice. At that location, he would have been far from the coast, but he presumably sailed as close as possible to the west coast of the islands forming the Palmer Archipelago in order to get there. There is less convincing evidence of another voyage in the same season to 66° or 68° S, possibly made by Nathaniel Palmer and/or Benjamin Pendleton, though there may be some confusion here with Johnson's voyage. Unfortunately, Palmer's log casts no light on the matter, and we have no log for Johnson. The log, however, that might prove to be most interesting of all if rediscovered would be that of the British sealer Andrew McFarlane of the brig *Dragon.* From Robert Fildes's log, we know that McFarlane was in the South Shetlands at the latest by very early November 1820. McFarlane Strait (between Livingston and Greenwich Islands) is named for him, presumably because he was the first to investigate it. In that case, he must have preceded Palmer, who was there toward the end of November 1820.

He may also have been to Deception Island and explored its harbor before Palmer. Most intriguing of all is the real possibility that McFarlane's landing on the continent, which, Fildes reports, may have taken place prior to Davis's landing on February 7, 1821.

From the perspective of the sealers, the most important expeditions were those of James Cook and William Smith. Both triggered intense sealing activity on South Georgia and the South Shetlands, respectively. Other discoveries—many made by the sealers themselves—were less significant simply because the land discovered was too far south for many, or often any, fur seals to be found—for example, the South Orkneys, the Balleny Islands, and along the continent itself, even the relatively mild Antarctic Peninsula. Had it been otherwise, there is little question, despite the difficulties of approaching it, that the coastline of Antarctica would have been explored in detail much earlier. As it was, there was no commercial value in undertaking such investigation and indeed every prospect of financial ruin, with vessels frequently uninsured and conditions such as to make shipwreck likely.

William James Mills

See also: Antarctic Fur Seal; Antarctic Peninsula; Cook, James (1728–1779); Crabeater Seal; Ross Seal; Southern Elephant Seal; Weddell Seal

Further Reading

Pelly, David F., and Peter Irniq. *Sacred Hunt: A Portrait of the Relationship between Seals and the Inuit.* Seattle: University of Washington Press, 2001.

Second German Antarctic Expedition (1911–1912)

The original goal of the Second German Antarctic Expedition was to determine if Antarctica was one continent or if the Ross Sea and the Weddell Sea were connected. The expedition was led by Wilhelm Filchner (1877–1957), a well-known explorer of central Asia without any prior polar experience, but an established record in geomagnetic research. Filchner's original design for the expedition included two ships, one for entering the Ross Sea and the other for the Weddell Sea, but needed to be changed to a one-ship design due to lack of funds.

After Filchner could not secure public funding, a lottery was established to provide the required funds and finally achieved to raise the required funds for an expedition with one ship. The vessel used by Filchner was the Norwegian built auxiliary steam ship *Bjørn*, which was refitted for the expedition and renamed *Deutschland.* The vessel was commanded by Captain Richard Vahsel, who had already participated in the First German Antarctic Expedition as second officer. On May 4, 1911, the *Deutschland* left Bremerhaven and arrived, after a stop in Buenos Aires on October 18, 1911, at South Georgia.

In February 1912, a land-station was erected at Vahsel Bay (77° 49′S 35° 7′W). The station should be used for overwintering, but movement of the ice forced Filchner to abandon the station after a couple of days only. At least it could be avoided that the ice crushed the ship, but the plans for the expedition needed to be changed completely. During the attempt to reach South Georgia for the winter, the *Deutschland* got frozen in, and the expedition became an ice drift in the Weddell Sea. Provisions for a transcontinental voyage could be landed prior to the drift, but finally all plans for such a voyage needed to be given up. During the drift, tents were erected on the ice, and a number of short journeys undertaken. While none of the main goals of the expedition could be achieved, valuable experiences for operations during the Antarctic winter could be gained and valuable scientific data on the area of the drift gathered. Finally, at the end of September 1912, the *Deutschland* could break free and reached South Georgia on December 19, 1912. Captain Vahsel had died during the drift, and Officer Kling took command. During the drift, a situation close to a mutiny occurred on board the vessel, which might have contributed to the fact that Filchner never returned to Antarctica despite being offered.

The original question of the expedition, the question of one solid or two separated landmasses, was definitely answered only after World War II, but the cartographic records of the Luitpold Coast and the Filchner Ice Shelf need to be qualified as important geographic achievements as well as the winter drift of the *Deutschland* provided important knowledge about ship-borne operations during the Antarctic winter.

Filchner returned to Germany on board a regular steamer in early 1914, and the *Deutschland* was sold to Austria to be used for another Antarctic expedition that never became a reality due to the outbreak of World War I.

Ingo Heidbrink

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

Further Reading

Filchner, W., A. Kling, E. Przybyllok, and W. Barr. *To the Sixth Continent: The Second German South Polar Expedition.* Bluntisham: Bluntisham Books, 1994.

Murphy, D. *German Exploration of the Polar World: A History, 1870–1940.* Lincoln: University of Nebraska Press, 2002.

Turney, C. *1912: The Year the World Discovered Antarctica.* Berkley, CA: Counterpoint, 2012.

Sector Principle in the Arctic

Canada, Denmark (Greenland), Norway, the Russian Federation, and the United States (Alaska) all border the Arctic Ocean. Territorial sovereignty claims over the Arctic region and the respective seafloor have a significant history that has not been completely resolved between these countries. Claiming the North Pole region is problematic because the ice is consistently moving and thus is not land that can be occupied. However, the passage of UNCLOS III has resulted in coastal countries bolstering Arctic claims. Presently, there is an increased interest in mineral rights and strategic military positioning in the Arctic. The sector principle is the way in which the territorial claims or boundaries are made. National claims of sovereignty to the Arctic region can be recognized under International Law providing the nation-state can prove physical occupation or sufficiently exercising state functions over the area.

Historically, Arctic sovereignty is based on two competing ideas. The first is called *res nullius*, which literally translates into "nobody's property." The application of res nullius is called *terra nullius*. Terra nullius translates into "land belonging to no one." Under terra nullius, if a nation can establish that it belongs to no country, the country can gain control over uninhabited or unclaimed lands through its citizens entering the territory and physically occupying it. The second competing idea is called *res communes* or that every nation shares the area and the Arctic cannot be owned. Under international law, countries' sovereignty can be derived if the respective government is able to establish governance or exercise of state function over a territory (terra nullius). Terra nullius has historically been used to justify colonization of Africa. Up until 1999, the North Pole and the Arctic Ocean waters and seafloor were international space.

Claims to Arctic sovereignty are based on the sector principle, which is a version of the geographic doctrine. The geographic doctrine is also called "doctrine of contiguity, propinquity, hinterland, and continuity." Under the geographic doctrine, if a government occupies and/or exercises state functions over the territory, the government can be granted title to the area. The sector principle at its basic definition is simply drawing a line out from the coastal country's borders along longitudinal parallels to the North Pole. The longitudinal lines results in sectors for establishing the coastal countries' territory from the neighboring countries. Historically, claims based exclusively on the sector principle have been rejected by most nation-states. The general consensus in the international community is that for a country to establish sovereignty and have it accepted under international law, the country must exercise governmental functions.

Nation-states have claimed sovereignty based on the sector principle. For example, Canada claimed that since their northern border faces the Arctic, they are entitled to the northern territory beyond their border. In 1925, Canada claimed its international maritime boundaries as being between the 60° W and 141° W to the North Pole. The distance from recognized northern most coastal territory of Canada to the North Pole is around 415 nautical miles (769 km; 478 miles). The following year, the Soviet Union argued its sector is between 32° 04′E and 168° 49′W to the North Pole. Norway also made a sector claim stating it is 5° E to 35° E to the North Pole and the United States sector claim is between 170° W and 141° W to the North Pole. Denmark claimed sovereignty over Greenland a claim that was recognized in an international court in 1933. Denmark claimed its international maritime boundaries as being between 60° W and 10° W to the North Pole.

Canada has attempted to both occupy and exercise governmental functions over the Arctic. For example, during the Cold War, the Canadian Government relocated 87 Inuit to the Arctic (See "Inuit Arctic Relocation"). The Canadian government claims that the relocation of the Inuit was a humanitarian act. The Inuit alleged that the relocation was based not on humanitarian motives but solely to claim sovereignty over the Arctic Archipelago. In regard to exercise governmental functions over the Arctic in 2000, Canada considered prosecuting a pilot for littering because of the suspected abandonment of a plane. The plane took off, and the case was not followed up on. The Canadian government contends that the Canadian Arctic Archipelago islands are a place that they exercise governmental functions over and thus are their own internal waters (see "Northwest Passage Claims and Disputes").

Andrew J. Hund

See also: Arctic Territorial Claims and Disputes; Continental Shelf Claims in the Arctic

Further Reading

Carman, J. "Economic and Strategic Implications of Ice-free Arctic Seas." Chapter 9 in Sam J. Tangredi, ed. *Globalization and Maritime Power.* Washington, DC: Institute for National Strategic Studies, National Defense University, 2002.

Griffiths, F. "The Arctic as an International Political Region." In Kari Möttölä, ed. *The Arctic Challenge: Nordic and Canadian Approaches to Security and Cooperation in an Emerging International Region.* London: Westview Press, 1988.

McKitterick, T. "The Validity of Territorial and Other Claims in Polar Regions." *Journal of Comparative Legislation and International Law* 3rd Series 21, no. 1 (1939): 89–97.

Selkup

Selkups are a forest people living on large rivers in western Siberia. They inhabit two areas that are hundreds of kilometers apart from each other. The Southern or Narym Selkups live in the middle part of the Ob River, today the Tomsk Province (*oblast*). The Northern or Taz Selkups live in the basin of the river Taz in the Yamal-Nenets autonomous region (*okrug*). A small community also lives in the Krasnoyarsk Territory (*krai*) on the Turukhan River. Northern and southern groups differ significantly from each other linguistically and culturally as there has been little or no contact between them for several hundred years.

In the nineteenth-century literature on the region, Selkups were known as Ostyak-Samoyeds; in the south also Tomsk Samoyeds. The name "Selkup" (forest person) comes from the name of a clan group on the Taz River. Today, it has become a common ethnonym for all Northern Selkups. Yet the Southern Selkups use this self-designation rarely. Instead various other ethnonyms are (or were) used. The people living on the rivers Tym, Vasyugan, Parabel, and the Ob near Narym call themselves "Chumylkups"; those on the Ob near Kolpashevo designate themselves as "Shyoshkups"; and those Selkup who dwell on the Ket, Chaya, and Chulym Rivers have the ethnonym "Syussykums." When speaking in Russian—as most Southern Selkups do nowadays—they do not call themselves "Selkups" but "Ostyaks," a name used by Russians that once designated to other neighboring ethnic groups, such as Khanty and Ket.

In 2010, it was estimated that there were 3,649 Selkups. Approximately one-third of all Selkups live in the south and two-thirds in the north. Statistically, the Selkup population has been relatively stable over the last centuries: it has been estimated that there were 3,200 Selkups at the beginning of the seventeenth century. Yet ethnic identification has always been negotiated and flexible, especially after years of Soviet ethnic policies that aimed at creating ethnic labels. For instance, among the Southern Selkups, there are families in which brothers and sisters identify themselves as a Selkup, Ostyak, Khanty, or Russian.

Language

Selkups speak (or spoke) the Selkup languages, which belong to the Samoyed branch of the Uralic family. Linguists distinguish three Selkup languages that are known as Northern Selkup (spoken in the Taz area), and Central Selkup and Southern Selkup (spoken in the Tomsk Province). The United Nations Educational, Scientific, and Cultural Organization (UNESCO) list the Selkup languages as endangered with a total of 610 fluent speakers. There are 600 fluent speakers of the Northern Selkup language and UNESCO lists it as severely endangered. The Central Selkup and Southern Selkup languages have five fluent speakers each and are listed as critically endangered by UNESCO. In the early Soviet period, there were some attempts made to revitalize the indigenous languages through schooling and creating a standard written language. Yet the speakers of different Selkup dialects have often favored Russian as lingua franca when communicating with each other. Furthermore, the state schools stopped teaching Selkup in the 1950s. In the northern areas, particularly in the villages with a Selkup majority (Ratta, Kikki-Akki) the youth can still speak in their language. The main reason why Northern Selkup is relatively better preserved is that people grow up in linguistically less mixed communities and are engaged in traditional occupations such as reindeer breeding. This means living out in the landscape with less exposure to the Russian language.

History and Subsistence

In the first millennium AD, the Selkups' ancestors occupied the middle part of the Ob River and its tributaries where they lived from fishing and hunting. When the Russian Cossacks started their raids into the Selkup areas in the sixteenth century, the Selkups organized themselves into a union known as "Pied Horde." Their simple fortifications could not protect them from the Russians' rule for too long. The Russian permanent colonization started with building the forts Narym (1596) and Ketsk (1597) from where they collected fur tax (*yasak*) among the indigenous population. Also Russian peasants began to settle there soon after. In the eighteenth century, priests of the Russian Orthodox Church started to baptize Selkups. To avoid baptism and taxes, many families fled in the seventeenth and eighteenth centuries to the Taz River area, which was then occupied by the Enets. This migration marks the beginning of the Northern Selkup community, which had relatively little contact with the Russians until the early twentieth century. Instead, they had tighter contacts with the Ket, Evenki, Enets, Forest Nenets, and Tundra Nenets. The Northern Selkups borrowed small-scale forest reindeer herding from the Nenets and Evenki.

In the tsarist period, Selkups hunted for sables and squirrels that they used for paying taxes and trading. Important game animals were elks that were still hunted with bows, arrows, and spears in the nineteenth century. Yet, their main food was fish caught in rivers and lakes with various traps and nets. For moving between seasonal camps, they used dugout boats. In the southernmost areas, sedentary Selkups kept horses and cattle, having borrowed this livelihood from the Russian settlers. Northern Selkups were more mobile, moving between seasonal campsites with conical pole tents; some of these campsites had so-called pit houses partly dug into the ground. Northern Selkups moved (some still do) between hunting and fishing grounds on sledges drawn by harnessed reindeer. Herds were small, as each family had a few dozen reindeer. In summer, reindeer were gathered in a shed around a smudge fire that repelled biting insects. While people were engaged in summer fishing, reindeer roamed free.

In the 1930s, collective farms were created, and the local population had no other choice but to join them. Many of those who were better-off (the so-called kulaks), shamans, or those who resisted were arrested. The fear made virtually all Selkup families join the kolkhozes, which decided who can use the local hunting and herding grounds or fishing waters. From the mid-twentieth century, most Northern Selkups had to settle down in the newly built collective farm villages, leaving forest camps and nomadic tents behind. In the 1960s, smaller villages were shut, and recently settled natives were relocated to bigger settlements that attracted nonindigenous population due to the geological exploration of oil and gas. While Southern Selkups had used garden plots for most of the twentieth century, Northern Selkups have only recently started to experiment with horticulture.

In the early 1990s, the collapse of the subsidized model of the Soviet economy compelled the Selkups to look for new opportunities to survive. While in the 1990s only a few dozen Northern Selkups remained nomads and reindeer herding almost disappeared, during the last years, there has been a tendency of returning to live in the forest and engage in fishing, hunting, and reindeer herding. The return to the forest is not only related to the lack of employment in the village but also to financial support by the Yamal-Nenets autonomous region that pays allowances from its gas and oil money to the indigenous individuals who are engaged in the traditional lifestyle.

Religion

As their other Siberian neighbors, Selkups have an animistic understanding of the world whereas shamanic techniques and animal sacrifices were once of great importance. During trance, a shaman's soul travels to other realms of the cosmos with the help of spirit assistants to solve requested tasks such as finding game animals or returning a soul stolen by malevolent spirits. Depending on local cosmological accounts, the world in which a shaman moves around has three layers on which different gods and spirits dwell. The creator god Nom, who has borrowed some traits of the Christian God, lives in the sky; Kyzy reigns the realm of the dead; *Ilinta Kota* ("Mother Earth") gives birth to children by placing a child's soul in the body of a woman. Numerous spirits called *losi* are said to be harmful, helpful, or neutral toward humans. The Selkups have a complex understanding of soul forces (*ilsa*) that are located inside (heart, blood), in between (breath), or outside of one's body (shadow, carved figures). A few days after a person dies, his or her life soul *ilsa* moves to the lower world and continues to live there in a similar way as the person did on earth. One's *ilsa* dies in the lower world and turns into an insect such as a water beetle or spider. This marks the final death of a person. When shamans die, their souls are regenerated in shamans-to-become.

The Russian Orthodox Church tried to eradicate Selkup shamanic practices but met only limited success. The Soviet campaign against shamans during the 1930s hit much harder, as many shamans were taken to prison camps not to return ever. As the tradition was not transmitted, this brought about a rupture in the shamanic practices. Yet some of it lingered on here and there until the 1970s or later. Nowadays, even if practicing shamans are gone, there are sensibilities and ideas that one can call animistic and shamanistic, often including elements from the Russian Orthodoxy and the state secular ideologies.

Laur Vallikivi

See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit; Ket; Khanty; Koryak; Mansi; Nenets; Nganasan; Sami; Yukaghir

Further Reading

Helimski, E. "Selkup." In David Abondolo, ed. *Uralic Languages.* London and New York: Routledge. 1998.

Sobanski, F. "The Southern Selkups of Tomsk Province before and after 1991." *Nationalities Papers* 29, no. 1 (2001): 171–79.

Sermilik Station

The Sermilik Station (65° 40′N 38° 10′E) is situated on the Sermilik Fjord coast. The main building is 645 square ft. (60 sq. m) insolated wooden house, with three rooms for scientists, one dining and relaxation room, and a kitchen and a storage room. A dry closet is in a separate room. Another not insolated house contains a garage for a rubber dinghy, a tool shop, storeroom, summer accommodation, and a washroom. A minor building is used for fuel storage. A small hut is located on a nunatak 1,700 ft. (520 m) above sea level, near the equilibrium line of the Mittivakkat Glacier. The hut is mainly used for glaciological purposes and for data loggers from the automatic weather station here. The station is reached from the nearby (20 km) town Tasiilaq by foot, by boat, or by helicopter. The geology consists of garnet gneiss of the Naqsuqtoqdian orogeny. The landscape is alpine with elevations up to 4,000 ft. (1200 m). The higher parts are covered by the 11.5-square-mile. (30-sq.-km) Mittivakkat Glacier that has a major outlet valley reaching the coast just south of the field station. The river drains through a well-developed delta into the Sermilik Fjord, which has a tidal range of up to 10 ft. (3 m). The vegetation in the area is sparse, with Arctic scrub and some grass with flowers on south-facing slopes. Animal life is sparse too. Polar bears are rather frequent together with Arctic foxes and hares. Ptarmigans and sparrows are the most frequent birds. Arctic chars are found in lakes and in rivers without too much sediment from glaciers. In the fjord, seals and whales are often observed. The river regime is glacio-nival.

Research in the area was initiated in 1933. Under the leadership of the famous polar researcher Knud Rasmussen (1879–1933), the geologist Keld Milthers measured ablation and took stereoscopic photographs of several glaciers including the Mittivakkat Glacier. During the International Geophysical Year 1958, the geographer Børge Fristrup revisited the Mittivakkat Glacier and initiated measurements of runoff. In 1970, the Department of Geography built the field station to support the glaciological research under the leadership of Børge Fristrup. In 1972, hydrologist Bent Hasholt initiated measurements of sediment transport in the outlet valley from the Mittivakkat Glacier, and the glacier was covered by aerial photographs. When Bent Hasholt took over the leadership in 1976, the research focus was gradually shifted from mainly glaciology to studies of Arctic land-forming processes in a morphological unit, the drainage basin, where the processes and their results could be quantified. The Mittivakkat Glacier became an important part of the basin as a geomorphological agent, and it is now the local glacier in Greenland with the longest record of its mass balance. It is found that glacial erosion can deliver more than 1,000 tons per sq. km per year of sediment, and the glacier is losing mass as an effect of global warming.

The station is fully modernized and runs a standardized monitoring program transmitting data by satellite and participates in international programs, for example, SCANNET and INTERACT.

Bent Hasholt

See also: Rasmussen, Knud (1879–1933)

Further Reading

Hasholt, B. "75 Years of Research at the Sermilik Station 1933–2008." *Danish Journal of Geography* 108, no. 1 (2008).

Shackleton, Ernest (1874–1922)

Ernest Henry Shackleton was one of the foremost explorers of the Heroic Age of Antarctic Exploration. He was born on February 15, 1874, in Kilkea, Ireland. His father Henry was a farmer until the serial failures of his potato crop caused him to take up medicine and move to London. Henry had hoped that his son

Grave of British explorer Ernest Shackleton on South Georgia Island in Antarctica. (National Oceanic and Atmospheric Administration)

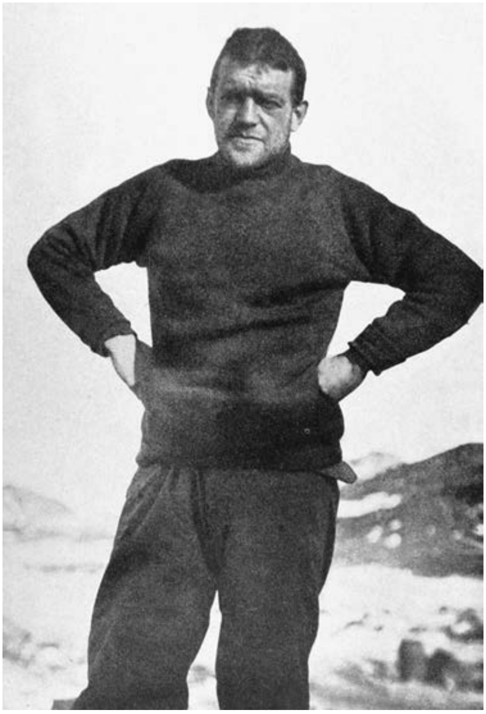


Image of Ernest Shackleton in Antartica, published in his book *The Heart of the Antarctic,* 1909. The book detailed the difficult but fascinating expedition led by Shackleton from 1907 to 1909. (National Oceanic and Atmospheric Administration)

would follow him into medicine, but at the age of 16, Ernest left school and joined the crew of the Hoghton Tower, a merchant ship. The year-long trip to and from Chile was difficult, but Shackleton was hooked. During the next eight years, he rose quickly through the ranks of the merchant service.

It was shortly after his acceptance into the prestigious Union Castle merchant line, and during his courtship of Emily Dorman, that Shackleton unexpectedly volunteered to join Robert Falcon Scott's National Antarctic Expedition in 1900. Although he joined Scott in the expedition slated for the first year, he became ill and was taken home early, where he married Emily and secured a job as the secretary of the Royal Scottish Geographical Society. In the next few years, the first of Shackleton's three children were born, although he spent much of his time away from home, traveling around England giving speeches about exploration and lining up investors for future expeditions. He suffered a setback when he quit his job and ran, unsuccessfully, for Parliament, but emerged from that episode unscathed to raise money for a venture that would become known as the Nimrod Expedition.

Although it likely never occurred, the ad Shackleton supposedly ran seeking volunteers for this expedition has become part of the lore of polar exploration: "Men wanted for hazardous journey. Low wages, bitter cold, long hours of complete darkness. Safe return doubtful. Honour and recognition in event of success." Taking place during 1908 and early 1909, this expedition did not reach the geographical pole but was nevertheless considered a resounding success, with achievements that included the following: the discovery of the magnetic pole, the first navigation of the polar plateau, and a new furthest south record set, breaking Scott's old record. Shackleton returned to England to great acclaim, becoming something of a romantic hero following the publication of his account of the expedition, *Heart of the Antarctic.* Among other honors, he was invested by King Edward VII as the commander of the Royal Victorian Order.

Before Shackleton managed to put together another expedition, two other explorers reached the pole, first Roald Amundsen and then the ill-fated Scott, who died on the return leg. Understanding that firsts were critical for raising money for such ventures, Shackleton proposed an even more dangerous journey: the first full crossing of the Antarctic continent, from sea to sea, via the South Pole. Initial funding fell through, although he was able to cobble together moneys that included sled dog donor drives by public schools, where each dog was named for a donating school. The Imperial Trans-Antarctic Expedition (1914–1917) would go down in history as one of the greatest tales of heroism and endurance, although not for the reasons that Shackleton foresaw. Ironically named *Endurance*, Shackleton's ship was caught in the ice and eventually destroyed. After then floating on an ice floe for several months and a risky sea voyage to Elephant Island, Shackleton and five others sailed 800 miles through rough seas in a 20-foot open boat, reaching South Georgia Island and safety two weeks later. He was eventually able to secure a ship to rescue his men on Elephant Island. Gone nearly three years, Shackleton had missed most of World War I, and although he volunteered for the war both before and after the expedition, he was criticized for the resources that had been expended.

Shackleton's final expedition would come in 1920, after several more years on the lecture circuit. The Shackleton–Rowett Expedition had a broad mandate to explore the circumpolar Antarctic region. On the way south, Shackleton took sick, recovering briefly but suffering a heart attack on South Georgia Island, where he died on January 4, 1922. His legacy was not immediately secure, with other explorers from this era, chiefly Scott, overshadowing him. With the publication of Alfred Lansing's *Endurance: Shackleton's Incredible Journey* (1959), however, came renewed interest in the events of the Imperial Trans-Antarctic Expedition. From this point on, the heroism of his journey and qualities of his leadership would be increasingly celebrated. Shackleton now serves as the model for the spirit of exploration, heroism, and above all indomitability that typified the explorers of the Heroic Age of Antarctic Exploration.

Andrew J. Howe

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s)

Further Reading

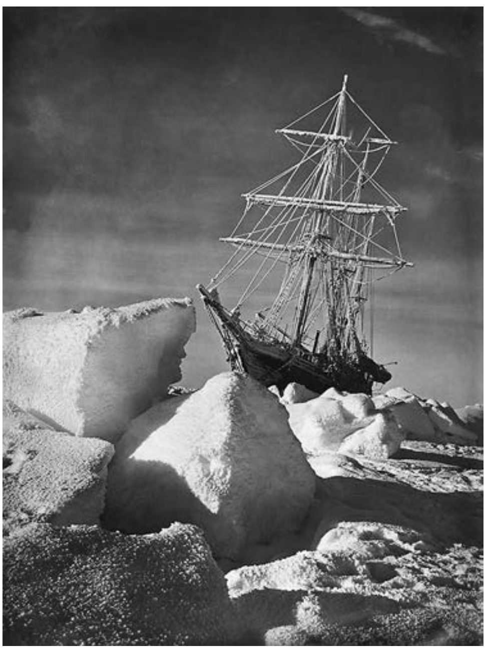
Huntford, R. *The Shackleton Voyages.* London: Weidenfeld and Nicolson, 2002.

Lansing, A. *Endurance: Shackleton's Incredible Adventure.* New York: McGraw-Hill Book Company, 1959.

Shackleton, Ernest. *South: The Story of Shackleton's Last Expedition 1914–17.* New York: The MacMillan Company, 1926.

Shackleton–Rowett Expedition (1921–1922)

The Shackleton–Rowett Expedition (1921–1922) was the last of Sir Ernest Shackleton's four visits to the Antarctic. This expedition, the third that the famed explorer would lead, ended in failure, and many consider his death of a heart attack at the age of 47 to signal the end of the Heroic Age of polar exploration. Although both failed to accomplish their goals, this expedition stands in marked contrast to his most famous Antarctic effort, the Imperial Trans-Antarctic Expedition (1914–1917). Displaying legendary bravery and perseverance, Shackleton and company had survived long odds and returned to Europe to find the continent embroiled in World War I. This conflagration delayed plans for another expedition, and funding would prove difficult to obtain even after the war. Despite the fame it had won him, saving the crew of the *Endurance* proved a costly affair, and Shackleton had accrued a debt that needed to be paid off before a return to the polar regions was feasible.



Explorer Ernest Shackleton's ship *Endurance* trapped in ice. In a harrowing attempt to make a transantarctic journey, Shackleton's group lost the ship and nearly all of their pack animals, but escaped with their lives, many of them signing on with their captain for a subsequent (failed) attempt. (Hulton-Deutsch Collection/Corbis)

After an aborted attempt to put together an expedition to the Canadian High Arctic, Shackleton convinced his childhood friend John Quiller Rowett (1876–1924) to finance an Antarctic expedition. Rowett, who had made a fortune selling rum and other spirits, contributed £70,000 to the effort, bankrolling the enterprise. The overall aim of the expedition was unclear; among its goals were projects involving Antarctic and subantarctic cartography, search for new animal life, an oceanographic study of underwater features, and a search for mineral deposits. As in the Imperial Trans-Antarctic Expedition, John Robert Francis "Frank" Wild (1873–1939) served as Shackleton's second in command.

Shackleton secured a former Norwegian sealer–the *Quest*–that turned out to be ill suited to the needs of polar exploration. It was slow and handled poorly the large waves of the southern oceans, burning coal at an impressive rate. The engine performed badly, leading to numerous delays. Of the 20 men who began the expedition (several additional sailors joined in Rio de Janeiro), about half had served with Shackleton before, most of them on the *Endurance.* Among those new to polar exploration were two boy scouts who had been selected from 1700 applicants as winners of a special competition.

The expedition began on September 17, 1921, the day after a royal send-off by King George V. The voyage south was beset by problems at every turn, including broken engine parts that required fixing at nearly every port, as well as a complete engine overhaul in Rio de Janeiro. After several months, Shackleton became ill. He declined quickly, although managed to hold on until the expedition reached South Georgia Island. Despite his condition, he visited the whaling station that had signaled salvation four years earlier during the Imperial Trans-Antarctic Expedition, writing as a final journal entry:

> At last after 16 days of turmoil and anxiety on a peaceful sun shining day we came to anchor in Grytvitken. How familiar the coast seemed as we passed down. We saw with full interest the places we struggled over after the boat journey. Now we must speed all we can but the prospect is not too bright for labor is scarce. The old smell of whale permeates everything. It is a strange and curious place. A wonderful evening. In the darkening twilight I saw a lone star hover, gem like above the bay.

A few hours later, in the early morning of January 5, 1922, Shackleton died of a heart attack.

After an aborted attempt to return his body to England, Shackleton was buried on South Georgia at the request of his widow. Meanwhile, the *Quest* continued south under the leadership of Frank Wild, reaching the pack ice after a three-week trip. The ship was too small, slow, and light to negotiate the ice successfully, and Wild was forced to turn back, trying to break through on several other occasions after continuing west. Each attempt ended in failure, and with the summer rapidly coming to an end, Wild turned toward South Georgia, reaching it on April 6, nearly three months to the day after Shackleton's death. Even the trip back was not uneventful, as the ship was trapped in ice for a week and a coal shortage meant that the stokers had to mix elephant seal blubber with the coal to make it last.

The next part of the voyage took the *Quest* east toward Cape Town. The expedition visited the Tristan da Cunha Islands, and later Gough Island, collecting bird, plant, and rock specimens. While resupplying and planning the next summer's expedition in Cape Town, Wild received word from Rowett that the expedition had been recalled. The *Quest* arrived in Plymouth Harbor on September 16, 2012, one year to the day after the royal send-off.

Even setting aside the untimely death of Shackleton, the expedition was conceded to be a failure by all concerned. It essentially ended Wild's career, as he was blamed for many of the problems, even though most of the critical ones were attributable to Shackleton. The boat had been poorly chosen, and stopping in Rio de Janeiro instead of Cape Town resulted in equipment that had been shipped to the latter location sitting unused. Shackleton's idea to bring along an airplane for exploration was intriguing, but some needed parts were not taken and the plane never flew, the pilot hired to fly it spending the entirety of the expedition doing other jobs. Future expeditions would make better use of technology, and polar exploration entered its mechanical age. Only two of the crew ever returned to the Antarctic, and none of these were ones who had served on the *Endurance* (the only expedition member to become an Antarctic explorer of any note was Boy Scout James Marr). Sir Ernst Shackleton was the last of the romantic heroes who, instead of marshaling technology in their bid for glory, had instead relied on courage and a flair for the dramatic. The ill-fated Shackleton–Rowett expedition served as an ignominious end to not only the Heroic Age of exploration, but also its most heroic explorer.

Andrew J. Howe

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s); Shackleton, Ernest (1874–1922)

Further Reading

Huntford, R. *The Shackleton Voyages.* London: Weidenfeld and Nicolson, 2002.

Shackleton, Ernest. *South: The Story of Shackleton's Last Expedition 1914–17.* New York: The MacMillan Company, 1926.

Siberian Yup'ik

The Siberian Yup'ik are an indigenous group that live in the coastal villages of Novoye Chaplino, Sireniki, Rovideniya, and Uel'kal' on the Chukchi Peninsula in the northeastern part of Russia. A small group of Siberian Yup'ik live in the villages of Savoonga and Gambell on St. Lawrence Island in Alaska. The Siberian Yup'ik is the smallest of the three groups of Yup'ik in Alaska. The other two groups are the Central Yup'ik and the Alutiiq (also called the "Chugach" or "Sugpiaq"). In 1931, the Soviet Union official named the Siberian Yup'ik the "Yuit." The Siberian Yup'ik are also known as Yup'ik, Bering Strait Yup'ik, Yuk, or Siberian Eskimo.

The name Yup'ik is broken down into two parts to derive its meaning. In the Yup'ik language, *yuk* means a "person" and *pik* means "real." Thus, to the translations of Yup'ik to English would be roughly the equivalent of "real people."

Until the middle of the twentieth century, the Yup'ik were a nomadic group that followed the food sources with the change of seasons. For example, in the spring, summer, and early fall, the Yup'ik would travel to fish camps and harvest salmon. The salmon would be smoked and dried to preservation and food throughout the winter. During other times of the year, seals, moose, bears, and caribou would be harvested for food. Many of these traditional food gathering activities persist today.

Language

The Siberian Yup'ik speak the Central Siberian Yup'ik language. The Central Siberian Yup'ik language is one branch of the Eskimo-Aleut family. There is almost no difference in the dialect spoken on the Chukchi Peninsula and the St. Lawrence Island Siberian Yup'ik. Children on St. Lawrence Island are taught the language, which results in more speakers than in Russia, where children are not taught. In the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the Central Siberian Yup'ik language is listed as severely endangered with less than 1,200 fluent speakers (1,000 in Alaska and 200 in Russia).

Worldview

The traditional Siberian Yup'ik belief system was that all natural things (animate and inanimate) have a spirit (e.g., an animistic worldview) and must be respected as a living being. Under this worldview, it is taboo to disrespect nature. The Yup'ik group holds the belief that no one dies but cycles through stages of birth, death, and rebirth. The naming of a newborn child is traditionally named after the last village person to have passed away. Shamans are important to the Siberian Yup'ik. Shamans were the protectors and mediator of the Siberian Yup'ik from the harmful and benign elements. The Siberian Yup'ik shamans had the ability to cure people of illness (by removing the evil spirit), facilitate childbirth, ensure successful hunts, locate hidden or lost items, and see into the future. They also guided the dead on their journey beyond. An important task of the shaman was to maintain good relationships with marine mammals.

Environmental Concerns

On St. Lawrence Island is a former air force base and radar site built in 1952 during the Cold War. The Siberian Yup'ik used the area for subsistence activities. Siberian Yup'ik elder Annie Alowa (1924–1999), while working as a community health aid, noticed more cancers and elevated miscarriages. In the 1970s, the base was closed leaving behind almost tens of thousands of barrels of unknown fluids. Almost 9 square miles (23 sq. km) on St. Lawrence Island were contaminated with 220,000 gallons of chemicals. Annie Alowa tried for two decades to compel the military to clean up the toxic waste. The film *I Will Fight until I Melt* (*Whanga Pillugaghlleqaqa*

Kenlanga Ughullemnun) was made about her struggle. Annie Alowa died of cancer in 1999 and was not successful in getting St. Lawrence Island cleaned up.

Andrew J. Hund

See also: Aleuts/Unangax; Coastal Erosion; Eskimos; Migration Waves of the Eskimo-Aleut

Further Reading

de Reuse, W. *Siberian Yupik Eskimo: The Language and Its Contacts with Chukchi.* Studies in Indigenous Languages of the Americas. Salt Lake City: University of Utah Press, 1994.

Krupnik, I., and N. Vakhtin. "Indigenous Knowledge in Modern Culture: Siberian Yupik Ecological Legacy in Transition." *Arctic Anthropology* 34, no. 1 (1997): 236.

Smeerenburg

Smeerenburg (79° 43′N 10° 59′E) is a settlement located northwest of Svalbard on Amsterdam Island. The name "Smeerenburg" literally translates to "blubber town." It is an example of an early modern whaling station. In the seventeenth century, it was often considered one of the largest and most relevant shore research stations of the whole European whaling hubs. After the arrival of the first Dutch whalers in 1614, Smeerenburg developed quickly into a large multinational processing center for the reduction of whale blubber to train oil. By the 1630s, there were at least eight large tripods being used, and almost 20 buildings had been constructed in Smeerenburg. Smeerenburg, however, remained largely a seasonal whaling station with the whalers arriving in early summer and leaving at the beginning of the fall.

In the beginning, Smeerenburg was used as a whaling station by Dutch, Danish, and Basque whalers. The Dutch forced the other nations out of Smeerenburg in the mid-1620s, and the use of the place remained limited to whalers from various Dutch cities. Only during the winters of 1633/1634 and 1634/1635 did Dutch whalers overwintered at Smeerenburg. This was done to protect the installations from being taken over by other whalers after their return in the spring. According to modern estimates, up to 200 whalers have been living and working at Smeerenburg during the season. The actual number of people living in Smeerenburg has often been overestimated substantially, and the place was depicted as an Arctic metropolis with an infrastructure comparable with a midsized European town of Early Modern.

The decline of Smeerenburg began during the 1640s as pelagic whaling replaced shore-based whaling after the introduction of ship-based train oil production. Finally, abandoned in the 1660s, Smeerenburg became largely forgotten. Archaeological excavations during the second half of the twentieth century and in particular during the years 1979 and 9181 helped to understand the real size of the operations at Smeerenburg and at the same time to falsify the widespread exaggerations of the size of the city. None of the claims for an extended city could be verified, and it needs to be stated that Smeerenburg was without any doubt the most important center of Early Modern shore-based whaling, but by no means an Arctic metropolis. Today the ruins of Smeerenburg are part of the Northwest Spitsbergen National Park and one of the most visited places on the whole Spitsbergen Archipelago during the summer tourist season.

Ingo Heidbrink

See also: Whaling and Arctic Exploration

Further Reading

Conway, W. *No Man's Land: A History of Spitsbergen from Its Discovery in 1596 to the Beginning of the Scientific Exploration of the Country.* Cambridge: Cambridge University Press, 1906.

Scoresby, W. *An Account of the Arctic Regions with a History and a Description of the Northern Whale-Fishery.* Edinburgh: 1820, n.p.

Snow Bunting

The snow bunting (*Plectrophenax nivalis*) is a 6–7 inches (15–18 cm) long and with a wingspan of 12.5–15 inches (32–38 cm), and weighing between 1 and 1.8 ounces (26–50 g). The appearance of the male, with its white plumage and black back, tail, and wing tips, in summer is colorful. By contrast, the female is much less colorful. The species is known under many poetic folk names, such as *snow flake* in Alaska, *снегурка* "snow maiden" in northern Russia, *snjófugl* "snow bird" as well as *snjótittlingur* "little snow bird" in Iceland, which has to do with its presence in the harsh, frozen surroundings during winter. All circumpolar people are acquainted with this bird. It is known as *alap* in North Sami, *Туллук* in Sakha, *qateghrewaaq* in Siberian Yup'ik, *qupoloraarsuk* in Kalaalisut (West Greenlandic), *gwigee-zuu* in Kutchin (Gwich'in), and *nehggux* "grayish" in the Dené languages. Many of its numerous folk names in Finno-Ugrian and Germanic languages refer to its reputation of being a sign of a forthcoming cold weather or snow storm. The Sami too associate the appearance of the snow bunting with forthcoming bad weather, a view they shared with many other peoples in northern Eurasia.

The snow bunting is a true Arctic passerine. The species was described for the scientific community by Friedrich Martens 1671 in his description of Svalbard, and it was first depicted by the Swedish scholar Professor Olof Rudbeck, the younger who encountered the bird on his travel to Lapland in 1695.

It is found on the vegetated tundra and mountains above the tree line in Alaska, northern Canada, Greenland/Kalaallit Nunaat, Faroe Islands, Iceland, Jan Mayen, Svalbard, Bear Island, Franz Josef Land, northern Scotland, northern Scandinavian

Peninsula, northern Russia, Novaya Zemlya and Siberia, Kamchatka, Commander Islands, and the Aleutian Islands. A part of the population spends the winter in central Eurasia and central United States, while other birds are residents. In Greenland, we can distinguish between two populations: the one of northeast Greenland winter north of the Caspian Sea, while those of southeast and western Greenland spend their winter around the large lake areas in central United States. The population has decreased in northern Europe and North America the last decades. The reason for this decline is not known.

Taxonomists differ between four subspecies with small differences in the male summer dresses. Its characteristic melodic song can be heard only in the breeding areas in the far north. It is a ground-loving bird, which during its migration appears in large flocks and always in open meadows. The males arrive first at the breeding grounds in the northern circumpolar areas, and the females join between two and six weeks later. Snow buntings forage on the ground for seeds, insects, and other invertebrates. Food is available around human settlements, where manure from animals, as well as somewhat higher temperature, creates fertile soil conditions for the vegetation eaten by the birds in springtime. Huge flocks of male birds can therefore be seen in or near inhabited areas in the Arctic. In Greenland, they are not uncommon in the villages.

The snow bunting plays a role in many Arctic folk tales and myths, for instance, among the Chukchi, Yukaghir, Yup'ik, and Inuit. The symbolic value of the bird is still important and it has, for instance, also been featured on stamps from Greenland (1989) and Iceland (1989).

According to the Danish missionary Otto Fabricius records from 1780, children on Greenland caught the buntings when the birds came down to the dwellings in the course of their migration. The birds were either shot with small bows or captured with snares made from the small horsehair-like fringes found on the edge of baleen. The snow bunting was thus the first prey that the young hunter boys of Greenland hunted (at an age of five or six years). Otherwise, it was considered of poor value, although the Greenlanders did dry its meat. Also Inuit children of the southern part of Barren Grounds, and probably elsewhere, amused themselves with trapping the small birds. It was also trapped and eaten by the various Athabaskan peoples in Alaska. In northern Eurasia, it was a welcome addition to the poor nutrients in early springtime when large flocks arrived. It has therefore been hunted for food in many parts of the northern circumpolar area, particularly during spring migration.

The snow bunting was once sought after as a cage bird in Europe and is still mentioned in many handbooks in the early twentieth century. It was regarded as an excellent bird for the show bench, among British aviculturists. On a visit to southwest Greenland in 2000, I found that it was sometimes kept as a cage bird there, although it has been mostly replaced by exotic more or less domesticated species. The Dutch Nobel prize winner and pioneering ethologist Nikolaas Tinbergen published a trailblazing study in 1939 on the spring behavior and territoriality of the snow bunting based on his extensive fieldwork in Greenland.

Ingvar Svanberg

See also: Arctic Loon; Arctic Redpoll; Arctic Seabirds; Arctic Skua; Arctic Tern; Common Raven; Gyrfalcon; Lapland Longspur; Red-Throated Loon; Rock Ptarmigan; Snow Goose; Snowy Owl; Sooty Albatross; Wandering Albatross

Further Reading

Lyon, B., and R. Montgomerie. "Snow Bunting and McKay's Bunting (*Plectrophenax nivalis* and *Plectrophenax hyperboreus*)." In A. Poole and F. Gill, eds. *The Birds of North America.* No. 198–199. Philadelphia: Academy of Natural Sciences; Washington, DC: American Ornithologists' Union, 1995.

Svanberg, I. "The Snow Bunting (*Plectrophenax nivalis*) as Food in the Northern Circumpolar Region." *Fróðskaparrit* 48 (2001): 29–40.

Snow Goose

The snow goose (*Chen caerulescens*) is a small goose native to North America. Size and weight vary widely based on gender and subspecies, with birds standing 25–38 inches (64–97 cm) tall, weighing between 4.5 and 9 pounds (2–4 kg), and with a wingspan of 53–65 inches (135–165 cm). In the more common color morph, adult birds are nearly all white, except for pink legs, a pink bill with a black grinning patch, and black primary wing feathers. In the blue morph (sometimes called "blue goose"), birds have a bluish-gray body, wings, and neck, although the head is still white. The two color morphs interbreed freely, and the offspring can be of either morph.

The goose breeds in the High Arctic regions of Canada, Alaska, and Greenland, and winters in locations throughout the United States and Mexico. They are long-distance migrants, with some populations flying more than 3,000 miles (4,800 km) between breeding and wintering sites. Migrant and wintering flocks of snow geese are often comingled with other geese species and can be massive. Several areas with significant wintering populations include the Platte River in Nebraska, the Chesapeake Bay, and the Imperial Valley of California. Due to differences in size and weight, most ornithologists recognize two subspecies, both of which are predominantly made up of the white morph: the lesser snow goose (western and central Canada) and the greater snow goose (northeastern Canada). Vagrant birds have reached Europe and Central America.

The geese achieve sexual maturity in their third year and are reported to mate for life. They return annually to the colonies in which they were hatched. To store up body fat, females forage for up to 18 hours a day after arriving at their breeding grounds. They then lay three to five eggs in a shallow depression, incubating these eggs for three to four weeks and eating very little during that time period. As is typical with ducks and geese, the young are quite precocious and leave the nest almost immediately after hatching, walking up to 50 miles (80 km) in the first few weeks of life in search of food. The majority of snow geese predation—from Arctic foxes and skuas—takes place in the six to seven weeks it takes for young to learn how to fly. The geese that survive until this point will often stay with their parents until they reach sexual maturity.

In the 1970s, the geese modified their feeding habits to include rice fields. From there, the geese learned how to feed in fields with other crops, and as a result, the population has exploded. Due to the remoteness of the various breeding populations, wildlife managers have had a difficult time estimating numbers, although the global population is felt to be up to 25 million. Despite the fact that more than 500,000 birds are killed every year by hunters, and many more birds die of predation and lead poisoning, ornithologists and ecologists agree that the snow goose population represents a potential ecological disaster to an Arctic coastline already undergoing transformation due to climate change.

Andrew J. Howe

See also: Arctic Loon; Arctic Redpoll; Arctic Seabirds; Arctic Skua; Arctic Tern; Common Raven; Gyrfalcon; Lapland Longspur; Red-Throated Loon; Rock Ptarmigan; Snow Bunting; Snowy Owl; Sooty Albatross; Wandering Albatross

Further Reading

Mowbray, T., F. Cooke, and B. Ganter. "Snow Goose (*Chen caerulescens*)." In A. Poole, ed. *The Birds of North America.* No. 514. Ithaca, NY: The Birds of North America Online, 2000.

Snow Hill Island

Snow Hill (64° 28′S 57° 12′W) is an island located in the Weddell Sea, on the east coast of the Antarctic Peninsula. It is southeast of James Ross Island, separated by the Admiralty Sound. It was discovered by James Clark Ross (1800–1862) while on the British Antarctic Expedition in 1843. Ross thought the island was a snowy slope from James Ross Island and named it only "Snow Hill."

In early 1902, the Swedish Expedition under the command of Dr. Otto Nordenskjold (1869–1928) landed in Snow Hill. The main goal of this expedition was conducting studies of various disciplines including geology, paleontology, biology, meteorology, and astronomy. Snow Hill Island functioned as the base camp for their countless voyages of exploration and collection of samples for the next two years. To survive during the expedition, they built a wooden hut that consisted of four small rooms, three bedrooms for two people each, one for the kitchen, and a gap to be used as a dining room and cabinetwork. After spending two Antarctic winters waiting for the *Antarctic* ship to go pick them up, they were finally rescued by the argentine corvette *Uruguay*, together with the rest of the crew of the *Antarctic*, which had sunk on the way Snow Hill. The remains of the hut, which contains original objects from the expedition and functions as a living museum managed by Argentina and Sweden, were designated as a historical site and monument in the framework of the Antarctic Treaty. Only a few kilometers south of Snow Hill is where the northernmost emperor penguin colony is found.

Luciana M. Motta

See also: Paulet Island

Further Reading

Fogg, G. *The Biology of Polar Habitats.* New York: Oxford University Press, 1998.

Snowy Owl

The snowy owl (*Bubo scandiacus*) is a large owl that breeds throughout the circumpolar region of the Arctic Circle, wintering further south although still largely above 50° N. In its nearly pure white plumage, black beak, and piercing yellow eyes, the bird is unmistakable. Populations are sparsely distributed and highly nomadic based on its primary food source: lemmings. Although owls are known to prey on other rodents, fish, small birds, and even carrion, snowy owl populations are highly correlated to the boom/bust cycle of the lemming. When that food source crashes or a winter is particularly harsh, birds have shown up as far south as California, Texas, and Georgia, as well as China.

Recent mitochondrial DNA research has resulted in the reclassification of the species. Once thought to be the sole member of the *Nyctea* genus, it is now classified as a member of the horned and eagle-owls of the *Bubo* genus. Adult males are nearly pure white, whereas females and young birds develop black scalloping on their back, wings, cap, and breast. Size varies widely due to sex; in owls, females are larger and heavier. Length ranges from 20 to 28 inches (51–71 cm), with wingspan extending between 50 and 60 inches (127–152 cm). Ranging between 3.5 and 6.5 pounds (1.5–3 kg), the snowy owl is on average the heaviest owl species in North America. It is well suited for life in the Arctic, with a dense configuration of feathering and feathered feet for warmth, as well as a plumage that allows them to blend in with their surroundings when hunting.

To protect themselves against predators, snowy owls lay their eggs at a high point in the tundra, on top of large rocks with indentations, or upon gravel bars in large rivers. Clutch size is dependent on the quantity or availability of lemmings

Snowy owl in flight. (Shutterstock.com)

and can vary from a couple of eggs to up to a dozen. Eggs laid first produce larger offspring that are more likely to survive to adulthood. Predators are numerous, including gray wolves, Arctic foxes, ravens, and skuas. To protect their young, parents will dive-bomb predators or engage in distraction displays to divert their attention. Snow geese and other birds will often nest near owls to benefit from their ability to combat predators.

Historically, Inuit used snowy owl feathers for fletching arrows. Although now forbidden due to federal protections, baby owls were routinely captured and raised as pets. Inuit stone carvings, paintings, and knit hangings indicate the respect with which this species is held in indigenous culture, particularly in the Mackenzie River delta region, where names chosen upon passage into adulthood are most often bird-themed. The snowy owl is the official bird of Quebec and, due to its rarity and beauty, is highly sought after by birdwatchers both in North America and Eurasia. The species was introduced to an even wider audience due to the Harry Potter book series, during the course of which the title character acquires a beloved pet snowy owl named Hedwig.

Andrew J. Howe

See also: Arctic Loon; Arctic Redpoll; Arctic Seabirds; Arctic Skua; Arctic Tern; Common Raven; Gyrfalcon; Lapland Longspur; Red-Throated Loon; Rock Ptarmigan; Snow Bunting; Snow Goose; Sooty Albatross; Wandering Albatross

Further Reading

Parmelee, D. "Snowy Owl (*Bubo scandiacus*)." In A. Poole, P. Stettenheim, and F. Gill, eds. *The Birds of North America.* No. 10. Ithaca, NY: The Birds of North America Online, 1992.

Sooty Albatross

Named after the sooty brown color of its feathers, the sooty albatross (*Phoebetria fusca*) is one of the many species of albatrosses that inhabit the Southern Ocean territories. Albatrosses are the largest of the procellariforms, a taxonomic group they share along with shearwaters, fulmars, storm petrels, and diving petrels.

Sooty albatrosses are not as big as their wandering albatross cousins; they are medium-sized birds measuring around 33 inches (85 cm) from beak to tail. They have a wingspan of around 6 ft. (2 m). Adult sooty albatrosses weigh between 4.5 and 7.5 pounds (2.1–3.4 kg). The tail of this albatross is wide diamond shaped. Juveniles are similar to adults, although they can have paler feathers on the nape and upper back. Its distinctive feature is a white crescent that surrounds the eye, and the bill is black with a yellow-orange groove in the lower jaw.

Spending most of the year at sea, the sooty albatross nests in islands in the South Atlantic (Gough Island and the Tristan da Cunha group) and Indian Oceans (Prince Edward Island, Marion Island, the Crozet Islands, Amsterdam Island, and Kerguelen Islands). They are colonial, nesting in loose colonies of up to 50–60 nests. The sooty albatross performs an elegant and complex courtship display at a nest site at the moment of choosing their mates. The pair bond formed following these displays lasts for life, and pair bonds are reestablished each breeding season (repeating displays at nest sites on arrival). Laying occurs between September and December, with a single egg laid in a nest made of mud and plant matter, in steep slopes and cliffs. The egg is incubated by both parents for 65 to 75 days. Parental care continues for five months after hatching, at which time the chick leaves the nest and becomes independent. Albatrosses are highly philopatric, meaning they will usually return to their natal colony to breed. After breeding season, adults move north from subantarctic to subtropical seas, whereas immature birds tend to remain in subtropical areas year-round.

Sooty albatrosses are pelagic birds, which means they use land only for nesting, but they forage in the open ocean covering impressive extensions of water areas to find food, from subantarctic islands to south of the Antarctic polar front. Their diet is predominately squid, fish, crustaceans, and carrion, although proportions of each vary between years and locations. As predators, albatrosses are supremely adapted for economic long-distance flight. Their long wings (up to 2 m wingspan) and light bodies make them perfect natural gliders. They are highly efficient in the air, using dynamic soaring and slope soaring to cover great distances with a low energy cost. During the breeding season, they have a potential maximum foraging range of a little more than 1,300 miles (2,150 km). The flying speed and foraging ranges appear very high for birds of this size and weight, with records of 3,700 miles (6,000 km) traveled in 15 days, at maximum speed records of more than 50 mph (84 km/h) for the light-mantled albatross (*Phoebetria palpebrata*), a species very similar to the sooty.

Most recorded feeding methods in these birds involve scavenge and surface seizing, supplemented by shallow plunges and dives from the surface, sometimes in association with fishing trawling discard. They are not well adapted to dive (dives don't exceed 1 m) differently from other albatrosses that can dive up to 50 ft. (15 m) to catch prey.

All albatross colonies are on islands that historically were free of land mammals, the only potential predators they would have on land. In the water, their natural predators can be orcas and leopard seals. But both adults and juveniles are subject to either indirect or direct pressure from humans, in the ocean and on land. Drowning in longline fishing gear is their primary threat, but also hook and plastic ingestion and predation by introduced rats in some of their nesting areas are likely to cause breeding failures.

Limited information is available to determine population trends, but declines have been reported at all sites. With total annual breeding population estimations at 13,200–14,500 pairs and decreasing, estimations of global decline are of 20–50 percent in the last three generations. Sooty albatrosses are enlisted as endangered by IUCN and are part of the ACAP (a multilateral agreement that seeks to conserve albatrosses and petrels) species list. Determining foraging distribution of the species and its overlap with longline fisheries, promoting adoption of best-practice mitigation measures in all fisheries within the species range and education programs, is part of the conservation actions proposed to help keep albatrosses populations safe.

Luciana M. Motta

See also: Arctic Loon; Arctic Redpoll; Arctic Seabirds; Arctic Skua; Arctic Tern; Common Raven; Gyrfalcon; Lapland Longspur; Red-Throated Loon; Rock Ptarmigan; Snow Bunting; Snow Goose; Snowy Owl; Wandering Albatross

Further Reading

Croxall, J., and R. Gales. "Assessment of the Conservation Status of Albatrosses." In G. Robertson and R. Gales, eds. *Albatross Biology and Conservation.* Chipping Norton, Australia: Surrey Beatty and Sons, 1998, pp. 46–65.

Weimerskirch. G., H. Weimerskirch, and G. Robertson. "Satellite Tracking of Light-Mantled Sooty Albatrosses." *Polar Biology* 14 (1994): 123–26.

Southern Bottlenose Whale

The southern bottlenose whale (*Hyperoodon planifrons*) is a member of the family Ziphiidae. Other common names for this whale are the Antarctic bottlenose whale and the flathead whale. This whale is circumpolar in the Southern Hemisphere as low as 30° S. They migrate with seasonal movements of more than 620 miles (1,000 km) and summer in the Antarctic waters and are common as close as 60–75 miles (100–120 km) to the ice edge and sometimes reaching the ice edge. *H. planifrons* is a deepwater oceanic cetacean not usually found over the continental shelf. Known areas of concentration include the Atlantic and eastern Indian Ocean between 58° and 62° S. They are the most common beaked whale sighted in Antarctic waters and are considered abundant there.

This species is characterized by its robust, stocky body, a large, steep forehead, and a bulbous melon. The beak is dolphin-like. The blow is short. Adult males have a squared-off forehead with a melon that may overhang and a pair of conical teeth at the tip of the lower jaw that are not visible outside the closed mouth. Males are usually heavily scarred. Both sexes have a prominent dorsal fin located along the rear half of the back. Their color ranges from grayish-brown to yellow with a lighter-colored belly and head. Young animals have white heads giving them a distinct color pattern. Females are slightly longer than males, but this is based on a small sample size. Confirmed maximum lengths for *H. planifrons* are 24.5–25.5 ft. (7.5–7.8 m) for females and 23 ft. (7.0 m) for males. Calves and young specimens are less than two-thirds of the adult size. The diet of the southern bottlenose whale is limited. Most of what is known has been retrieved from the stomachs of stranded or caught from temperate zones. What is known suggests that their diet consists of oceanic cephalopods (primarily squid).

The ecology, social organization, courtship behavior, reproductive biology, and longevity for *H. planifrons* are largely unstudied. Groups of fewer than 10 appear to be the most common, but pods of 25 have been sighted. They do breach and may porpoise away from vessels. They are deep divers and can remain underwater for an hour or more. The southern bottlenose whale was never commercially hunted. They are not rare and appear to be abundant in Antarctic waters. Commercial whaling of this species is regulated by the International Convention for the Regulation of Whaling. It is listed in Appendix I of CITES.

Joyce M. Shaw

See also: Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Northern Bottlenose

Whale; Orca; Southern Right Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Department of the Environment (Australia). *Hyperoodon planifrons in Species Profile and Threats Database.* Canberra, Australia: Department of the Environment, 2013.

Ross, G. *Review of the Conservation Status of Australia's Smaller Whales and Dolphins.* Canberra, Australia: Department of the Environment and Water Resources, 2006.

Taylor, B., R. Baird, J. Barlow, S. Dawson, J. Ford, J. Mead, G. Notarbartolo di Sciara, P. Wade, and R.L. Pitman. "Hyperoodonplanifrons." In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.

Southern Elephant Seal

The southern elephant seal (*Mirounga leonina*) breeds almost exclusively on Southern Ocean islands, with one continental population at the Valdés Peninsula in Argentina, and occasionally on seasonal pack ice near Signy Island, South Orkney Islands. Large populations breed on South Georgia, Iles Kerguelen, Heard Island, and Macquarie Island, with numerous smaller populations primarily at the Prince Edward, Crozet, South Shetland, South Sandwich, and the South Orkney islands. The genus name is from *miouroung*, the Australian aboriginal name for the "species," and *leonina* from Latin *leoninus*, "lionlike," probably referring to both size and roar. Elephant seal females may grow to about 9 ft. (2.8 m) in length and weigh up to almost 2,000 pounds (900 kg). Adult males are considerably larger at maximally 16 ft. (5 m) and more than 11,000 pounds (5,000 kg), a remarkable sexual dimorphism. They can live up to more than 23 years of age. Female southern elephant seals sexually mature at about two to six years, while males sexually mature about four to five years. Males mature socially between six to eight years, with the majority of breeding bulls being between 9 and 12 years of age. The age at social maturity is related to the intensity of competition within differently sized populations. A Southern Ocean-wide estimate of numbers is around 600,000.

Southern elephant seals are heavily built, neck inconspicuous with a large thorax. Males after the first three years are already larger than females. The adult male has a conspicuous proboscis that enlarges during the breeding season. The males especially have large canines with small peg-like postcanines. The short pelage is typically dark gray, lighter ventrally, fading to various shades of brown. No superimposed pattern of spots or other markings, but adults have scarring around the neck and chest, adult females a lighter yoke around the neck from bites during mating.

The southern female elephant seals aged 3 to 23 years give birth to single pups from late September to early November singly but usually within aggregations of

2–1,600 females (the largest on record, in October 1985, at Heard Island) depending on location. Pups nurse for a period of three weeks, to late November, but the timing of events depends on latitude, usually delayed at higher latitudes. A few days before the pups wean, females mate on land with dominant males (beachmasters) that usually allow assistant beachmasters into the harem when it exceeds about 60 females. After the breeding season adults depart to sea, only to return for a drastic molt on land where the entire epidermis are shed in patches from December to March with younger age classes starting already in November. Elephant seals dive deeply, feeding primarily in the mid-water regions of the water column at depths of around 650–2,000 ft. (200–600 m) with dives of about 20–30 minutes in duration. They have been known to dive to depths of around 7,000 ft. (2,133 m) lasting up to two hours. Elephant seals spend up to 90 percent of their time at sea diving with surface intervals of approximately two to three minutes. They exhibit diel diving patterns with shallower dives at night, and deeper dives during the day, likely as a response to vertically migrating prey. Myctophid fish and cephalopods are the usual prey although there appears to be substantial geographic variability as well as considerable variability within areas and seasons.

Elephant seals primarily use beaches for breeding, and vegetated areas inland from breeding beaches during the monthlong molt haul out. There is a predictable migration in elephant seals: a post-breeding pelagic period of about two to three months in females (approx. late October to mid-January) and six months for males when they remain in a reasonably well-circumscribed area, for example, mostly within 930 miles (1,500 km) from Marion Island, while during the eight-month post-molting period. Their feeding area is some 1,200–2,000 miles (2,000–3,100 km) distant at the Antarctic Polar Front and farther south on the Antarctic continental shelf. These statistics vary with different populations and the bathymetry of foraging areas and depend on whether the animals use a pelagic or benthic diving strategy. Single individuals are commonly sighted on the southern fringes of Australia, New Zealand, South Africa, and South America, primarily in summer.

Threats

Although they were exploited for their oil in the eighteenth and nineteenth centuries, it subsequently recovered under protection, and then followed a period of decline from the 1950s, at different rates at different places and periods. A subsequent stabilization, and currently a detectable increase, followed despite the attention of their main predator, the killer whale *Orcinus orca*, especially where the populations are smaller. Their foraging range overlap with fisheries activities, especially longlining for Patagonian toothfish, and individuals frequently become entangled in lines and hooks, which may result in death. The distribution and abundance of the ice-tolerant southern elephant seal will be the least negatively influenced by changes in pack ice characteristics, although population size and distribution may be influenced most immediately by changes in their food resources due to factors other than climate.

Conservation Status

The southern elephant seal is listed as lower risk, least concern on the IUCN Red List and is protected under legislation of the various states that have sovereignty of island sites; within the Antarctic Treaty Area, it is protected under the Protocol on Environmental Protection to the Antarctic Treaty. It is also fully protected under the Convention for the Conservation of Antarctic Seals and the Convention on the Conservation of Antarctic Marine Living Resources.

Marthán Bester

See also: Antarctic Fur Seals; Bearded Seal; Crabeater Seal; Harp Seal; Hooded Seal; Leopard Seal; Polar Bear; Ribbon Seal; Ringed Seal; Ross Seal; Sealing and Antarctic Exploration; Spotted Seal, Weddell Seal

Further Reading

Bester, M., and G. Hofmeyr. "Seals: Overview." In B. Riffenburgh, ed. *Encyclopedia of the Antarctic.* New York: Taylor and Francis Books, Inc., 2007, pp. 877–81.

Reeves, R., (ed.). "Southern Elephant Seal." In *National Audubon Society Guide to Marine Mammals of the World.* New York: Alfred A. Knopf, Inc./Chanticleer Press, 2002, pp. 158–61.

Siniff, D. B., et al. "Projecting the Effects of Environmental Change on Antarctic Seals." *Antarctic Science* 20 (2008): 425–35.

Southern Right Whale

The southern right whale (*Eubalaena australis*) is one of three species of right whales in the genus *Eubalaena.* The name "right whale" was coined by early whalers because they were the right (correct) whales to catch because they are large, slow moving, and float when dead. Populations of the southern right whale were seriously overexploited by the commercial whaling industry from the 1600s until the 1930s.

The southern right whale is circumpolar in the Southern Hemisphere and is seen from 20° to 50° S. They move from the subpolar regions as winter begins in the lower latitudes, stay more or less near continents, and avoid warm equatorial regions. The winter breeding population is concentrated near coastlines.

E. australis generally is in a uniform dark color with lighter patches including scars, belly patches, parasites, and outgrowths of callosities (raised patches of hard skin) found on and around the head that are used for identifying individual whales.

The bonnet is the largest of the callosities and is located on the anterior portion of the head. Other callosities are above the eye, behind the blowhole, and along the upper edge of the lower jaw. The southern right whale is a baleen whale that is characterized by having long plates that hang in a row from the upper jaw. These strong and flexible plates are broad at the base and taper to a fringe forming a curtain inside the whale's mouth. They move through patches of zooplankton using the baleen to strain an enormous amount of seawater as they capture their primary food source, krill and copepods.

The southern right whale is large with a rotund stocky body and head that makes up one-third of its total length. They reach an adult length of 39–59 ft. (12–18 m) with females being slightly larger than males. They can weigh up to 60 tons. A newborn calf is 13–15 ft. (4–4.5 m) in length. Females are sexually mature at about 8–10 years and produce calves every three to five years depending on feeding conditions. *E. australis* live at least 50 years.

All right whales have been protected by international treaties since 1935, but the population has never regained its precommercial hunting numbers. Illegal capture continued into the early 1970s. Several countries, Brazil, Argentina, and Australia, have designated marine protected areas that include right whale breeding habitat and calving grounds. Other threats include warming sea-surface temperatures that affect whale breeding success. The southern right whale is listed in Appendix I of CITES and CMS.

Joyce M. Shaw

See also: Antarctic Fur Seals; Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Northern Bottlenose Whale; Orca; Southern Bottlenose Whale; Sperm Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Leaper, R., J. Cooke, P. Trathan, K. Reid, V. Rowntree, and R. Payne. "Global Climate Drives Southern Right Whale (*Eubalaena australis*) Population Dynamics." *Biology Letters* 2, no. 2 (2006): 289–92.

Rosenbaum, H., et al. "World-Wide Genetic Differentiation of Eubalaena: Questioning the Number of Right Whale Species." *Molecular Ecology* 9, no. 11 (2000): 1793–802.

South Pole

The South Pole (90° S) is opposite of the North Pole (90° N), located on the Antarctica continent, and is the southernmost location of the earth. It has a featureless, desolate, barren, frozen desert climate where all directions face north. No native plants or animals live at the South Pole, and there is almost no precipitation. The snow accumulation of roughly 8 inches (20 cm) is the result of windswept snow. The South Pole is around 9,300 ft. (2,835 m) above sea level when considering the ice it sits on. Below the ice, at the bedrock, the South Pole is only 100 ft. (30 m) above sea level. The closest body of water to the South Pole is the Bay of Whales around 800 miles (1,300 km) away.

The South Pole is frigid with an average winter temperature of −58°F (−50°C). The summer temperatures average (in January) −15°F (−25.9°C). The highest temperature recorded in the South Pole was 9.9°F (−12.3°C) on December 25, 2011, at Amundsen–Scott Station, while the lowest temperature was −117.0°F (−82.8°C) on June 23, 1982. This is not the coldest temperature ever recorded, but one of the coldest. The lowest officially recorded temperature ever was −128.6°F (−89.2°C) at the Russian Vostok Station on July 21, 1983. In 2010, remote temperatures collected from high ridge in the East Antarctic Plateau were −136°F (−93°C).

There are technically three locations for the South Pole. Two of these locations are near the U.S. Amundsen–Scott South Pole Station. At the Amundsen–Scott station, there is the ceremonial South Pole, where the Antarctic Treaty was signed. The exact spot has a striped barber pole with a reflective globe on the top that is circled by the flags of 12 signatory states of Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the Soviet Union, the United Kingdom, and the United States. The actual South Pole (also sometimes called the Terrestrial South Pole,

View of the South Pole and the Antarctic Plateau. The ice here is more than 9,000 feet thick. (National Oceanic and Atmospheric Administration)

Geodetic Pole, or the geographic South Pole) is the place where the earth's axis of rotation intersects the earth's surface. Presently, the geographic South Pole is a short distance from the ceremonial South Pole and is marked with a brass plaque with sign that reads "Geographic South Pole." There are a series of old poles that mark the previous geographic South Poles. The geographic South Pole travels roughly 32 ft. (9.9 m) per year, because the ice beneath the spot is shifting downhill toward the Weddell Sea.

The other South Pole is the South Magnetic Pole, which is the point on the earth surface where the direction of the magnetic field of the earth is vertical. Presently, it is located about 1,700 miles (2,828 km) from the geographic South Pole and just off the coast of Adélie Land (64° 4′S 137° 3′ E) in 2010. It is outside the Antarctica Circle and is constantly moving approximately 6–9 miles (10–14 km) per year due to polar drift. The Geomagnetic Pole (also called the dipole pole) should not be confused with the South Magnetic Pole. The Geomagnetic Pole is the place where two points, that are antipodal, intersect the earth surface. Its present location is 80° 1′S 107° 6′E (2010), which is close to the Russian Vostok Station.

There are two seasons at the geographic South Pole, which are six months of summer (September to March) and six months of winter (March to September). The South Pole has six months of daylight where the sun never sets and six months of night where the sun never rises. During summer, the sun is low in the sky and continuously moves above the horizon. The South Pole has a high albedo, and as a result, the amount of sunlight reaching the area is limited because the snow and ice cover reflects it. With much of the sunlight reflected and an elevation of more than 9,000 ft. (2,800 m), the South Pole is one of the coldest climates on earth. Temperatures are significantly lower at the South Pole than the North Pole, principally because the South Pole is in the middle of a continental landmass and at a higher altitude rather than in the middle of an ocean, which acts as a heat reservoir. There is no time zone in the South Pole, and thus people, expeditions, and others can use whichever time zone they choose or find fitting.

Andrew J. Hund

See also: North Pole; Three-Pole Concept

Further Reading

Amundsen, R. *The South Pole: An Account of the Norwegian Antarctic Expedition.* n.p.: L. Keedick, 1913.

Huntford, R. *The Last Place on Earth.* London and Sydney, Australia: Pan Books, 1985.

South Sandwich Islands

There is a crescent-shaped chain of 11 subantarctic uninhabited volcanic islands located in the South Atlantic, 470 miles (760 km) southeast of South Georgia and

800 miles (1,300 km) from the Antarctic Continent, between 56º 18′ and 59º 28′ S, and 26º 14′ and 28º 11′ W. The islands are noted for their extreme beauty, active volcanism, harsh climate, treacherous waters, and abundant fauna, including penguins, seals, and birds. Their total area is 310 sq. km. Part of the British overseas territory of South Georgia and the South Sandwich Islands, these are claimed by Argentina. The bigger islands are almost permanently covered in ice, while the smallest isles are free. These islands are open to visitors but devoid of basic supporting infrastructure and medical or search and rescue facilities.

South Sandwich Islands are located between a deep (up to 28,000 ft. [8,625 m]) sea trench on the east and the Scotia Sea on the west. From north to south, the islands are called Zavodovski Island, Leskov Island, Visokoi Island, Candlemas Island, Vindication Island, Saunders Island, Montagu Island, Bristol Island, Bellingshausen, Thule (or Morrell) Island, and Cook Island. They are of great interest to tourists and scientists, and sport attractions such as one of the largest penguin colonies in the world, found in Zavodovski Island, home to around 1 million breeding couples of chinstrap penguins. Active volcanoes include Mount Michael, a glaciated yet active volcanic cone in Saunders Island. They may be surrounded by pack ice in winter.

The islands are open to researchers and tourists but contain no airstrips and enjoy no regular ship services. A license must be obtained before landing, irrespective of nationality, and this involves a fee. Cruisers, yachts, and other chartered ships are the only means of travel. The islands have no roads. The former whaling stations, in a state of disrepair, cannot be approached without permission, due to safety concerns (including asbestos dust).

Captain Cook first sighted the islands in 1775, on board HMS *Resolution*, claiming them for Great Britain. Together with South Georgia, they are a British Overseas Territory, administered by the Commissioner of South Georgia and the South Sandwich Islands, a post held concurrently by the governor of the Falkland Islands, based on Stanley. The three northernmost islands, missed by Cook, were discovered by Russian explorer Fabian von Bellingshausen 45 years later.

Argentina claims the islands and has not ruled out resorting to force. To this territorial dispute, we must add the question of the extent to which the exclusive economic zone (EEZ, giving exclusive rights to the coastal state to fisheries, oil, gas, and other natural resources) applies to the waters below 60º S, subject to the Antarctic Treaty System (whereby territorial claims are frozen). In declaring the EEZ in 1993, authorities stated that fisheries regulations did not apply below that parallel.

In 1976, Argentina established a clandestine base on Thule/Morrell Island (Southern Thule Group), called Corbeta Uruguay, and the British Government chose not to make the incident public. Some voices see it as an attempt to defuse tensions, while others perceive as an instance of appeasement. British forces evicted the Argentine personnel, who surrendered on June 20, 1982, in the final action of the

Falklands War (Operation Keyhole). Later that year, British forces destroyed the facilities to prevent a return of Argentine troops, leaving only a refuge hut.

Alex Calvo

See also: Paulet Island; Snow Hill Island

Further Reading

Foreign and Commonwealth Office. "UK Government Strategy: South Georgia and the South Sandwich Islands: 2010–2015." http://www.fco.gov.uk/resources/en/pdf/3052790/2010/SGSS-strategy-221210. Accessed January 30, 2013.

Joint Nature Conservation Committee. "South Sandwich Islands." http://jncc.defra.gov.uk/pdf/ot_ssandwichisles.pdf. Accessed January 30, 2013.

South Georgia and South Sandwich Islands. 2013. http://www.sgisland.gs. Accessed January 14, 2014.

Space Weather

The planet earth is embedded in the solar wind. This variable of plasma is made up of fast-flowing electrons and protons, a few heavier ions, the interplanetary magnetic field, and radiation. At the surface of the earth, we are protected from this hostile space environment by the atmosphere and the earth's magnetic field. The solar wind originates from the outer atmosphere of the sun. It flows at supersonic speed, which takes it from the sun to the vicinity of earth in two to three days. Any activity on the surface of the sun, for example, sunspots, flares, or coronal mass ejections (CME), causes disturbances in the solar wind. When these disturbances reach earth, a lot of energy and momentum can be exchanged between the solar wind and the geomagnetic field.

On the earth's surface, we can observe these processes in the variation of the geomagnetic field or in intense auroral displays. These episodes of disturbed magnetic field have long been called "geomagnetic storms." The intense auroral events were named "auroral substorms." Although we usually associate weather with clouds, wind, and precipitation (rain, snow, hail) in the lower atmosphere, similar terms had been used to describe the events and processes in the space environment of the earth (geospace). The plasma streaming away from the sun had been named solar wind because of its effect on comet trails; the strong magnetic variations on earth were geomagnetic storms, and the electrons and protons that penetrate the atmosphere from space to cause aurora were called "auroral precipitation." Consequently, in the mid-1990s, the overall interaction between the solar wind and the protective geomagnetic field was named space weather.

The most obvious consequence of space weather is the aurora. It goes on all the time, but has episodes of intense variability. Less obvious, yet important for our technology-based society, are other effects of space weather: geomagnetic storms can induce currents in pipelines or the transmission lines of the power grid. Pipelines then suffer accelerated corrosion, and the power grid can experience overloads that cause transformers to fail and cause electric outages. High-flying airplanes may be exposed to increased radiation (see sidebar on solar energetic proton events, SEP), causing health concerns for crew and passengers. Satellites are particularly sensitive to harsh conditions in their environment. Radiation can damage the electronics on satellites. This can render satellites inoperative and affect navigation (GPS) and satellite communication on the earth. Depending on how severe a space weather event is, satellites could suffer from brief interruption to complete failure. The ionosphere itself is part of space weather.

Changing conditions may disrupt HF radio communication or make GPS signals unreliable. Indirect consequences and failures from space weather events can come from the dependence of many systems on accurate timing using GPS signals. For example, cell phone service uses ground-based radio communication, which is not affected by space weather. However, cell phone service requires accurate timing for synchronization and relies on GPS signals for that timing. Especially, data traffic and the Internet depend on accurate timing. We cannot prevent space weather events, but we can prepare and forecast space weather. For example, the power distribution grid can prepare for adverse effects from space weather by shutting down interties and isolating a large grid into smaller subgrids. To be practical, this requires reliable forecasts and warnings.

Forecasting space weather is, however, still an emerging technology. The science to understand space weather is an active research area. To predict space weather, we start with the sun. After observing a solar event like a flare or CME, models are used predict whether the event will affect the earth and the time when it is likely to arrive here. It is also necessary to predict the nature of the event to estimate how severe the resulting space weather event would be and what likely consequences it will have on the earth. There are satellites to gather data from the sun, from the solar wind, and from geospace. These observations are processed in real time to refine predictions and to make forecasts. The science behind space weather is very complex, and we are still in the beginning of getting an understanding of it. Much research is conducted to observe and understand the solar–terrestrial interaction, which is called "space weather."

Dirk Lummerzheim

See also: Arctic Observatories; Aurora Australis; Aurora Borealis; Auroral Substorm; Geospace; Ionosphere, Polar

Further Reading

Bothmer, V., and I. Daglis. *Space Weather: Physics and Effects.* New York: Springer-Verlag, 2006.

Freeman, J. *Storms in Space.* Cambridge: Cambridge University Press, 2001.

Reay, S., W. Allen, O. Baillie, J. Bowe, E. Clarke, V. Lesur, and S. Macmillan. "Space Weather Effects on Drilling Accuracy in the North Sea." *Annales Geophysicae* 23 (2005): 3081–88.

Sperm Whale

Probably, the best-known sperm whale is the one of Herman Melville's novel, the enormous white-toothed whale called "Moby Dick." It is portrayed as a huge monster that strikes ships and swallows sailors. We really don't know much about sperm whales because they spend almost 90 percent of their time underwater (what makes them really hard to study for marine biologists). What we do know is that they are not harmful to man at all; actually, they are very shy when ships come close to them. They are harder to find than other cetaceans because they don't stick out of the water as much or have aerial displays. But the little we know about them allows us to say one thing for sure: sperm whales are animals of extreme.

They are the largest of the odontocets or toothed whales; they have conical teeth located only in the lower jaw, which fit into holes in the roof of the mouth. Sperm whales are found in all deep water of the world oceans. They feed in deep waters where giant squids are (their favorite dish), being one of the most significant predators in these waters. They have the biggest head in the animal kingdom (it is one-third of its total length) inside of which is the largest brain on the earth.

Females are big animals, measuring up to 30 ft. (9 m) in length and weighing 15 tons (30,000 pounds). Males are considerably bigger measuring up to 65 ft. (20 m) in length and weight up to 50 tons (100,000 pounds). Sexual segregation (which means that males and females use different territories) is also extreme. Females are found in the tropics and subtropics, and males have much greater ranges from the tropics to the poles. Males return to low latitudes to breed at the age of about 27. The males rove between groups of females. They appear to be solitary, while females are highly social.

Sperm whales (as many other whales and dolphins) are thought to have advanced cognition and have complex social structures with long-term bonds. Females group together in units of usually 10 animals moving and feeding together, defending themselves as a group, suckling and babysitting other calves. Calves are born in summer weighing approximately 2 tons (4,000 pounds) and stay with their mothers for several years.

One of the most surprising features of sperm whales is their ability to perform extreme dives, some of them recorded to reach more than 10,000 ft. (3,000 m) in depth. At this depth, there is no sunlight, temperatures are very low, and pressure is very high. What do sperm whales have that allows them to do such a thing? The secret of this ability seems to be in their heads. As we said before, the sperm whales' head is so big that it can make up more than a third of its total length. The skull accounts for a 12 percent of that, and the other 88 percent is accounted by a very particular anatomical feature located in the whale's snout called "spermaceti organ." This bubble-shaped organ is a complex mass of muscle and creates a special waxy oil that has an important function in the life of the animal. Even though it is not very certain, the prevalent theory is that the spermaceti organ is a buoyancy control device. By controlling blood flow to the organ, the whale might be able to control its temperature and therefore depends on whether the oil is liquid or solid. If the oil is solid, it becomes denser, helping the whale to sink. When melted again, the oil becomes liquid making the whale less dense. This technique could be a way of helping the whale descending and ascending.

In deep waters, where there is no light, sperm whales hunt using echolocation. The snout of these animals holds the most powerful sonar system in the natural world. Sperm whales produce loud click sounds to find food, which travel through water and bounce off any object they hit. The reflected sound bounces back to the whale, and its brain interprets the echo making a sonic image of the surroundings. This is the way that many dolphins see underwater.

Another suggested theory of the function of the spermaceti organ is that it is used for amplifying and focusing sound. Sperm whales produce sound not only to find food, but also to communicate, which is another key aspect of their lives. There are different patterns of clicks known as "codas," and they are used for communication. The different codas define different groups or clans.

Sperm whales were the focus of the Yankee whaling industry in the Atlantic Ocean when the United States was in its infancy, and this business accounted for a significant amount of the products that lit lamps and lubricated machinery. During early twentieth century, they were a major target of the whaling activities in Antarctic waters. Modern sperm whaling was particularly intense during the 1960s after the decline of most baleen whale populations. The refined oil in the spermaceti organ (after which the whale was named) was very prized by the whalers, who commercialized it to make fine lubricants, cosmetics, and other products. Due to the International Whaling Commission's moratorium on commercial whaling in 1988, sperm whaling stopped. Even though more studies are needed to give precise population estimates, it is thought that it is one of the populations with best recovery.

Luciana M. Motta

See also: Beluga Whale; Bowhead Whale; Gray's Beaked Whale; Gray Whale; Humpback Whale; Long-Finned Pilot Whale; Narwhal; Narwhal Tooth; Northern Bottlenose Whale; Orca; Southern Bottlenose Whale; Southern Right Whale; Whaling and Antarctic Exploration; Whaling and Arctic Exploration; Whaling Fleet Disaster of 1871

Further Reading

Clarke, M. "The Head of the Sperm Whale." *Scientific American* 240 (1979): 128–41.

Falkens, P., R. Reeves, B. Stewart, P. Clapham, and J. Powell. *Guide to Marine Mammals of the World.* North Reading, MA: Oceanic Research Group, 2002.

Whitehead, H. "Estimates of the Current Global Population Size and Historical Trajectory for Sperm Whales." *Marine Ecology Program Series* 242 (2002): 295–304.

Spotted Seal

The spotted seal (*Phoca largha*) also known as the largha seal is a member of family Phocidae. For a long time, it was considered a subspecies of harbor seal, but now it is considered a full separate species. Since both species are very similar, it is often difficult or even impossible to distinguish both species in the areas where they co-occur. Spotted seals are smaller and more compact with dark contrasting face and back, and unlike harbor seals that breed on land, they breed on small, moving ice floes. Spotted seals are pale silver to gray, with irregular dark spots, usually denser on back. Newborns have woolly, whitish shed called "lanugo," which is shed after two to four weeks. Spotted seals are rather small, but chunky, with round head and narrow short flippers. There is only little difference between males and females: males are slightly larger than females and can reach maximum length up to 5.5 ft. (1.7 m), while females are up to 5.2 ft. (1.6 m). However, on average, spotted seals are about 5 ft. (1.5 m) long and weigh between 155 and 250 pounds (70–115 kg). Spotted seals are widespread in the northern Pacific, from the northern Yellow Sea and Sea of Japan to the Okhotsk, Bering, Chukchi, and Beaufort Seas. There are three populations of spotted seals: one in the Bering Sea, one in the Sea of Japan and the Sea of Okhotsk, and the third one in the Yellow Sea. Their abundance has never been well known, but poorly documented estimates suggest a total population size of about 400,000 in the 1970s. There is no reliable estimate of the current total population size.

Spotted seals prefer the outer margins of shifting ice floes and rarely inhabit areas of dense pack ice. They haul out on the ice floes during breeding season that lasts from January to mid-April with a peak of pup births in mid-March. Females become sexually mature at the age of three to four years and males at four to five years. Spotted seals are solitary animals, but during breeding season, they become annually monogamous and form groups composed of a female with her pup and a male, called "triads." Males defend females on ice floes during lactating period. Male and female pair remains together and separate from the others for about two months. In spring, spotted seals give birth to a single pup, which is 17–24 pounds (8–11 kg) and about 31 inches (80 cm) long, within a shelter of ice hummocks or in crevices. Pups are weaned after about six weeks, and afterward mating occurs. The gestation lasts for 11 months, including a delayed implantation period of up to 4 months. Although spotted and harbor seals may occupy the same area, they do not interbreed since their breeding seasons are out of phase. In late spring and summer, many spotted seals leave the sea ice and haul out on land. They can live up to at least 35 years.

Spotted seals forage on a variety of prey including fish like capelin, pollock, herring, smelts, salmonids and flounders, crustaceans like shrimps and small crabs, and octopuses and squids. They can dive up to 980 ft. (300 m). During summer and fall, they tend to congregate near coasts and rivers where anadromous fish are available. Among their predators, there are not only polar and brown bears, killer whales and Greenland sharks, but also gulls, wolves, Arctic foxes, and walruses. Except for a short period of Japanese commercial hunting in the 1970s and Soviet Union hunting between the 1960s and the 1980s, they were not the target of commercial hunting. Commercial harvesting of spotted seal ended in 1994 and no longer occurs in Russia. Subsistence hunting has been taking place for a long time, and nowadays, it remains an important subsistence resource for coastal Natives in western Alaska and Siberia. Intensive fishery in the Okhotsk and Bering seas may become a risk to spotted seals as several of their main prey species are targets of commercial fisheries. Since spotted seals use pack ice at the southern limit of the ice extent for pupping, the reduction of sea-ice cover in late winter and spring in the Sea of Okhotsk and the central and southern Bering Sea may pose another risk to their populations. Gas and oil exploration in the Chukchi and Beaufort seas may also become a threat to spotted seals. In the United States, the spotted seal is protected from all but subsistence hunting by Alaska Natives by the Marine Mammal Protection Act of 1972. Currently, spotted seals are considered low risk—least concern species on the IUCN Red List.

Monika Kędra

See also: Antarctic Fur Seals; Bearded Seal; Crabeater Seal; Harp Seal; Hooded Seal; Leopard Seal; Polar Bear; Ribbon Seal; Ringed Seal; Ross Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Weddell Seal

Further Reading

Boveng, P., et al. "Status Review of the Spotted Seal (*Phoca largha*)." U.S. Department of Commerce, NOAA Tech. Memo, NMFS-AFSC-200, 2009.

Katin, I., and V. Nesterenko. "Inshore Associations of the Spotted Seal (*Phoca largha* Pallas, 1811)." *Sibirskii Ekologicheskii Zhurnal* 17 (2010): 173–80.

Lowry. L., et al. "Habitat Use and Habitat Selection by Spotted Seals (*Phoca largha*) in the Bering Sea." *Canadian Journal of Zoology* 78 (2000): 1959–71.

Subglacial Lake

A subglacial lake is a lake of liquid water that exists under a glacier, typically an ice cap or an ice sheet. Subglacial water forms when geothermal heat is trapped by the insulating effect of the ice sheet. Pressure from the overlaying ice also lowers the melting point at the base by a few degrees. The trapped heat melts the lowest layer of the glacier, and water forms a sheet or pools into depressions in the bedrock to form a lake. Recent research suggests that these lakes are connected, forming a vast subglacial drainage system. While subglacial lakes exist under polar and temperate glaciers, the focus of the scientific world lies under Antarctica.

Discovery

Russian scientist Peter Kropotkin first proposed the theory that freshwater may exist under Antarctic ice late in the nineteenth century. He suggested that the tremendous pressure exerted by massive amounts of ice would increase the temperature at the bottom to the point where the ice would melt. While others built on that idea, the existence of subglacial lakes was not proven until the late 1960s, during airborne radio-echo sounding surveys over the East Antarctic Ice Sheet to determine ice thickness. Radio-echo sounding works by emitting a radio wave from an airplane. The signal bounces differently off contrasting boundaries, such as rock/ice, rock/water, ice/water, and air/ice. The result is a cross section of the ice sheet topography. Hundreds of subglacial lakes have now been identified, most concentrated under the plateau of the East Antarctic Ice Sheet. Specific characteristics identify lakes under the ice: an especially strong reflection from the base of the sheet (stronger than surrounding ice/bedrock readings), echoes with a consistent strength over multiple readings (indicating a smooth surface), and a very flat horizontal ice surface with slopes under 1 percent. One of the earliest lakes found is also the largest found to date. Lake Vostok, far beneath Russian Vostok Station in the Dome C region of East Antarctica, measures 150 miles (240 km) long, around 30 miles (50 km) wide, and hundreds of meters deep. This lake is of particular interest to researchers for its potential to harbor life.

Subglacial lakes appear to form under specific pressure and melting conditions in two main settings: beneath the center of the ice sheet where the ice is thickest, and on the margins of the ice sheet where ice flow quickens. These bodies of water were initially thought to be stagnant pools, but current research indicates that Antarctica has a dynamic basal drainage system. Water is generated, stored, and discharged far under the ice, much like surface river and lake systems on other continents. The ice sheets of Antarctica move slowly. Ice streams drain portions of ice sheets into the ocean every year. As the ice moves over subglacial lakes, the sudden lack of friction causes the ice to accelerate, even though it is moving over a horizontal surface. Some of the lake water freezes onto the bottom of the ice sheet as it flows over the lake, but this ice is relatively warm and soft compared with the rest of the stream. Back on bedrock at the downstream side of the lake, the warmer, softer ice now on the base acts as a lubricant, allowing the ice to move more rapidly toward the ocean. Ice surface raising and slumping indicate that lakes fill and empty, implying drainage between the lakes. The interconnectedness of these water bodies has implications on research efforts.

Exploration

Subglacial lakes are some of the last unexplored ecosystems on earth. Many have been isolated from the outside world for millions of years, raising the possibility of finding unique life forms able to adapt to total darkness, low nutrient levels, and high pressure. Another goal is to acquire consistent climate records from ice cores and core samples of sediments from the subglacial lake beds. Finally, understanding the hydrologic systems underneath Antarctic ice is a crucial component of knowing how ice sheets evolve and affects models used for predicting climate changes.

Exploring this inhospitable environment requires careful and detailed planning, international cooperation, and the development of environmental protocols. Drilling, sampling, and studying subglacial lakes remotely without contaminating these pristine environments present a tremendous physical and technological challenge. Now that recent research has suggested that these lakes are interconnected, the risks from contamination of one site could theoretically spread over a great distance.

Over the next few years, research teams from three countries are expected to drill into three different types of subglacial lakes. The best-known project is the Russian team currently drilling toward Lake Vostok, situated in a depression near the center of the East Antarctic Ice Sheet, where the ice is the thickest. While technical problems and environmental concerns have slowed their progress, they are within a few hundred feet of the lake surface. Lake Vostok is thought to be 35 million years old and may contain ancient microbial life. Initially, scientists plan to extract water from the lake for study, allowing the borehole to immediately refreeze. Inserting instruments into the lake will happen only after additional environmental impact studies are complete.

The United Kingdom and the United States also have longer-term projects planned across the pole. The British Antarctic Survey is exploring Lake Ellsworth, which ranges along the foothills of the Ellsworth mountain range, under the Western Ice Sheet. Using seismic and radar surveys, the lake has been mapped, measured, and determined to have sediments suitable for coring. At the same time, U.S. researchers are surveying Lake Whillans, located near the Ross Ice Shelf. The surface of Lake Whillans is constantly rising and falling, due to a subsurface connection with the ocean under the ice shelf. It is far more dynamic than lakes such as Vostok, isolated under the center of an ice sheet.

Fortunately, treaties and agreements have been made to explore subglacial lakes with extreme caution. The potential dangers in exposing these pristine environments to contamination are understood. While a major commitment of resources is needed to perform these drilling projects without environmental impact, the potential scientific and educational payoff is immense.

Jill M. Church

See also: Microbial Survival

Further Reading

Benn, D., and D. Evans. *Glaciers and Glaciation.* London: Hodder Education Company, 2010.

Kohler, J. "Glaciology: Lubricating Lakes." *Nature* 445, no. 7130 (2007): 830–31.

Priscu, J., M. Kennicutt, R. Bell, et al. "Exploring Subglacial Antarctic Lake Environments." Eos, *Transactions American Geophysical Union* 86, no. 20 (2005): 193–97.

Vincent, W., and J. Laybourn-Parry. *Polar Lakes and Rivers: Limnology of Arctic and Antarctic Aquatic Ecosystems.* New York: Oxford University Press, 2008.

Sunken Soviet/Russian Nuclear Submarines in Arctic

There have been at least five sunken Soviet/Russian submarines in the Arctic. On March 2, 1965, a November-class Rostovskiy Komsomolets K-159 (K is short for *Kreyserskaya podvodnaya lodka*, meaning "cruising submarine" in English) submarine vented radioactive steam contaminating the propulsion area. Coolant tube leaks were the suspected cause of the venting. The leaks were apparently plugged, and the K-159 continued in service until 1968. In 1968, the K-159 was brought in to have the steam generators replaced and an overhaul. From 1970 to 1972 and again 1979 to 1980, the K-159 was back in the shipyard for repairs and refueling. In 1989, the K-159 was decommissioned and laid up in Gremikha Bay. Over the next 14 years, the outer hull rusted and later had to be held afloat by pontoons. In 2003, a number of countries donated $200 million to have the aging Russian submarine fleet dismantled. The K-159 was one of the 16 laid-up subs in Gremikha Bay scheduled for dismantling. On August 28, 2003, the K-159 was the thirteenth sub towed, and during a storm, the pontoons broke free resulting in the K-159 rolling and sinking down 781 ft. (238 m) to the seafloor of the Barents Sea (69° 22.64′N 33° 49.51′E). Nine people perished in the incident.

On May 24, 1968, the Soviet November-class Project 645 nuclear-powered attack submarine K-27 experienced a power drop (control rod failure) resulting in radioactive gases of cesium, iodine, xenon, and so on, being released in the engine room. About one-fifth of the reactor core was damaged. The release increased the crew's absorbed dose of radiation to dangerous level. The submarine crew was not adequately trained to determine the extent of damaged reactor core. Once the extensive damage was noticed, nine crew members had already died due to radiation exposure. On June 20, 1968, the K-27 was laid up in Gremikha Bay, where it remained until 1982. The K-27 was used for experiments during this time. In September 1982, the decommissioned K-27 submarine was sunk off the shore of the Novaya Zemlya Archipelago in the Kara Sea (72° 31′N 55° 30′E).

On June 24, 1983, the Soviet Charlie-class nuclear-powered cruise missile submarine K-429 sank in Savannaya Bay in the Bering Sea south of Petropavlovsk, Kamchatsky. The K-429 sank because the sub was ordered to dive to periscope depth, but the ventilation system was not sealed and the instruments for such a dive were not ready. Upon the dive, the ventilation system took on water, flooding the forward section of the sub. Captain First Rank Nikolay Suvorov ordered the ballast tanks' flood to resurface. The ballast tanks were misaligned resulting in the sub sinking 130 ft. (40 m) to the bottom of the Bering Sea. Most of the 120 crew members escaped to the surface, and two crew members swam ashore to get help. Sixteen crew members were lost. In August 1983, the vessel was recovered, serviced, and returned to service. In 1985, the K-429 sank again, killing one crew member, and was recovered. After this second recovery, the K-429 was removed from service.

On April 7, 1989, the Soviet Mike-class Project 685 nuclear-powered attack submarine K-278 *Komsomolets* caught fire in the rear (aft) engineering compartment while submerged about 112 miles (180 km) southwest of Bear Island, Norway, at a depth of 1,100 ft. (335 m). The K-278 was carrying two nuclear warheads. The fire spread throughout the sub resulting in significant electrical problems, such as the emergency shutdown button (scram) and propulsion system being damaged beyond repair. The ballast tank was blown, and the K-278 surfaced about 11 minutes after the start of the fire. Distress calls were initiated, and the crew abandoned ship. The K-278's compressed air system enabled the fire to burn for about five hours, until the sub sank 5,510 ft. (1,680 m) to the seafloor of the Barents Sea. Responding to the distress call, rescue aircraft dropped rafts. About 80 minutes after the sub sank, the fish factory vessel named *Aleksey Khlobystov* arrived and rescued 25 sailors and recovered 5 bodies. A total of 42 sailors perished with 4 being killed by the fire. The other 34 sailors perished from hypothermia due to being in the Arctic waters of the Barents Sea. Twenty-seven crew members survived. After several attempts, the Russians were able to hermetically seal the K-278 preventing further radiation leaks. This seal is only a short-term fix because the material used to seal the K-278 is expected to degrade by 2025.

On August 12, 2000, the Russian Oscar II–class submarine K-141 *Kursk* sank in the Barents Sea. The Oscar II–class subs are the world's largest cruise missile–type submarine. The reason K-141 sank was due to a fire in the torpedo room, which resulted in the detonation devices of the nuclear warhead to explode. The initial explosion triggered about a half dozen other warheads to explode. The multiple warhead explosions had a nuclear weapon yield of 3.7 tons of TNT. This blast allowed seawater into the sub, flooded most of the sub compartments, and killed almost all of the 118 sailors on board. Twenty-three sailors held up in stern of the K-141 for several days and either died from a fire or lack of oxygen (suffocation). International rescue groups were not able to or allowed to rescue the sailors holding up in the stern of the sub. All the K-141 sailors were lost. The K-141 was raised in 2001, and its nuclear reactor was recovered.

Andrew J. Hund

See also: Novaya Zemlya, Nuclear Tests; Novaya Zemlya, Nuclear Tests, Environmental Legacy of; Nuclear Power in the Arctic; Nuclear Waste in the Arctic

Further Reading

Szasz, P. "The Convention on the Liability of Operators of Nuclear Ships." *Journal of Maritime Law and Commerce* 2, no. 3 (1970).

Svalbard Archipelago

The Svalbard Archipelago, within the Kingdom of Norway, is a High Arctic polar tundra island formation situated approximately 350 miles (565 km) north from the mainland, located between 74° and 81° N and 10° and 35° E below the North Pole. Three main islands and other smaller ones cover an area of approximately 24,000 square miles (63,000 sq. km). The mainland and archipelago are separated by the Barents Sea whose characteristics are defined by the polar front, the point of contact for the North Atlantic and Arctic Oceans. This frontal boundary plays a critical role in the movement of nutrients upward to surface waters. Spitsbergen, named by William Barents (1550–1597) in 1596 during an expedition to find a Northern Sea Route, refers to the western flank of the archipelago, a long stretch and primary area habited by an international community of approximately 2,500 persons, the majority of whom live in the main city of Longyearbyen just west of the Adventdalen, north of Lars Breen. The rest of the archipelago is considered pristine with landscapes of glaciers, moraines, fjords, cliffs, canyons, valleys, wetland plains, and tundra. Bedrock from nearly every geological age is easily found in areas of sparse vegetation.

The area is noted for its warmer temperature gradient; in comparison with other stations in the High Arctic between 70° and 80° N, Longyearbyen has a mean annual air temperature of −38°F (3.8°C), while others in the same median range between 15.8 and 5°F (−9°C to −15°C). This is due to the warm Norwegian Current flowing along the western coast, supporting an ice-free winter sea. Svalbard is located inside the main North Atlantic cyclone track, which contributes to warmer winter temperatures in the region. Air temperatures are also affected by the Siberian high-pressure system, a cold anticyclone that contributes to fluctuations, heavy snowfall, and rains during the winter months. Other prominent islands include Nordauslandet, Barentsøya, Edgeøya, and Prins Karls Forlan. Norwegians typically use the name "Svalbard," a name found in early-twelfth-century Icelandic texts meaning "cold coasts," to refer to the entire archipelago territory.

During the years 2007–2009, a series of field observations were made of 109 snow pits located within a 6.5-square-mile (16.8-sq.-km) mountainous area surrounding the city of Longyearbyen at 78° N. Temperature gradients, grain shapes, grain sizes, and the hardness of every snow layer were computed to create the first systematic classification of the central Svalbard snow pack, defined as the "High Arctic maritime snow climate." These parameters and the meteorological observations made during the study characterized the area for its thin snowpack caused by a hole at the base level that was covered with a thin layer of ice and snow. This ground cover lasts 8–10 months of the year and is present year-round in some areas.

The strategic and commercial importance of the archipelago has been of interest to nations for hundreds of years; since the 1600s, it has been a popular and lucrative site for hunting, trapping, fishing, and research. The area functioned as an international commons until the twentieth century when issues arose regarding miner's land and mineral rights, and labor disputes. The Svalbard Treaty was drafted as a result of the Versailles Treaty; the lands were designated a sovereignty of Norway by treaty on February 9, 1920, effective August 14, 1925. Its international significance was codified in the signing of the Svalbard Treaty by 40 nations.

The treaty preserved the *terra nullius* rights of the signatories; while the term refers to lands that belong to no one, and Norway was authorized as the archipelago's absolute and unrestricted legal authority, nevertheless the other treaty partners are guaranteed equal rights to entry and residence; fishing, hunting, and trapping; certain maritime, industrial, mining, and commercial rights; and the right to acquire and operate property and the mineral rights of those entities. The 1920 Treaty specifically prohibited the establishment of naval bases and fortifications in the islands, outlawing the use of the lands for wartime operations.

Despite the pacifist principles established by the Svalbard Treaty, German forces occupied the islands during World War II, and Cold War ideologies framed the competing strategic and economic interests of the United States and the Soviet Union regarding the archipelago during the twentieth century. The strategic importance of the islands will continue to frame international policies governing cultural resource and environmental protection in the twentieth century.

The sea and the archipelago are considered one of the most ecologically productive regions in the world. Over thousands of years, species of polar bears, reindeer, walruses, seals, whales, millions of migrating birds, and fishes have adapted to the harsh Arctic climate. Nearly 65 percent of the islands and 75 percent of the surrounding waters to the 12-nautical-mile territorial limit are protected under the Svalbard Act of 1925 and the Svalbard Environmental Protection Act of July 1, 2002, amended in April 2012. The archipelago is further protected under the auspices of the Arctic Council, the Ramsar Convention on wetlands of international importance, the Nature Conservations Convention (1992) on the preservation of biodiversity, the Washington convention (CITES) on international trade in endangered species of animals and plants (1973), and the Bonn Convention on the protection of migrating species (1979). The natural history and cultural heritage of the province are secured by a public lands program that includes the protection of 7 national parks, 21 natural reserves, and 1 geotope, the Festningen Geotope Protection Area.

Since June 21, 2007, the region has petitioned for inclusion in the listing of sites recognized by the World Heritage Convention of the United Nations Educational, Scientific, and Cultural Organization. Approximately, 30 species of birds are known to nest in the archipelago; close to 20 million seabirds make their home along the Barents Sea, including the little auk, fulmar, Brünnich's guillemot, and kittiwake. Fifteen of the nature reserves along the western coast of the archipelago are protected breeding sites of birds. Keystone species include large populations of Arctic foxes (*Alopex lagopus*), Svalbard reindeer (*Rangifer tarandus platyrhynchus*), rock ptarmigans (*L. m. hyperboreus*) and marine mammals like polar bears (*Ursus maritimus*), various species of seals (including walrus), whales, and Svalbard char (*Salvelinus alpinus*).

Below the icy waters, so characteristic of the Arctic is a region known as the Arctic benthos, or bottom fauna, which is species rich and of great ecological significance. It is estimated that nearly 90 percent of the Arctic's known marine invertebrates live in bottom regions. In shallower regions, they are an important part of the diets of other endemic species including seabirds, walruses, seals, and bowhead whales. Potential climate change is predicted to have a profound influence on benthic life forms and the ice algae that support the larger species. Studies of the Bering Sea, the Barents Sea, and the Laptev Sea indicate that higher temperatures may contribute to dropping oxygen uptake in sediments with corresponding declines in populations of mussels and migrating populations of diving ducks, walruses, and gray whales. Studies of the sediments of Svalbard fjords also document high levels of heavy metals and other contaminants as a result of mining and coal industries.

Because of its proximity to the North Pole, the Svalbard Archipelago was and continues to be an important landmark for geological and meteorological study and research. Ambitious expeditions became possible as technology and the earth and applied sciences rapidly advanced in the nineteenth and twentieth centuries. The first International Polar Year (IPY) was the first extensive survey of the polar region; data and research evidence were compiled from 1881 to 1884. The inspiration that guided the first IPY was the result of earlier expeditions by Austrian explorer Carl Weyprecht, who died in 1881. The results of the first IPY continues to provide valuable data for understanding current climate change. Other IPY expeditions were held in 1932–1933, 1957–1958 (The International Geophysical Year), and 2007–2008. During April 22–27, 2012, more than 2,000 Arctic and Antarctic researchers, policy- and decision-makers, and a broad range of interested parties convened in Montréal, Canada, to begin the process of interpreting the findings of the 2007–2008 IPY to set an evidence-based global agenda for the polar region. Other important expeditions include the noted ventures of Adolf Hoel, Salomon August Andrée, Nils Strindberg, Knut Frankel, Umberto Nobile, and Roald Amundsen.

The Norwegian Polar Institute was established by Prince Albert I of Monaco in 1906; it was organized to provide ongoing research of the polar region, with particular attention to the Svalbard Archipelago and the Barents Sea. The institute operated from Oslo until 1999 when the main government departments were moved to the new Polar Environmental Centre at Trømso. A research station has been located at in Ny-Ålesund, Svalbard, since 1968. Another station building at Sverdurup was operational in 1999. The Zeppelin station for atmospheric monitoring and research was reopened in 2000 by Crown Prince Haakon Magnus for renovation and expansion.

The Nordic Gene Bank (NGB) was first established in 1979, representing the cooperative efforts of the Nordic countries to store frozen seeds to preserve genetic materials related to forestry and agriculture. The first Nordic seed bank was created in a coal mine at Svalbard in 1984. Later, the Nordic Genetic Resource Center (NordGen) was established in January 2008 as a development of the NGB project. It was founded to preserve important genetic resources in the event of unforeseen climate variances, evolving plant and animal diseases, and global warfare. The Svalbard Global Seed Vault opened on February 26, 2008, with a capacity to store 4.5 million seed samples. It is set at 350 miles within a mountain located at Spitsbergen near Longyearbyen. The Svalbard Global Seed Vault is managed by the Royal Norwegian Ministry of Agriculture and Food, the Global Crop Diversity Trust, and the Nordic Genetic Resource Center (NordGen).

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See also: Arctic Fox; Barents Sea; Geomagnetic Poles; International Polar Years (IPYs); Laptev Sea; North Pole; Polar Bear; Rock Ptarmigan

Further Reading

Capelloti, P. *The Svalbard Archipelago: American Military and Political Geographies of Spitsbergen and Other Norwegian Polar Territories, 1941–1950.* Jefferson, NC: Mcfarland and Company, Inc., 2000.

Finstad, Sissel. “The Svalbard Treaty.” Svalbard Museum. http://www.svalbardmseum.no. Accessed January 14, 2014.

Swedish Antarctic Expedition (1901–1903)

After the Europeans’ first encounter with the Antarctic continent in the early nineteenth century, interest in the marine resources in coastal waters increased. As a result, many countries carried out whale and seal hunting expeditions along the coast. However, in the early twentieth century, an intensifying scientific interest in the area emerged, and several Antarctic expeditions were organized, such as the Discovery Expedition 1901–1904, headed by the Royal Navy officer Robert Falcon Scott, the Gauss Expedition 1901–1903, headed by the German geographer Erich von Drygalski, and the Swedish Antarctic Expedition, headed by geologist Otto Nordenskjold (1869–1928), who went there with his vessel *Antarctic*, a Norwegian-built three mast bark and steamship. Nordenskjold was an experienced explorer, with geological and glaciological expeditions to Patagonia and Tierra del Fuego (1895–1897), Alaska, Klondike, and Yukon Territory (1898), and East Greenland (1900) behind him. He also conducted ethnographical studies during these expeditions.

His expedition to Antarctica started from Gothenburg on October 16, 1901. Nine of the twenty-seven members of the crew were scientists, among them paleontologist Johan Gunnar Andersson (later a famous sinologist), the botanist Carl Skottsberg (a leading expert on South American flora), and the cartographer Samuel A. Duse (later a pioneering Swedish crime writer). The ship was captained by the experienced Norwegian whaler and seafarer Carl Anton Larsen (1860–1924). American painter Frank W. Stokes (1858–1955) joined the expedition as illustrator. The Norwegian musher Ole Jonassen signed on in Falmouth with 14 Greenland dogs for use as draft animals. Further dogs were obtained in Port Stanley.

Adventures in the Antarctic

The expedition discovered Hope Bay in January 1902. The ship continued southward along the coast, and in February, they arrived at Snow Hill Island south of Graham Land, where they decided to make a camp. Six team members, José María Sobral, Ole Jonassen, Gösta Bodman, Erik Ekelöf, and Gustaf Åkerlundh, and headed by Otto Nordenskjold, were together with the dogs going to spend the coming winter there, while the ship and other crew members returned north to collect scientific material in Tierra del Fuego, the Falkland Islands, and South Georgia. The planned 11 months for the team actually became 21 months.

The Antarctic summer from October 1902 to March 1903 was characterized by unusually severe ice conditions. After provisioning and necessary repairs, the ship left Ushuaia in Tierra del Fuego for the Antarctic again. When the ship came at its appointment time at New Year to approach Nordenskjold's camp at Snow Hill, it got stuck in the ice. A company of three men, Johan Gunnar Andersson, Samuel Duse, and Toralf Gruden, went ashore in the bay, which was named Hope Fold, to walk overland to Snow Hill. It turned out to be a mistake. Two weeks later, they were back in the Hope Fold to wait on the ship Antarctic to become rescued. In the middle of February, they realized that their ship would not show up, and they began to prepare for overwintering.

After leaving the three men in Hope Fold, the ship Antarctic continued to move forward through the ice toward the rest of the expedition on the Snow Hill, but on February 12, 1903, the ship was crushed by the ice and sank in the Weddell Sea about 45 km east of Paulet Island. After walking and sledging for 16 days, the crew made it ashore on Paulet Island and prepared for the winter. They built a stone hut and killed more than a thousand Adélie penguins (*Pygoscelis adeliae*) for food before the birds left for the winter. One crew member, Norwegian sailor Ole Christian Wennersgaard, died of heart failure on Paulet Island in early June 1903.

Meanwhile, the other parts of the expedition independently began to move toward the main camp. In the vicinity of this, they came in contact with each other at about the same time as an Argentinean rescue expedition with the corvette Uruguay arrived. The meeting was regarded as little short of a miracle and almost certainly saved the lives of the majority of the members of the expedition. The expedition members arrived safely in Buenos Aires in December 1903, and a month later, they were back in Stockholm. Despite the dramatic events with its remarkable survival story experienced by the men, the expedition was regarded as very successful as they had made many new discoveries and mapped new land.

Aftermath

The main scientific results of the expedition were published in *Wissenschaftliche Ergebnisse der* schwedischen *Südpolar*-Expedition *1901–1903* (Stockholm: Lithographisches Institut des Generalstabs, 1904–1921), which up until 1921 had concluded 6 thick volumes with 59 papers. However, additional scientific volumes were published in *Further Zoological Results of the Swedish Antarctic Expedition, 1901–1903* vol. 1–5 (Stockholm: P. A. Norstedt, 1923–1959) on the many animal specimens brought back by the expedition. A major focus of academic work was on the geological surveys. In particular, the fossil record (mammals and birds from Seymour Island) expanded the knowledge of climate history of Antarctica significantly. We should also mention the glaciological work and the important regular meteorological observations and measurements over a period of about 600 days.

Several geographical places in Antarctica were given toponyms after the expedition members, such as Andersson Island (named after Johan Gunnar Andersson), Jonassen Island (after the musher), Ohlin Island (after Axel Ohlin, the zoologist), Wennersgaard Point (after the young Norwegian sailor who died while wintering on Paulet Island), and Antarctic Sound (after the ship), to honor their efforts. In 2002, the Swedish Posten AB issued a set of stamps to commemorate the expedition.

The expedition enabled Nordenskjold to make an international breakthrough as a polar explorer. In 1905, he was appointed full professor of geography and ethnography at Gothenburg University. He planned another expedition, but the outbreak of World War I came, and he never managed to do any further voyages to Antarctica. However, he made some smaller trips to southwestern Greenland (1909) and southern Patagonia (1920–1921), before being killed in a bus accident near his home in Gothenburg in 1928. Captain Carl Anton Larsen soon went back to Antarctica and established as a manager of Compañía Argentina de Pesca, the first whaling station in Grytviken, South Georgia, in 1904. He had located the place already during the Swedish Expedition in 1902. This station was the beginning of the large-scale industrial whaling in Antarctica, which dominated the interest for the region until the 1980s.

Sweden did not participate in any further Antarctic expeditions until after World War II, when the Norwegian–British–Swedish Antarctic Expedition (1949–1952) was organized.

Ingvar Svanberg

See also: Heroic Age of Antarctic Exploration (ca. 1890s–1920s); Swedish Polar Research Secretariat

Further Reading

Darbishire, O. The Lichens of the Swedish Antarctic Expedition. Wissenschaftliche Ergebnisse der schwedischen Südpolar-Expedition 1901–1903. Stockholm: Lithographisches Institut des Generalstabs, 1904–1921, 1912, pp. 1–74.

Etzinger, A., ed. *Antarctic Challenges: Historical and Current Perspectives on Otto Nordenskjöld's Antarctic Expedition 1901–1903.* Gothenburg, Sweden: Royal Society of Arts and Sciences, 2004.

Nordenskjöld, O., ed. *Antarctica: or, Two years amongst the Ice of the South Pole.* New York: Macmillan, 1905.

Nordenskjold, O., (ed.). *Further Zoological Results of the Swedish Antarctic Expedition, 1901–1903*, vol. 1–5. Stockholm: P. A. Norstedt, 1923–1959, 1923.

Swedish Polar Research Secretariat

Sweden has a long tradition in Arctic and Antarctic research. Carl Linnaeus's pupil Anton Rolandsson Martin (1729–1785) went to Spitsbergen in 1758 for botanical and zoological research. He also reported on the Dutch whaling in the area. In the 1850s and 1860s, there were several Swedish expeditions to Spitsbergen and Greenland. Adolf Erik Nordenskjold (1832–1901) conducted several Arctic expeditions to Spitsbergen (1864, 1868, 1872–1873), Greenland (1870), and subarctic areas of Russia (1875, 1876). Very important for establishing Swedish Arctic research was the Vega Expedition in its search for the northeast passage, organized by Nordenskjold in 1878–1880. Since then, Sweden has had a prominent position within international polar research. Very important was also the Swedish Antarctic Expedition (1901–1904) headed by the geologist Otto Nordenskjold.

Abisko Scientific Research Station, located 124 miles (200 km) north of the Arctic Circle in the Abisko National Park in the Swedish province of Lapland, was established already in 1903, and from the mid-1930s, it has been managed by The Swedish Academy of Sciences. It has been important especially for biological (ecology, botany, zoology) and geographical research, and the research station, with modern infrastructure and international standard laboratory facilities, is visited by several hundred scholars every year. In the last decade, many researchers visiting the station have focused on climate change research. Another important polar research platform in Swedish Lapland is Tarfala, which has specialized in glacial and climatological research.

Since 1984, the Swedish Polar Research Secretariat, which is an agency under the Ministry of Education and Research (Sweden), has been responsible for planning, coordinating, and organizing Swedish research activities in the Arctic and Antarctic regions. This includes organizing and leading research expeditions to the Arctic and the Antarctic regions. The secretariat also provide infrastructure through research platforms in the Antarctic. The heads of the Swedish Polar Research Secretariat have been Professor Anders Karlqvist (1984–1993, 1995–2009), Dr. Olle Melander (1993–1995), and Dr. Björn Dahlbäck (2010–). The Swedish Polar Research Secretariat is also an administrative authority for the Act on Antarctica and handles permit issues for research activities and visits to the region.

SWEDARP and SWEDARCTIC

The Swedish Antarctic Program (SWEDARP) has organized several expeditions, first in 1987–1988, to the Antarctic Peninsula and to Dronning Maud Land, where the research station Svea situated in the Himefrontfjella mountain range was established. During the next season 1988–1989, another but larger research station, Wasa (it can accommodate 30 persons), was established on Dronning Maud Land. Every season since, not only a new expedition has been sent to the Antarctic using these two research stations, but also expedition ships, for the scholarly work. Scientists from several countries participate in the expeditions and focus especially on glaciology, geology, oceanography, quaternary science, limnology, marine biology, and radiation physics. The icebreaker *Oden* has been of great importance for the Swedish research activities in marine geology and oceanography in the Antarctic. Corresponding research activities in the north is carried out within the Swedish Arctic Program (SWEDARCTIC). Expeditions have been sent to Greenland, Svalbard, Siberia (Taymyr), and Beringia. Since 2011, the secretariat has also encouraged research in social science focusing on the Arctic futures in a global context.

The secretariat publishes a yearbook in English and organizes the seminar series. Publications and research reports on Swedish Arctic and Antarctic research is listed in *Swedish Polar Bibliography. A Guide to Swedish Literature of Polar Research*

1945–1989 (1993), with several supplements, and is updated online on the Swedish Polar Research Secretariat's Web site. Besides research in the polar regions, scholars affiliated with the secretariat are also doing research in subpolar regions and the Swedish mountain areas in Lapland. Since 2010, the secretariat has also been the head organization for the Abisko Scientific Research Station.

The secretariat also continues the old tradition among polar expeditions to allow artists, including choreographers and poets (e.g., Lars Jonson to Siberia, Eva Löfdahl to Spitzbergen, Rose-Marie Huuva to Beringia, Mattias Fagerholm to Antarctic Peninsula) to accompany Swedish research expeditions. Thanks to the partnership with many various national and international institutions, the secretariat has developed into one of the most important agents within polar research worldwide.

Ingvar Svanberg

See also: Antarctic Programs and Research Stations/Bases; Swedish Antarctic Expedition (1091–1903)

Further Reading

Entzinga, A., ed. *Changing Trends in Antarctic Research.* Dordrecht, the Netherlands: Kluwer, 1993.

Karlqvist, A., ed. *Sweden and Antarctica.* Stockholm, Sweden: Swedish Polar Research Secretariat, 1985.

Liljequist, G. *High Latitudes: A History of Swedish Polar Travels and Research 1758–1980.* Stockholm, Sweden: Swedish Polar Research Secretariat, 1993.

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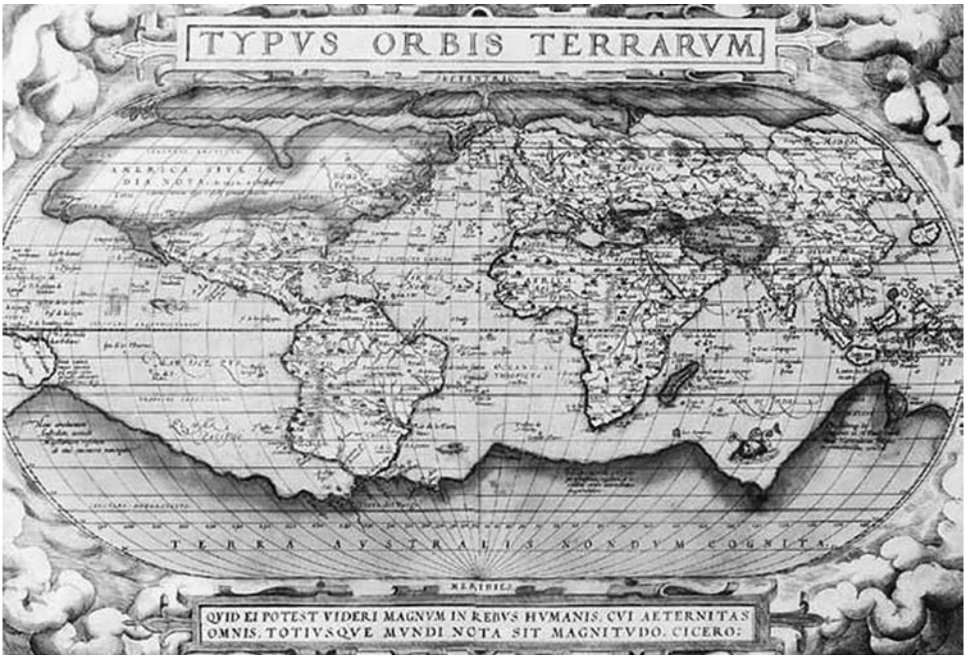
Terra Australis Incognita

The true nature of the world's southern regions would have come as a great surprise to the ancient Greeks and all those who were influenced by Greek thought down to the theoretical geographers of the eighteenth century. What would have surprised them would not have been the presence of an ice continent near the pole but rather the sheer extent of ocean in relation to land.

Ignorance of the true nature of Antarctica and its environs has never inhibited speculation. Having worked out the earth's approximate size and the fact that it was spherical, geographers of classical Greece and Rome built up an extensive knowledge of the world based partly on carefully collected travelers' tales and partly on deductive reasoning. The latter led some to claim that the earth was divided into a series of climatic zones, a theory later systematized by the Roman geographer Pomponius Mela as two inhabitable temperate zones separated by an uninhabitable torrid zone near the equator, with two uninhabitable frigid zones at the poles. Symmetry was an attractive concept in the absence of proof to the contrary, and in general, it was assumed that whatever was found in the Northern Hemisphere would also be found in the Southern Hemisphere. Thus, the Arctic was the realm of "Arctos" where the constellation known as the Great Bear circled. The Antarctic, "Antarctos," was its opposite.

Greek and Roman concepts of the world's far southern regions were selectively inherited by the Christian and Islamic civilizations that followed them. In particular, they were preserved in the writings of Claudius Ptolemy (AD 150), which reached a wider audience following the translation of his geography into Latin in 1410. With regard to the far south, Ptolemy was most influential for his depiction of the Indian Ocean as an inland sea bordered to its south by a great continent linking Africa with Southeast Asia and encircling the globe. In a presiding culture where knowledge inherited from the ancient world was held to be superior to anything achievable by the "moderns," Ptolemy's portrayal of the Southern Hemisphere was dutifully preserved by Renaissance cartographers with modifications to it only reluctantly introduced as voyages of exploration demonstrated errors of detail. Thus, Portuguese voyages around the Cape of Good Hope to India showed that the Indian Ocean was not an inland sea and that no continent extended so far north. Ferdinand Magellan's circumnavigation (1519–1522) also led to minor modifications. Although Magellan himself believed that the land he had sighted to



During the sixteenth and seventeenth centuries, explorers attempted to find Terra Australis Incognita, the "unknown southern land" in the atlas published by Flemish cartographer Abraham Ortelius in 1570. Despite great progress in the exploration of the globe, huge portions of the earth remained incompletely or inaccurately mapped in the sixteenth century. (The British Library/StockphotoPro)

the south of the straits named after him formed only an island (Tierra del Fuego), cartographers depicted that land as a peninsula of the great southern continent. This is how, for example, it is shown in Orontius Finaeus's map of 1531. Finaeus was the first to use the term *Terra Australis*, inscribed on his map as *Terra Australis recenter inventa sed nondum plene cognita* (the Southern Land newly discovered but not yet fully known). This interpretation was subsequently followed by Abraham Ortelius's atlas *Theatrum Orbis Terrarum* (1570). The latter's widely circulated "Theatre of the World" included a magnificent world map in which the southern continent, labeled *Terra Australis nondum cognita*, spreads itself across the Southern Hemisphere, occupying every space where its presence was not yet disproved. Strange as this concept might now seem to us, it was not simply a cartographic figment but appeared to be confirmed by certain discoveries. Thus, whereas voyages such as those of Vasco da Gama and Magellan might have proved that some areas were sea that had previously been thought to be land, others such as that of Binot Paulmyer de Gonneville (1503–1505) appeared to provide firm confirmation of extensive land far south. Indeed, it was this vast southern continent that was claimed for Philip III of Spain by Pedro Fernandez de Quiros when he reached the New Hebrides in 1606. Assuming this to be a promontory of *Terra Australis Incognita*, de Quiros named his continent *Australia del Espiritu Santo*, in so doing taking possession "in the name of the Holy Trinity of all islands and lands which I have recently discovered and will discover even to the Pole."

Although further modifications to the received view of Southern Hemispheric geography were introduced following the discoveries of Francis Drake (1577–1580) and Abel Tasman (1642–1643), the Southern Hemisphere as depicted by Ortelius remained very much that taught and understood throughout the seventeenth century and into the eighteenth century. In 1756, Charles de Brosses brought together knowledge of these regions in his compilation *Histoire des navigations aux terres australes.* In this important work, de Brosses discussed in detail all that was known about the large continent that, on both theoretical and observational grounds, he was certain was to be found far to the south. Theoretically, he shared the contemporary view that in order for the earth's equilibrium to be maintained, a large landmass must exist in the Southern Hemisphere to counterbalance the great continents of the Northern Hemisphere. Furthermore, he believed that the sheer quantity of ice reported by explorers proved the existence of land nearby since it was widely, though incorrectly, believed that only freshwater but not seawater could freeze. It was this belief, for example, that persuaded a number of eighteenth-century explorers that, although only relatively small areas of land were visible to them, being surrounded by ice, they must form part of a much larger landmass. With the case for a southern continent irrefutable, all that was required was the dispatch of an expedition to discover it.

The views of de Brosses were taken up in Great Britain by Sir Alexander Dalrymple, an able if choleric Scot, who published two compilations summarizing all that was known from voyages to the South Pacific (1770–1771) and South Atlantic (1775). Dalrymple was a respected member of the Royal Society, and when the British government proposed sending an expedition to the South Pacific to observe the transit of Venus in 1769, the Royal Society put forward Dalrymple's name as the prospective leader. He was not chosen due to Dalrymple's insistence that he be placed in absolute command of a naval vessel with the power of appointment of all officers, and the Admiralty's refusal to appoint any commander other than a naval officer. Instead, James Cook was appointed, and Dalrymple was left to fume at home, particularly when Cook returned having accomplished much, but not having discovered South Land, Dalrymple's name for the southern continent. Always an eloquent man, Dalrymple damned Cook's expedition, stating that it had failed in its major objective and that if he had been in command, "I would not have come back in ignorance" (Mill 1905, 59). Dalrymple's strictures were sufficiently loud and widely disseminated to persuade the Admiralty to adopt Cook's plan for another expedition—this time to search specifically for *Terra Australis* and, once and for all, prove or disprove its existence. This Cook proceeded to do in the most expeditious manner conceivable, accomplishing in 1772–1775 the first circumnavigation of Antarctica. During that voyage, the only land seen south of 55° S was the South Sandwich Islands, and the only place where a landing was possible was South Georgia. Cook's voyage marks the death of *Terra Australis Incognita* and its replacement by the Southern Ocean and, soon, Antarctica.

William James Mills

See also: Cook, James (1728–1779); Cook, James, Voyages of; East Antarctica; West Antarctica

Further Reading

Brosses, C. *Histoire des navigations aux terres australes [History of the Navigations of the* Terra australis*].* Amsterdam: N. Israel, 1967.

Mill, H. *The Siege of the South Pole: The Story of Antarctic Exploration.* London: Alston Rivers, 1905.

Three-Pole Concept

There are three regions in the world that carry the largest amount of snow and ice, and the coldest temperatures: the Arctic, the Antarctic, and the Hindu Kush-Himalaya (HKH). These are referred to as the three poles. But beyond ice and snow, and despite being located so far apart from each other, the three poles share many features and characteristics that unite them into a single globally relevant region.

The first pole is the North Pole, which has a long history of exploration; however, a large and sophisticated indigenous population have lived there for thousands of years and been ignored, overthrown, and in part destroyed by outsiders; many observers of this situation speak of a still ongoing genocide. The recently started man-made destruction of Arctic sea ice, an inherent feature and life-support system for Arctic indigenous people, supports such arguments vividly.

The second pole (the land and sea of the Antarctic) was never really populated by indigenous groups. Its exploration and settling started with the industrial age with people from Norway, the United Kingdom, France, the United States, and elsewhere (e.g., Ukraine, Poland, Malaysia, Brazil, Chile, South Korea, China, and India). Already by the end of the nineteenth century, major marine resources like marine mammals had been overused commercially to the point of extinction. This was achieved by an effluent international community. But most decay of the second pole occurred after World War II. The internationally disputed harvest management of Antarctic toothfish is illustrative of this point. The ozone hole, as well as global warming, now provide for other major problems on land and in sea.

Now, more than 1,000 scientists and support staff are found living in Antarctica year-round, and a number of tourists arrive yearly. Regular commercial flights and even hotels are expected next. While the human density is still relatively low in Antarctica, the human footprint is significant.

The third pole makes for another unique sphere. The HKH region is equally vast and shares a culturally extremely complex indigenous population. Conflict zones such as Tibet, the Hindu Kush, Punjab, and Helmand are of known global relevance. HKH offers major global religions and belief systems as well. The biodiversity of this region looks for its equal. As with the other two poles, climate change, atmospheric contamination (e.g., Asian Brown Cloud), and resource exploitation make for additional discussion items. The HKH region adds a strategic spin to the discussion because it also provides water (which equals life) for more than 2 billion people.

Many more details about the three poles and the underlying concept can be found in, for instance, Huettmann (2012) as a contribution to the International Polar Year (IPY.org). Because a decoupling from the three poles is obviously impossible for us, some key questions remain, such as what has the future in stock for each of the three poles, and how will they fare in concert and with the world all around them?

In this regard, first, history has already provided some answers for us: dinosaurs, once thriving on the poles, are now globally extinct; similar can be said for many mammoth and elephant species that once roamed parts of these poles. Many other species are currently declining worldwide such as frogs, and many Arctic shorebirds and Himalayan pheasants; other species are expected to soon follow suit. Second, human warfare has already raged around two poles (Arctic and HKH). While the third pole has been spared from most physical conflict as of yet, this will likely change.

Arctic warfare is now on the forefront of the superpowers, and some violent conflicts started to evolve already around Antarctic resources (e.g., fisheries and whaling); mining still remains under a time-limited embargo. It is in the future, though, that the poles are to be divided among the global community, with the help of the Security Council, often using (polar) research dominance. Even as the third pole remains unused as per the Antarctic Treaty System, resource embargos will have repercussions elsewhere due to worldwide shortages of food and resources.

The three-pole concept, the relevance of cold temperatures, and their maintenance and protection, have not entered the global policy discussion, yet. That can easily be seen with the Rio Summit (Kyoto and Biodiversity Conventions), in the climate change discussions, with the World Bank, and in various summits of G2, G10, G20, or in Davos meetings, for instance. The United Nations Environmental Program, International Council for Science (www.ICSU.org), and DIVERSITAS (www.diversitas-international.org/), for instance, are still far away from a coherent and efficient policy for the three poles. The three poles matter for mankind and the world.

Considering an ongoing and massive decline of glacier volume for most poles, we can expect the worse: the global climate will not be buffered well anymore, flooding will increase, global land water supply will be reduced, sea-level rise will increase, fire impacts will be bigger, and global resource conflicts and tensions will be on the rise and virtually uncontrollable. The idea of natural resource management will receive a new definition once more. With such an outlook, one can only be shocked by the fact that virtually no governmental body or NGO has moved away from business-as-usual policies and no preparation is being done to proactively address these problems. The glaciers will track our doings well.

Falk Huettmann

See also: Climate Change and Invasive Species in the Arctic; Climate Change and Permafrost; Climate Change in the Arctic; Environmental Concerns, Arctic Mining Operations; Human Impacts and the Antarctic Wilderness

Further Reading

Huettmann, F. *Protection of the Three Poles.* Tokyo: Springer, 2012.

Knowles, K., and M. Diggle. *Health of Antarctic Wildlife: A Challenge for Science and Policy.* New York: Springer, 2009.

Nemitz, D., F. Huettmann, E.M. Spehn, and W.B. Dickoré. "Mining the Himalayan Uplands Plant Database for a Conservation Baseline Using the Public GMBA Webportal." In F. Huettmann, ed. *Protection of the Three Poles.* Tokyo: Springer, 2012, pp. 135–58.

Tin T., D. Ligget, P.T. Maher, and M. Lamers, eds. *Antarctic Futures: Human Engagement with the Antarctic Environment.* New York: Springer, 2014.

Thule Air Base, Greenland, B52G Stratofortress Crash of 1968

On January 21, 1968, a U.S. Air Force B52G Stratofortress, operating under the call sign "HOBO 28" originating out of Plattsburgh, New York, Airbase 380th Strategic Bomb Wing as part of Operation Chrome Dome crashed near Thule Airbase in Greenland and nearby Baffin Bay (76° 31′ 40″N 69° 16′ 55″W). The B52 bomber was carrying four 1.1 megaton nuclear weapons and, upon impact, the high explosive charges of the nuclear warheads went off. Although a nuclear explosion was averted, the radioactive material of the B28FI nuclear weapons was strewn across a large area. The burn-off of the B52's remaining fuel of 225,000 pounds lasted more than five hours, melting the ice and sending most of the wreckage and munitions to the ocean floor.

The crash was caused by a fire after three cloth-covered foam cushions had been placed on the heating vents resulting in an in-flight fire that could not be contained. The B52 was ordered abandoned, and seven of the eight crew members on board ejected. The eighth crew member escaped out the lower hatches but sustained head injuries. The unpiloted B52 crashed about 7 miles (11 km) from the U.S. air base in Thule, Greenland. The conventional explosives and the nuclear weapons tangled and spread in the wreckage covering a 1–3-mile (1.6–4.8-km) area, releasing radioactive material, including americium-241, tritium, and plutonium-241, into the Arctic and the atmosphere.

The U.S. and Danish officials launched a cleanup and environmental containment effort called "Project Crested Ice." Despite being hindered by the adverse weather of the Arctic, the recovery and decontamination crews of Project Crested Ice recovered 550,000 gallons of contaminated liquid as well as 30 tanks of miscellaneous material. This material was taken to Thule Air Base and held at what became known as "Tank Farm." The recovered radioactive contaminated ice and debris was returned to the United States and buried. The nuclear weapon debris was sent to Amarillo, Texas, and evaluated by the company Pantex. The 30 tanks were sent to Savannah River, South Carolina. Project Crested Ice lasted until September 13, 1968, costing $9.4 million ($62.8 million as of 2013) and using more than 700 personnel.

Several controversies came out of this incident. The first was whether there was a lost nuclear weapon, which the U.S. military refers to as a "Broken Arrow" or an accidentally lost nuclear weapon that does not pose a risk of war. It is presently not completely known whether all of the nuclear weapons were recovered. Officially, all weapons were accounted for; however, some critics and journalist argue that one of the B28FI nuclear weapons was never recovered. The incident exposed the U.S. military and the Danish government's tacit approval of the housing of surface-to-air nuclear weapons and other tactical warheads in Greenland, which was in violation of the Greenland Danish agreement of 1957 prohibiting nuclear weapons on the island. Protests have repeatedly occurred in Denmark over the accident and the U.S. housing nuclear weapons on their territory. The island of Greenland, and predominately Inuit population, is still a Danish colony and under Denmark rule.

Andrew J. Hund

See also: Eskimo Coast Disaster of 1885; Lost Patrol

Further Reading

Danish Institute of International Affairs. *Greenland during the Cold War: Danish and American Security Policy 1945–1968.* Copenhagen, Denmark: Danish Institute of International Affairs, 1997.

Weiss, E. "Cold War under the Ice: The Army's Bid for a Long-Range Nuclear Role, 1959–1963." *Journal of Cold War Studies* 3 (2001): 31–58.

Thule Culture

The Thule culture is a prehistoric culture associated with the Eskimos or the Inuit, significant in representing the expansion of Alaskan Inuit across Arctic Canada. Their heirs live in the northern Labrador. The Thule or proto-Inuit people are the ancestors of the modern Inuit population. The name "Thule" comes from Thule, now called Qaanaaq, in northwest Greenland. At the nearby Comer's Midden region, some archaeological sites have uncovered remnants of the culture that have chalked out quite strong links between the Thule and the Inuit people, including commonalities in biology, culture, and language. Thule culture had a marginal link with the Vikings as well, who knew the Thule people as the "Skræling."

The Arctic coast in northern Alaska was its seat of development. The culture spread up the Amundsen Gulf in the Far East until about AD 900. It became prominent up to Greenland, also known as Kalaallit Nunaat, until the end of the twelfth century, and proliferated in the central parts of Arctic Canada. During the fifteenth century, the culture started waning from central Canada perhaps due to climatic cooling during 1250–1500, the Medieval Cool Period. During their expansion from Canada to Greenland, the Thule culture encountered the Dorset culture in that region and, with superior strength and more advanced survival technology, replaced it. The Thule cultures in Eastern Alaska and Western Alaska were well linked and communicating during 1300–1700.

Thule people were advanced in indigenous technology, and they survived in the Arctic because of their unique patterns of house making, hunting, and combating the harsh weather conditions. The unfavorable natural conditions in the Little Ice Age during 1650–1850 disrupted the Thule culture and, with the passage of time, created the identities of the Eskimo and the Inuit, respectively.

The economy of the Thule people was based on hunting the large animals in the sea. They killed whales, seals, walrus, polar bears, caribou, musk oxen, and smaller mammals with slate knives and toggling harpoons. They used the rib cages and bones for structures of their homes. Animal fat was used for their diets as well as heating oil to stay warm. They collected birds, fish, mussels, and wild plants.

They made two different types of houses for winters and summers. They made pit houses/snow houses built with whale bones, skin, ribs and jaws, and sod, during the winter and houses made with skin tents for the same purposes in summer. Stony pavements existed inside their houses, and lamps and furs were used inside to warm themselves. Other inventions of Thule culture include the making of Igloos as camp houses during hunting and traveling seasons; kayaks, small boats covered with skin for carrying one person; umiaks, large open boats, made of bones and covered with skin for a group expedition; and dog-drawn sleds as means of transport. The practice of stitching was another major discovery in Thule culture, and Thule women were adept in it. They knew clothing and sewing technology.

Thule culture had many unique artifacts like whole-bone instruments, unique cooking pots, and lamps made of stone. Their art is shown in small carved ivory or wooden figures that were used possibly for magic or religious purposes or as game pieces.

Ravindra Pratap Singh

See also: Eskimos; Inuit

Further Reading

McGhee, Robert. *Canadian Arctic Prehistory.* Ottawa: National Museums of Canada, National Museum of Man, 1978.

Toolik Field Station (TFS)

The Toolik Field Station (TFS; 68° 38′N, 149° 36′W) is located at mile 284.5 of the Dalton Highway. It is 158 miles (240 km) north of the Arctic Circle and 117 miles (188 km) south of the Arctic Ocean. From November 27 to January 14, the sun never rises, and from May 26 to July 17, the sun never sets.

The TFS is operated by the Institute of Arctic Biology at the University of Alaska Fairbanks (UAF) with support from National Science Foundation (NSF). Its mission is to support research and education that creates a greater understanding of the Arctic and its relationship to the global environment. To carry out this mission, TFS provides housing, meals, laboratories, and support services for Arctic research and education to scientists and students from throughout the United States and the world. Research support includes GIS and mapping services, technical and IT assistance, shared common equipment, and a standardized set of environmental data.

TFS was originally established to support an aquatic program designed to obtain baseline data on the North Slope. In 1975, Toolik Lake was selected as the site for the aquatic research, and a 16-foot travel trailer belonging to the UAF was placed at the north end of the lake. In the late 1970s and early 1980s, the camp continued to grow, adding a kitchen, laboratories, and sleeping quarters. In 1983, the camp outgrew available space, and a closed pad, left over from the construction of the Alaska Pipeline, was identified on the south shore of Toolik Lake where it was officially named “Toolik Field Station.” Throughout the 1980s, 1990s, and 2000s, the facilities were upgraded through funding from the Department of Energy, UAF, state of Alaska, and NSF. In 1998, winter quarters were established, making Toolik a year-round facility.

The TFS consists of modular laboratories with running water, fume hoods, bench and desk stations, storage, and outside staging decks. Electricity is provided by diesel generators, and all wastewater is collected and trucked to Prudhoe Bay for disposal.

TFS has developed from a 10-person tent camp into a premier Arctic research laboratory and science support facility with a capacity of more than 100 users. Current research themes and funding levels are very dynamic and responsive to national interests in the Arctic.

Bruce Taterka

See also: Greenland, U.S. Bases in; Nuuk Ecological Research Operations (NERO); Sermilik Station; Smeerenburg

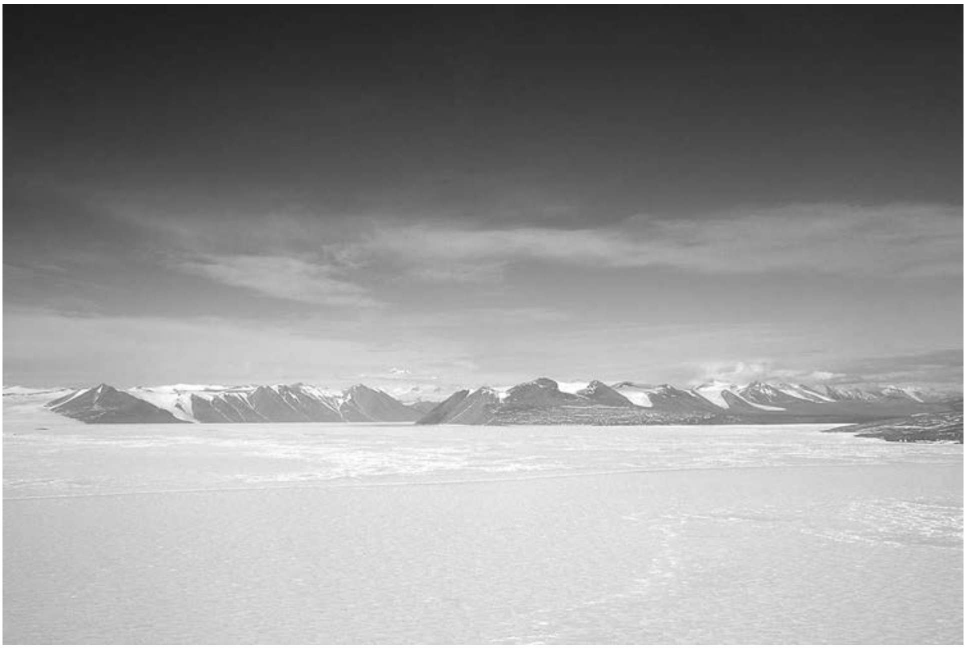
Further Reading

Toolik Field Station, Institute of Arctic Biology. http://toolik.alaska.edu/. Accessed January 14, 2014.

Transantarctic Mountains

The Transantarctic Mountains (85° S 175° W) is an extensive collection of separately named mountain ranges stretching across the Antarctic continent from Cape Adare (71° 17′S 170° 14′E) in Victoria Land to Coats Land (77° S 27° 30′ W). It is one of the largest mountain ranges in the world at more than 2,200 miles (3,500 km). The Transantarctic Mountains divides West and East Antarctica passing within 370 miles (600 km) of the geographic South Pole. The Transantarctic Mountains were first seen from the Ross Sea by Captain Sir James Clark Ross (1800–1862), in 1841.

A segment of the Transantarctic Mountains. (National Oceanic and Atmospheric Administration)



Transantarctic Mountains. (Shutterstock.com)

The Transantarctic Mountains range from 60 to 185 miles (100–300 km) wide. The western side of the Transantarctic Mountains are bordered by the Ross Sea in Victoria Land to the McMurdo Sound, where the range runs along the Ross Ice Shelf to roughly Scott Glacier (85° 45′S 153° W). After passing Scott Glacier, the Transantarctic Mountains are bordered by the Western Ice Shelf to Coats Land. On the eastern side, the Transantarctic Mountains are bordered the entire length by the Eastern Antarctic Ice Sheet. The Transantarctic Mountains were not explored extensively until the 1940s and 1950s, with U.S. Navy Antarctic Developments Program in 1946–1947 or more commonly known as Operation Highjump and the International Geophysical Year 1957–1958. These two research activities made extensive aerial photography of Antarctica.

In many places along the Transantarctic Mountain range, only jagged sandstone, diabase, and granite nunataks push through the ice sheet. The West Antarctic Ice Sheet (WAIS) has three drainage basin embayments, which are the Ross Sea, Weddell Sea, and Amundsen. The Ross Sea Embayment is the drainage basin that flows from the Transantarctic Mountains into the Ross Ice Shelf then into the Ross Sea. Several ice streams drain into the Ross shelf on the western side, such as the MacAyeal (80° S 143° W), Bindschadler (81° S 142° W), Whillans (83° 40′S 145° W), and Mercer (84° 50′S 145° W) ice streams. These ice streams were formerly known as the Ice Stream E, D, B, and A, respectively. On the eastern side, several major glaciers drain into the Ross Ice Shelf, such as the Leverett (85° 38′S 147° 35′W), Scott (85° 45′S 153° W), Beardmore (83° 45′S 171° E), Nimrod (via the Shackleton Inlet) (82° 19′S 164° E), Byrd (80° 20′S 159° E), Mulock (79° S 160° E), and Skelton (78° 41′S 161° 38′ E).

The Weddell Sea Embayment is the ice drainage basin of the WAIS and consists of the Ronne–Filchner Ice Shelf. Three ice streams flowing into the Ronne Ice Shelves are the Rutford (79° S 81° W), Evans (76° S 78° W), and the Foundation (83° 15′S 60° W) ice streams. The Support Force glacier (82° 45′S 46° 30′W) flows into the Ronne–Filchner ice shelf. The Recovery (81° 10′S 28° W) and Slessor (79° 50′S 28° 30′W) Glaciers drain into the Filchner Ice Shelf.

The Amundsen Sea Embayment is made up of multiple outlet glaciers and is an ice drainage basin of the WAIS. The Amundsen Sea Embayment has a total area of 68,800 square miles (175,000 sq. km) and drains around 10 percent of the WAIS. There are two major ice formations that flow into Pine Island Bay of the Amundsen Sea, which are Pine Island and Thwaites Glacier. Pine Island Glacier (75° 10′S 100° W) is located near Cape Flying Fish, and Thwaites Glacier (75° 30′S 106° 45′W) extends into Pine Island Bay forming an ice spit or tongue about 30 miles (50 km) wide and is called Thwaites Ice Tongue (75° S 106° 50′W). The average thickness of the Thwaites Ice Tongue ice is almost 2 miles (3 km). Icebergs that have broken off the Thwaites Ice Tongue have formed the Thwaites Iceberg Tongue (74° S 108° 30′W).

Only a few places in the Transantarctic Mountains are not covered by ice. Most of these are found in the dry valleys near the McMurdo Sound, such as the Barwick and Balham, and Taylor valleys on the western shores of the Ross Sea. A Victoria Land mountain range of the Transantarctic Mountains is the Royal Society Range (78° 10′S 162° 40′E). The Royal Society Range is unusual terrain. The highest point in this range is Mount Lister at 13,162 ft. (4,012 m), which is on the western shore of McMurdo Sound, sandwiched between the large Koettlitz, Skelton, and Ferrar Glaciers. Other notable mountains are Huggins, Rucker, and Sailent. Neighboring the Koettlitz Glacier are two dormant stratovolcanoes of Mount Discovery (78° 22′S 165° 1′E) and Mount Morning (78° 31′S 163° 35′E).

The highest peaks of southern Transantarctic Mountain range are Mount Markham (82° 51′ S 161° 21′E) and Mount Miller (83° 20′S 165° 48′E). Mount Markham is twin peaked with one peak being 14,272 ft. (4,350 m) and the other being 14,042 ft. (4,280 m) high. Mount Miller is located in the Holland Range at 13,650 ft. (4,160 m). The tallest peak in the Transantarctic Mountain is Mount Kirkpatrick at 14,856 ft. (4,528 m) in the Alexandra Range. Temperatures on the summits can regularly reach −40°F (−40°C).

The extensive ice cover on the Transantarctic Mountains results in little life inhabiting the area. Almost all of the life is limited to cryptograms algae, bacteria, fungi, and lichens. Many fossils are found in the sedimentary formations throughout the Transantarctic Mountain range, such as dinosaurs, various forest plants, songbirds, and flowers. The abundance of vegetation in the fossils made the earlier explorers and researchers, such as Hedley, Scott, Shackleton, and Debenham recognize that the climate of Antarctica had been dramatically different many years ago.

The Transantarctic Mountains are a natural barrier to reaching the South Pole from the Ross Ice Shelf. Ernest Shackleton (1874–1922) of the British Antarctic Expedition of 1908–1909 was the first to traverse the Transantarctic Mountains via the Beardmore Glacier. Captain Robert Falcon Scott (1868–1912) traversed the Beardmore in his ill-fated Terra Nova Expedition of 1911–1912. Norwegian polar explorer Roald Amundsen (1872–1928) lead the first team to the South Pole and used the Axel Heiberg Glacier (85° 25′S, 163° W) to traverse the Transantarctic Mountains. The Leverett Glacier is considered the best possible overland supply route to traverse the Transantarctic Mountain range from U.S. stations of McMurdo to the Amundsen–Scott.

Andrew J. Hund

See also: Antarctic Ice Sheet; Ice Shelves of Antarctica; Sea Ice

Further Reading

Borg, S., D. DePaolo, and B. Smith. "Isotopic Structure and Tectonics of the Central Transantarctic Mountains." *Journal of Geophysical Research B: Solid Earth and Planets* 95, no. 5 (1990): 6647–67.

Fitzgerald, P. "The Transantarctic Mountains of Southern Victoria Land: The Application of Apatite Fission Track Analysis to a Rift Shoulder Uplift." *Tectonics* 11, no. 3 (1992): 634–62.

Troll Station

Troll Station is a year-round research center established in the eastern part of Princess Martha Coast in Queen Maud Land, Antarctica. Its location at Jutulsessen in Dronning Maud Land on the far north corner of the continent is set on a nunatak break of snow-free solid rock 1,275 m (4,183 ft.) above the mean sea level. It is surrounded by ice sheet; nevertheless, it operates in a desert climate, cold and dry with a temperature variance of 0°C (32°F) and −50°C (−58°F). Because of its position south of the Antarctic Circle, extremes of midnight sun and polar night are common. This station is owned by the Government of Norway, and it is operated by the Norwegian Polar Institute. It was operated as a summer-only institute when it opened in 1990; in 2005, it was remodeled to accommodate year-round research. Securing Norwegian interests in Antarctica annexed on January 14, 1939, strengthened Norway's position within the Antarctic Treaty.

Norwegian astronomer and meteorologist Henrik Mohn (1835–1916) is regarded as the founder of Norwegian meteorological research. He served as the director of the Norwegian Meteorological Institute from its inception in 1866 until 1913. The institute maintains offices in Oslo, Bergen, and Tromsø; it continues to represent Norwegian interests within the World Meteorological Organization, the European Centre for Medium-Range Weather Forecasts, and the European Organization for the Exploitation of Meteorological Satellites. Until 2010, it operated the *MS Polarfront*, the last working weather ship in the world, operable until its retirement in January 2010 and the transition to satellite data receivers.

In 2007, an atmospheric monitoring and research station was installed at Troll by the Norwegian Institute for Air Research (NILU). The station samples and archives data measuring atmospheric phenomena—including aerosols, pollutants, ozone, and UV radiation—in tandem with parallel scientific research in operation at the NILU Arctic station (Zeppelin) at Ny-Ålesund, Svalbard. These values are further analyzed against comparable datasets collected at other research stations located between the Arctic and Antarctic. Weekly samples were collected from 2007 until 2010, measuring 32 PCB congeners, a- and g-hexachlorocyclohexane, *trans*- and *cis*-chlordane, *trans*- and *cis*-nonachlor, *p*, *p'*- and *o*, *p*-DDT, DDD, DDE, and hexachlorobenzene. Concentrations of these target contaminants were lower than similar samples collected in the early 1990s, attributed to stringent international regulation of these environmental toxins.

In June 2007, the Troll instrument set recorded a series of aerosol particle distributions that for the first time provided evidence that the Antarctic continent is the recipient of biomass burning aerosols emissions derived from biomass fires set in South America. That same year, Kongsberg Satellite Services announced a joint venture between Kongs group and the Norwegian Space Center to install a satellite ground station at Troll (TrollSat), providing state-of-the-art narrow and broadband communication between Antarctica and Europe/United States. It is one of 30 ground stations operating within the European Galileo network.

Victoria M. Breting-Garcia

See also: Antarctic Circle; Arctic Council; Ice Sheet

Further Reading

Feibig, M., C. Lunder, and A. Stohl. "Tracing Biomass Burning Aerosol from South America to Troll Research Station, Antarctica." *Geophysical Research Letters* 36, no. 14 (2009): L14815.

Hansen, G., C. Lunder, N. Schmidbauer, K. Stebel, W. Aas, R. Kallenborn, K. Holmen, K. Tørseth, and T. Berg. "Troll Station—A New Year-Round Atmospheric Monitoring and Research Station in Antarctica." *Geophysical Research Abstracts* 9 (2007): 08866.

Kallenborn, R., K. Breivik, S. Eckhardt, C. R. Lunder, S. Manø, M. Schlabach, and A. Stohl. "Long-Term Monitoring Of Persistent Organic Pollutants (POPs) at the Norwegian Troll Station in Dronning Maud Land, Antarctica." *Atmospheric Chemistry and Physics: Discussion* 13 (2013): 6219–46.

Tuktut Nogait National Park

Tuktut Nogait National Park (68° 49′N 121° 44′W) is located at the northwestern corner of the Canadian mainland. It is at the far northeastern corner of the Northwest Territories, just on the Nunavut border on Amundsen Gulf. It looks out from the Gulf toward Beaufort Sea; the Arctic Ocean lies just beyond. The Tuktut Park is 6,900 square miles (18,000 sq. km). The Rocky Mountains and the Pacific Coast Mountains rise on the far left of the Northwest Territories, down the Yukon Territory between Alaska and British Columbia coastline to the northwestern Pacific corner of the United States. Canada's coastlines are the longest in the world, covering a distance of more than 93,000 square miles (243,000 sq. km), filling a surface area of 1.9 million square miles (5 million sq. km). More than three quarters of the Canadian lands are surrounded by water.

To the east of Amundsen's Gulf lies the Canadian Arctic Archipelago. Baffin Bay lies at the end of the Labrador Sea bordering Greenland at the far eastern corner of the archipelago. An estimated 36,563 islands are found in this archipelago. The total territory includes most of Nunavut (established as an independent Canadian territory on April 1, 1999) and a part of the Northwest Territories, including the Tuktut Nogait parklands. The total area of the Canadian Arctic Archipelago ranges up to 550,000 square miles (1.4 million sq. km).

Tuktut Nogait National Park was established in the Low Arctic region of the Northwest Territories of Canada in 1996. It is located on the mainland near the coast in a sparsely populated area; the total area of the parkland is 16,340 square miles (42,320 sq. km), and it lies approximately 105 miles (170 km) north of the Arctic Circle (69° 17′N 123° 01′W). Its climate is characterized by very long winters (during two months of the year, the sun does not rise above the horizon) and a very short summer, during which the sun does not set for nearly two months. The landscape, formed of sedimentary rocks, shale, sandstone, dolomites, and quartzes, and permafrost and cryosols, supports a variety of wildflowers, sedges, willows, poplars, and birches. Three main rivers flow upland, draining into the Amundsen Gulf. The Hornaday, Brock, and

Stamp printed by Canada shows flag and Tuktut Nogait National Park, Northwest Territories, ca. 2006. (Shutterstock.com)

Roscoe Rivers provide important riverine habitats supporting small mammals and migratory birds including raptors, falcons, hawks, and eagles.

Canada has a national park legacy that began with a park established at Banff in 1885; later additions included sites in the Rocky Mountains, and the Prairie, Central, and Maritime Provinces. Since 1976, 10 parks and natural reserves were established in the northern provinces. These selections are guided by the National Parks System Plan of 1997, which divided the country into 39 regions with the intent of establishing a national park in each one. This complex process is administered by Parks Canada under the auspices of the Department of Canadian Heritage.

Interest in preserving Canada's northern landscapes was motivated by a growing understanding of the importance of the unique ecosystems and wildlife that depended on Canada's fragile Arctic boundary. In 1980, the World Conservation Strategy (IUCN) recognized the need to conserve Canada's Arctic and subarctic ecosystems. Since 1922, Canada has established a national precedent for creating and preserving ecosystems such as Banks Island, home to one of the highest populations of musk ox in the world and Ivvavik and Vuntut, calving grounds of the Porcupine caribou herd. Wapusk was settled as a national preserve for denning polar bears.

The Tuktut Nogait National Park was created to protect the Tundra Hills natural region in the territories, a core habitat for the Bluenose-West caribou herd, and an important homeland for the Inuvialuit and other native communities. In the language of the Inuvialuit, the term "Tuktut Nogait" refers to caribou yearlings before they reach their first year of life. The State of the Park Report 2011 for Tuktut Nogait National Park noted that the number of Bluenose-West caribou (current population is estimated at 85,000) is declining. Nevertheless, its tundra ecosystems are stable with healthy stocks of breeding birds and plant productivity.

Public interest in establishing northern parks in Canada has its roots in movements to recognize the rights of Aboriginal First Peoples, a concept that was recognized by the Canadian Supreme Court in 1973. Parks are established in agreement with the federal Department of Indian Affairs and Northern Development (DIAND). Parks Canada created its own internal Aboriginal Affairs Secretariat in 1999 to strengthen relationships with Canadian natives and to actively recruit representatives from the country's First Nations in all matters concerning Canada's natural resources and cultural heritage. Tuktut Nogait National Park is managed co-operatively with the Inuvialuit, the Sahtú Dene and Métis, and the Government of the Northwest Territories.

Victoria M. Breting-Garcia

See also: Beaufort Sea; Canadian Arctic Archipelago; Northwest Passage

Further Reading

Atkinson, K. "New National Parks in the Canadian North." *Geography* 86, no. 2 (2001): 141–49.

Tundra

The tundra is the treeless area along the coast of the Arctic Ocean in Europe, North America, and Asia, north of the boreal forest. It covers approximately 10 percent of the earth's land surface, although its extent is diminishing as the climate warms. The tundra is the coldest of the biomes and receives little precipitation, roughly 6–10 inches (15–25 cm) of rainfall per year.

Despite receiving little rainfall, the tundra is typically wet because cold temperatures and six to eight months of darkness keep evaporation rates low, allowing moisture to remain in the soil. The tundra is dotted with ponds and bogs.

Tundra vegetation has adapted to cold, wet, windy conditions and a short growing season. The tundra is dominated by a thick cover of mosses, which stabilize soil and provide habitat for a diverse community of invertebrates. Lichens, grasses, and sedges are also common on the tundra. With a short growing season and low solar intensity at Arctic latitudes, many tundra plants reproduce by budding rather than expending scarce energy resources to make flowers and seeds.

With temperatures below 32°F (0°C) most of the year, tundra soil is underlain by permanently frozen ground, known as permafrost. In the summer, temperatures rise up to 64°F (18°C), thawing the top meter or so of soil, which is known as the active layer. The thawing of the active layer in the Arctic summer allows

Reindeer skull in tundra, Dovrefjell National Park, Norway. (Shutterstock.com) plant roots to grow, and long daylight hours promote photosynthesis. Thawing also promotes plant respiration and microbial action that decomposes dead organic matter.

The tundra is known for an explosion of insects in the spring, including spiders, moths, grasshoppers, blackflies, and large voracious mosquitoes. There is a diverse population of tundra mammals; herbivores include lemmings, squirrels, hare, and caribou, which are preyed on by foxes, wolves, black bear, and grizzly. Salmon, trout, and other fishes are found in tundra lakes and rivers. Most bird species are migratory, arriving in the tundra in spring to feast on insects and raise young before heading south at the end of the short Arctic summer. Some bird species, such as ptarmigan, overwinter on the tundra in burrows in the snow. Reptiles and amphibians, which are not suited to extreme cold owing to their cold-blooded physiology, are essentially absent on the tundra.

Tundra ecosystems are under threat on several fronts. In the past 50 years, the Arctic has seen the most extreme warming on the planet, as high as 43°F (6°C) above twentieth-century averages. Warming temperatures have caused melting permafrost, increasing evaporation rates, and greater incidence and extent of wildfire. The 2007 Anaktuvuk River fire burned across more than 380 square miles (1,000 sq. km), which was more than twice the extent of wildfire in the Alaskan tundra in the past 50 years. Warming is also shifting the northern boundary of the boreal forest north, into territory that was previously tundra, thus decreasing the overall extent of the Arctic tundra. Some studies predict that at least half of the tundra would see changes in plant communities by 2050, including a 50 percent increase in woody plants and trees.

The warming tundra raises important concerns in the earth's carbon cycle as climate warms. Tundra soils hold vast reserves of carbon, which potentially could be released to the atmosphere as the tundra thaws. In the past, the tundra has served as a carbon sink because microbial decomposition of organic matter has not kept up with carbon uptake by plants through photosynthesis, resulting in the tundra taking in more carbon that it released to the atmosphere on an annual basis. As the tundra warms, however, the balance between the uptake of carbon through photosynthesis and the release of carbon through respiration could change. While warming temperatures will promote photosynthesis during the short Arctic summer, and thus make the tundra more of a carbon sink, plant respiration and microbial decomposition will also increase, tending the tundra toward more of a carbon source. While the precise carbon balance of the tundra is poorly understood at present, and will in the future largely depend on the amount of warming that takes place, some studies have raised the likelihood that the tundra will shift toward being carbon neutral on an annual basis, or even becoming a carbon source. In addition, melting permafrost and sinkholes, or "thermokarst" features, could release carbon directly to Arctic waters and expose organic material to sunlight, further enhancing movement of carbon from the tundra to the atmosphere or surface waters and, eventually, the ocean.

The tundra is rich in mineral resources. Oil and gas exploration and production is the largest source of revenue on the Alaskan tundra and drives the state's economy. The Canadian Arctic is a major source of oil and gas, and also produces diamonds. The Alaska pipeline crosses the Alaskan tundra to transport petroleum from drilling operations on the tundra to terminals in the south.

Bruce Taterka

See also: Arctic Botany; Arctic Shrub Range Expansion; Caribou; Climate Change and Invasive Species in the Arctic; Climate Change and Permafrost

Further Reading

Chernov, Y. *The Living Tundra.* Translated by D. Love. Cambridge: Cambridge University Press. 1985 [1980].

Scheffer, M., M. Hirota, M. Holmgren, E. Van Nes, and F. Chapin III. "Thresholds for Boreal Biome Transitions." *PNAS* 109, no. 52 (2012): 21384–89.

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U

Unangax. *See* Aleuts/Unangax

United Nations Convention on the Law of the Sea (UNCLOS)

The United Nations Convention on the Law of the Sea (UNCLOS) is the international agreement that establishes and defines nations' use, management, jurisdiction, and governance over the world's oceans, fisheries, vessel transit, and marine natural resources. UNCLOS is commonly referred to as the Law of the Sea Treaty or sometimes as the Law of the Sea Convention. From 1949 to 1956, the United Nations formally discussed issues related to the use, management, jurisdiction, and governance of the high seas.

The first UN Conference on the Law of the Sea (referred to as UNCLOS I) was held in Geneva, Switzerland, in 1958. UNCLOS I updated, revised, and replaced the freedom of the seas model. The four treaties agreed on at this meeting were the (1) Convention on the Territorial Sea and Contiguous Zone entered into force on September 10, 1964; (2) Convention on the Continental Shelf entered into force on June 10, 1964; (3) Convention on the High Seas entered into force on September 30, 1962; and (4) Convention on Fishing and Conservation of Living Resources of the High Seas entered into force on March 20, 1966. The Convention on the Territorial Sea and Contiguous Zone specified that the innocent passage of foreign vessels navigating through between high seas via and international straits was allowable. The Convention on the Continental Shelf specified that coastal states have authority over their continental shelf and the areas surrounding them. The Convention on the High Seas focused high sea international regulations. The Convention on Fishing and Conservation of Living Resources of the High Seas focused on the protection and management of ocean life from being depleted. These four treaties of UNCLOS I were considered a major success, but did fail to resolve the boundary of territorial waters.

The second Conference on the Law of the Sea (called "UNCLOS II") was held in Geneva in 1960. The six-week conference did not produce any new conventions. The third Conference on the Law of the Sea (called "UNCLOS III") was held in New York, in 1973. The main issue being discussed at UNCLOS III was territorial waters. The framework was based on achieving a negotiated consensus among 160 nations as opposed to a majority vote. The negotiations of the conference continued for nine years (1982). The purpose of UNCLOS III was to establish rules for governing the oceans and update/revise the 1958 treaties. UNCLOS III established specific and clarified ocean jurisdictional limits of waters (internal, territorial, and archipelagic), clarified zones (contiguous and economic), and continental shelves.

Internal waters under UNCLOS III were defined as landside water and waterways and specified that coastal states have the right to set laws, regulate, and determine resource use. UNCLOS III noted that foreign vessels did not have any passage rights within internal waters of the coastal state. Territorial waters were defined as out of 12 nautical (14 miles; 22 km) miles. As with internal waters, the coastal states were offered the right to set laws, regulate, and determine resource use in territorial waters. Foreign vessels provided with two types of passage through any territorial waters: transit and innocent passage. Transit was meant to include passage of military craft through strategic straits. Under the convention, it is compulsory for underwater vessels, such as submarines to surface and fly their nation flag during passage. Innocent passage is traveling through waters in a prompt, direct, and uninterrupted manner that does not interfere with the coastal states' security, peace, and/or stability. Things considered not innocent passage are polluting fishing in waters, firing missiles and weapons, and espionage activities. The coastal state can safeguard its security and temporarily suspend innocent passage in their territorial waters. The archipelagic water under UNCLOS III defines what an archipelagic state is and sets out how a nation can establish its territorial borders, which is based on its outermost islands. The coastal states have the right to set laws, regulate, and determine resource use in archipelagic waters (like internal and territorial waters).

The UNCLOS III established the contiguous zone as an additional 12 nautical (14 miles; 22 km) miles and allowed the coastal states four specific areas of regulation enforcement, which are taxation, customs, immigration, and pollution. Violations or impending violations within the contiguous zone allow immediate pursuit with the coastal states' recognized waters. The exclusive economic zones (EEZs) gave coastal states exclusive development rights over all natural resources in continental shelf and territorial waters and out to 200 nautical miles (230 miles; 370 km). The EEZs were focused on clarifying coastal states' control over their fishing and oil rights out 200 nautical miles. The continental shelf is defined as a natural prolongation or seabed that extends beyond the 200 nautical miles, but not further than 350 nautical miles (400 miles; 650 km). This provision allows the coastal states to have exclusive right to and the harvesting of mineral resources to the end of the natural prolongation, but not exclusive rights over living resources beyond the EEZ. Noncoastal states were granted access rights to move to and from the seas without being taxed for transit. UNCLOS III was opened for signature in 1982 and entered into force on

November 16, 1994. This convention was approved by 165 nations (162 member nations of the United Nations and the European Union, Niue, and the Cook Islands). Countries that have signed one, but not ratified are Afghanistan, Bhutan, Burundi, Cambodia, Central African Republic, Colombia, El Salvador, Ethiopia, Iran, Democratic People's Republic of Korea, Libya, Liechtenstein, Niger, Rwanda, and the United Arab Emirates. Nonsignatory countries are Andorra, Azerbaijan, Eritrea, Israel, Kazakhstan, Kyrgyzstan, Peru, San Marino, South Sudan, Syria, Tajikistan, Turkey, Turkmenistan, United States, Uzbekistan, Vatican City, and Venezuela.

The United States from 1983 to 1990 accepted the UNCLOS as customary law, but refused to ratify the treaty over objections to Part XI. Part XI created International Seabed Authority (ISA), which had the authority over seabed exploration and mining. The ISA authority over seabed mining included the ability to impose fines, decide mining activities, and terminate or suspend contracts due to environmental or marine harm. Those opposed to Part XI viewed it as being against national security interests and as economically disadvantageous to U.S. companies. Since 1994, the United States has supported and resisted ratifying UNCLOS. In 2007, President George W. Bush urged the U.S. Senate to ratify UNCLOS as did secretary of state, Hillary Clinton, in 2009. In 2012, 34 Republican senators sent a letter to Senator John Kerry (R-Mass) stating that they would vote against the ratification of the treaty. The ratification of the treaty was tabled because 67 senators or a two-third vote is need for ratification.

Andrew J. Hund

See also: Antarctic Territorial Claims; Arctic Territorial Claims and Disputes; Continental Shelf Claims in the Arctic

Further Reading

Stoke, O. "A Legal Regime for the Arctic? Interplay with the Law of the Sea Convention." *Marine Policy* 31 (2007): 402–8.

University of the Arctic (UARCTIC)

The UARCTIC is a cooperative network of universities, colleges, and other organizations committed to higher education and research in the North (www.uarctic.org). The goal of this network is to create a strong, sustainable circumpolar region based on the values of shared knowledge, community, place-based education, and regional identity. As an Arctic education and research network, it promotes northern interests, rural access, and the creation of northern educational legacy, recognizing the integral role of indigenous people. The current president, Lars Kullerud, and the office of the Secretariat are located at the University of Lapland, Finland. There is also a board of directors and an Assembly of the General Membership, which meets a minimum of once per year. UARCTIC deans and various program offices are distributed among member institutions.

The UARCTIC as a network was launched in 2001 to both supplement and serve as a local knowledge generator to member institutions active in the North. The UARCTIC received the endorsement of the Arctic Council's senior officials during the 10-year anniversary of the Rovaniemi Process, a.k.a. the Arctic Environmental Protective Strategy. Beginning with 33 member institutions, the network has grown to include 138 institutions of which 102 are higher education colleges and universities. The diversity of UARCTIC's member institutions is reflected by the size of their student enrollments, varying from small northern indigenous colleges to large research universities. More than 50 percent of UARCTIC higher education institutions are relatively small with fewer than 10,000 students. A measure of the membership's geographic presence in the North can also be seen from the fact that many of UARCTIC's members are located on or above the Arctic boundary as defined by the Arctic Human Development Report. Collectively, UARCTIC's members have more than 700,000 students and 50,000 faculty members. The member organizations contribute resources and funding to support its programs: North 2 North, Field School, Northtrex, Northern Research Forum, Bachelor of Circumpolar Studies, and Graduate Studies.

During the International Polar Year (IPY), the UARCTIC coordinated education efforts by bringing a network of scholars, scientists, and educators together to inspect challenges and opportunities in the Arctic. For example, the IPY Young Researchers' Network, a group of graduate students, postdoctoral fellows, and early-career researchers, was established in 2006 to promote Arctic research through informal lectures, community-based monitoring projects, and activities to engage K-12 educators and their students. Research thematic networks have been found in specific areas of northern interests ranging from climate change to northern governance.

The Baccalaureate of Circumpolar Studies (BCS) was the first key educational endeavor at the undergraduate level. The BCS program consists of an introductory course, six core courses, and several advanced-level options, all described on UARCTIC's homepage (www.uarctic.org).

The UARCTIC represents a growing movement in polar regions to expand the education and research productivity through the process of networking. This parallels the Arctic region's emerging leadership role in local issues related to education and research. An example of this newfound empowerment is an increased emphasis on indigenous and traditional knowledge. These UARCTIC courses embrace the idea that what is taught in class should be meaningful to students' daily experiences.

Lawrence K. Duffy

See also: International Polar Years (IPYs)

Further Reading

Duffy, L., et al. "Engaging Students in Science Courses: Lessons of Change from the Arctic." *Interchange* 42 (2011).

Dyssegard, S. "A Key Player in the Arctic: The University of the Arctic and Changes Ahead." 2009. www.fremtidsforskning.dk. Accessed January 14, 2014.

Unsupported Expeditions

Until the second half of the twentieth century, expedition leaders used every means at their disposal to reach their goals. The support structure of any journey was the key to its success. To travel unsupported for its own sake was but the whim of a few adventurers and often considered an eccentric endeavor.

The ascent of the world's highest mountain, Everest, helps define the terms "supported" and "unsupported." In the 1950s, Sir John Hunt, the team leader, used the latest techniques and equipment as well as the best climbers. His summit team, Edmund Hillary and Tenzing Norgay, succeeded with the use of oxygen and a pyramid system of many Sherpas. Thanks to every available form of support, Hunt's team

The British Arctic Expedition: from left to right are Oliver Shepard, Sir Ranulph Fiennes, and Laurence Howell, shown at Heathrow Airport, London, February 26, 1986, prior to flying out to Montreal. They would spend three months on Ward Hunt Island where they would establish the most northerly base on earth. (Press Association/AP Photo) was successful and made history. Two decades later, the Italian climber Reinhold Messner achieved the first unsupported ascent of Everest—and did it solo, with no oxygen and no Sherpa help, an astounding endeavor and clearly more arduous than the Hillary–Norgay climb. But Messner used parts of the routes pioneered by Hunt's men, without which his own success would have been impossible. Clearly, then, there were two first ascents of Everest: the supported first of Hunt's team and the unsupported first of Messner. Since then, more than 1,000 climbers have made the ascent, nearly all with Sherpas and oxygen.

Roald Amundsen achieved the first supported South Pole journey in 1910, and Vivian Fuchs made the first crossing of Antarctica in 1958 using an exit route from the pole prepared for him by a tractor team under Hillary (fresh from Everest). In 1980, the author of this encyclopedia entry (Ranulph Fiennes) led a three-man team to complete the first one-way crossing of Antarctica, pioneering the Scott Glacier exit from the polar plateau. The Fuchs and the Fiennes journeys were made possible by air support. In 1993, with Dr. Mike Stroud, this author made the first unsupported crossing of the Antarctic continent, from the Atlantic to the Pacific, and in 1996–1997, Børge Ousland made the first unsupported crossing of Antarctica.

The history of North Pole journeys is not so clear-cut due to disputes over who was first. In 1909, Robert Peary and Frederick Cook both claimed the prize, but neither claim was proven. In 1967, Ralph Plaisted, using snowmobiles, claimed to have reached the North Pole, and a year later, Wally Herbert achieved the first supported crossing of the Arctic Ocean. In 1982, with Charles Burton, this author led the first circumnavigation of the earth crossing both the Southern Ocean and the Arctic Ocean through the poles. Again, all these journeys were supported. Since then, many individuals and groups from various countries have claimed success in supported and unsupported records in both polar regions, but they cannot all be named here.

In the mid-1980s, with Oliver Shepard and Stroud, this author began work on extending the current world record for unsupported travel toward the North Pole, which at that time was held by Hugh Simpson's expedition of 1968 (he had reached 98 miles from land toward the pole). Gradually, between 1985 and 1990, we extended his record by more than 300 miles (482 km). Two competing teams, also unsupported, raced us. The Russians, under Vladimir Chukov, reached the pole but removed dead and injured members along the way. The Norwegians had an injured man removed by ski plane before they too reached the pole.

This caused an interesting situation due to different interpretations of the word "unsupported." The Russians agreed that their attempt had been compromised due to their contact with an airplane to remove the injured, whereas the Norwegians ignored that factor and claimed priority to the pole. Both the Russians and the Canadians accepted that our own journey (which had ended 89 miles [143 km] short of the pole when we were airlifted out short of rations) held the unsupported record since we had gone farther north than the others without air contact. Such distinctions might seem immaterial to someone who has not been involved, but within the generally accepted (and unwritten) rules of unsupported polar travel, any form of air contact taints the record.

Most of the rules are clear and seldom disputed. There can be no supply depots prearranged along the route by the team or anyone else. No contact should be made with any other humans during the journey. No living creature should be killed, so the only additional intake to consuming what one carries is water. The team members must not be helped by vehicles, animals, or other such aides. Each person who sets out must complete the journey; otherwise one person could carry a load part way then drop out, thereby acting as a Sherpa for the others. This includes a death en route or somebody who skis back to the starting point.

The longest unsupported dog journey in history, according to the *Guinness Book of Records*, was that of Martin Lindsay, Andrew Croft, and Daniel Godfrey in 1934 in Greenland. They traveled 1,080 miles (1,700 km), and the power and energy of the men were clearly supported by the dogs. They never made any claim to the contrary.

Some of the rules are not clear-cut, for instance, the use of radios, the Global Positioning System (GPS), or even the wind. Some critics claim that any use of radios or GPS navigation instruments constitutes outside support. Some even include the use by Robert Falcon Scott and Ernest Shackleton of sails attached to their sledges. I have spoken to many proponents of unsupported polar travel, and the general opinion is that radios and GPS units do not help the *physical* effort of progress and so do not constitute outside support; neither do sails attached to sledges prior to the advent of high-tech sails in 1994.

Sir Ranulph Fiennes

See also: Cook, James (1728–1779); Peary, Robert Edwin (1856–1920); Shackleton, Ernest (1874–1922)

Further Reading

Jarvis, Tim. *Chasing Shackleton: Re-Creating the World's Greatest Journey of Survival.* New York: William Morrow, 2014.

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V

Victoria Island

Victoria Island (71° N 110° W) is the second-largest island in the Canadian Arctic Archipelago and the eighth largest island in the world. The shape of island resembles a maple leaf, which is the Canadian symbol. Victoria Island covers an area of 83,897 square miles (217,291 sq. km).

From an administrative point of view, it is divided in two territories, which are the Northwest and Nunavut. Dolphin Strait, Union Strait, Coronation Gulf, Dease Strait, and Queen Maud Gulf separate it from the mainland on the south. It is about 320 miles (515 km) long and 168–370 miles (270–600 km) wide. The terrain rises from a deeply indented coast to about 2,150 ft. (655 m) in the northwest. Strategically, Viscount Melville Sound is situated to the north of Victoria Island, while to the east is McClintock Channel and to the west Amundsen Gulf and Banks Island. Amundsen Gulf and Banks Island are separated from Victoria Island by the Prince of Wales Strait. The scattered population of Victoria Island is found mainly in the settlements of Holman in the west and Cambridge Bay in the southeast, with a population of about 1,900 with 1,500 living in Nunavut and 400 in the Northwest Territories.

Victoria Island, discovered in 1838 by Thomas Simpson, was named in the honor of Queen Victoria, who was the sovereign of Canada from 1867 to 1901. John Richardson is credited with being the first European to see the southwest coast of what is today Victoria Island in 1826, and he named it "Wollaston Land." Three years later, Peter Warren Dease and Thomas Simpson sailed along its southeast coast and called it "Victoria Land" in 1839. John Rae explored it in 1851. Also known as *Kitlineq*, it is situated in the Canadian Arctic Archipelago and straddles the region between Nunavut and the Northwest Territorial parts of Canada. The uses of the expression "Victoria Island" sometimes become misnomer. Many people use "Victoria Island" when referring to Vancouver Island, which is incorrect. Victoria, the capital city of the state of British Columbia in Canada, is located on southern Vancouver Island. Therefore, people get confused. Victoria Island relates neither with the city of Vancouver, situated on the mainland of British Columbia, nor with the diminutive Victoria Island in the Ottawa River in downtown Ottawa, Ontario. The larger Victoria Island is one of the major tourist attractions in Canada, drawing more than 6 million tourists from around the world. Both from the perspective of landscape and history, it is a prime attraction. It has the mildest climate in

Canada, allowing for a romantic atmosphere, cosmopolitan dining, superb shopping, and a colorful nightlife. Rich in history, it portrays a 150-year-old British colonial heritage. The southern waterways and the Prince of Wales Strait comprise part of the disputed Northwest Passage. The Canadian Government claims it to be Canadian Internal Sea, and other nations find it to be territorial sea or international waters.

Ravindra Pratap Singh

See also: Canadian Arctic Archipelago

Further Reading

Jakimchuk, R., and D. Carruthers. *Caribou and Muskoxen on Victoria Island, N.W.T.* Sidney, BC: R.D. Jakimchuk Management Associates Ltd, 1980.

McGoogan, K. *Fatal Passage: The True Story of John Rae, the Arctic Hero Time Forgot.* New York: Carroll and Graf Publishers, 2003.

Vinson Massif

Vinson Massif (78° 35′S 85° 25′W) is sometimes called Mount Vinson. This mountain is the tallest point in Antarctica. It is located south of the Antarctic Peninsula near Ronne Ice Shelf and is 746 miles (1,200 km) away from the South Pole. Mount Vinson is part of the Ellsworth Mountains and a prominent feature of the southern portion of the Sentinel Range of the Ellsworth Mountains. The mountain is 13 miles (21 km) long and 8 miles (approx. 13 km) wide. Vinson Massif reaches 16,050 ft. (4,892 m) making it the eighth most prominent peak in the world.

The mountain range that houses Vinson Massif was first discovered in 1935. During the first transcontinental flight by Hubert Hollick-Kenyon and Lincoln Ellsworth on board the single-engine plane, *Polar Star*, Ellsworth made note of a small group of mountains, which he named the Sentinel Range. Vinson Massif was not seen during this flight due to cloud cover. The discovery and surveying of Mount Vinson did not occur until December 1957. In 1957, in conjunction with the International Geophysical Year, U.S. naval pilots from the Byrd Station sighted a large mountain in what would later be called "Vinson Massif" while on a reconnaissance flight. In 2006, the mountain was officially named after Congressman Carl G. Vinson (Democrat, Georgia), who had been a determined supporter of acquiring government funding for Americans' scientific exploration of Antarctica from 1935 to 1961. From 1958 to 1961, there were multiple aerial, mapping, and survey activities of Vinson Massif. In 1959, the original height estimate of Vinson Massif was 16,684 ft. (5,085 m), but this was later reduced to 16,050 ft. (4,892 m).

In December 1966, a U.S. expedition team, sponsored by the National Geographic Society, The National Science Foundation, and the American Alpine Club, was the first to summit Vinson Massif. The team of 10 members was flown to the location in the U.S. Navy C-130 *Hercules* aircraft equipped with ski landing gear (ski plane) and landed on the Nimitz Glacier. Nimitz Glacier is approximately 20 miles (32 km) from Vinson Massif. The expedition team was led by Nicholas Clinch and accompanied by Barry Corbet, John Evans, Eiichi Fukushima, Charles Hollister, William Long, Brian Marts, Pete Schoening, Samuel Silverstein, and Richard Wahlstrom. Once on Vinson Massif, the group established three camps along the western side of the mountain up the Branscomb Glacier, which is called the "normal route" today. The first group of Corbet, Evans, Long, and Schoening reached the summit on December 18, 1966. The remaining team made the summit in two trips over the next few days. Over the next 40 days, the U.S. team explored the local area and climbed the five neighboring peaks, which were Mount Gardner (approx. 15,370 ft./4,685 m), Mount Tyree (approx. 15,919 ft./4,852 m), Long Gables (13,620 ft. /4,150m), Mount Ostenso (13,714′ ft /4,180 m), and Mount Shinn (approx. 15,292 ft./4,661 m).

The average climbing team can reach the Vinson Massif summit via the normal route in 10 days (with a range of a couple of days to a couple of weeks). Ascending Vinson Massif typically occurs in the Antarctic summer (roughly November and February) during the Midnight Sun or when the sun stays above the horizon for more than 24 hours. Vinson Massif is in one of the coldest places on the earth, with little snow fall and high winds. During the summer months, the mean temperature is −20°F (−29°C). The high winds and cold temperatures result in severe wind chill temperatures that challenge and tire climbers.

Since the U.S.-led expedition, there have been only a few hundred people who have ascended Vinson Massif. Vinson Massif is not considered a technically difficult climb, but getting equipment and people to the mountain is logistically challenging. The remoteness of Vinson Massif requires a long-range cargo plane equipped with ski landing gear. Flights to the region originate out of Southern Chile and take at least six hours. Presently, Vinson Massif is one of the Seven Summits, which is a grouping of the seven highest mountains on each of the seven major continents. Serious mountaineers seek to climb all the seven major continent summits. The seven summits by continent are Mount Kilimanjaro (Africa), Vinson Massif (Antarctica), Mount Everest (Asia), Mount Elbrus (Europe); Denali (North America), Aconcagua (South America), and either Kosciuszko or Puncak Jaya (Australia). Vinson Massif is the eighth most prominent peak in the world and the highest peak in Antarctica. The first person to have achieved this goal was Richard Bass in 1985, when he climbed Vinson Massif.

Andrew J. Hund

See also: East Antarctica; Volcanoes in Antarctica

Further Reading

"Vinson: Summit of Antarctica." http://7summits.com/vinson/vinson.htm. Accessed January 14, 2014.

Volcanoes in Antarctica

Antarctica is one of the least volcanically active regions in the world. It surpasses only the Pacific and Atlantic Ocean regions, which are the least active areas on the planet. Antarctica has the highest number of volcanoes listed as uncertain in the world. A complete history of volcanic activity in Antarctica is limited primarily to recent history and because ice is a significant barrier to scientific dating processes. In addition, the ice and cold weather conditions hinder travel and limit data collection. Mount Erebus is one of five long-lasting lava lakes in the world.

Within the Antarctic continent, there are four active volcanoes. Active does not mean volcanic eruptions but rather the volcano is emitting steam and gases

EREBUS CRYSTAL

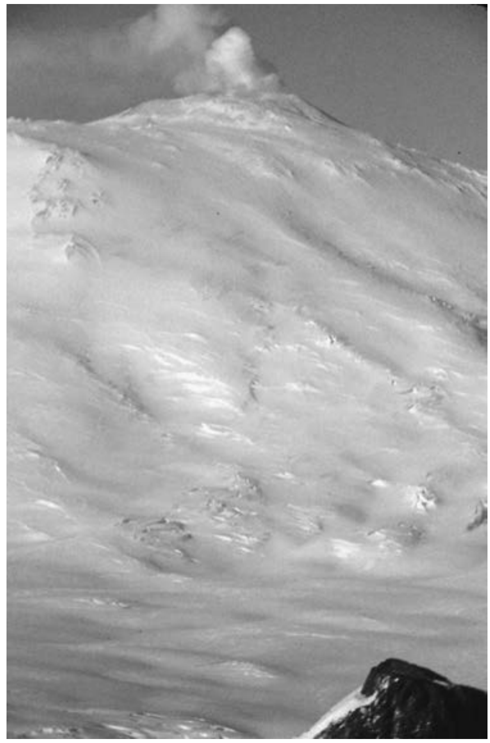
Erebus crystals are crystallized rocks that are spewed out of the Erebus volcano as glassy encased projectiles, commonly called "volcano bombs." These crystals are formed in the magma of Mount Erebus volcano, which is a polygenetic stratovolcano. Mount Erebus located in Antarctica is one of the few places where the crystals are found. Another place is Mount Kenya, Africa. Mount Erebus is Antarctica's only active volcano last erupting in 2012.

Erebus crystals are classified as the mineral anorthoclase, which is a type of feldspar. The crystal is primarily composed of silicate, sodium–aluminum, and potassium. Although not completely understood, Erebus crystals are formed in a two-stage process. During the first stage, the crystals' formulation occurs by the growth of a spongy core that contains an abundance of melt inclusions (similar in composition to matrix glass). In the second stage, crystal rims are formed of fine layers. The volcano bombs are formed in the magma between the surface and a depth of 1,300 ft. (400 m).

During volcanic activity, the volcano bombs are hurled to the surface. The glassy encased volcanic bombs quickly weather away leaving the mountain sides of Mount Erebus and the surrounding local area strewn with the crystallized rocks.

Andrew J. Hund

(fumaroles). These four volcanoes are Mount Melbourne (74° 21′S 164° 42′E), Mount Berlin (76° 3′S 135° 52′W.), Mount Kauffman (75° 37′S 132° 25′W), and Mount Hampton (76° 29′S 125° 48′W). Mounts Melbourne, Berlin, and Kauffman are stratovolcanoes, while Mount Hampton is a volcanic caldera. Mount Melbourne is about 9,000 ft. (2700 m) tall and last erupted around 1750. Mount Berlin is about 11,400 ft. (3,500 m) tall, and it is unknown as to the last time it erupted, but has steaming fumaroles. Mount Kauffman is 7,759 ft. (2,365 m) tall in 1977. Mount Hampton is 10,902 ft. (3,323 m), and it is unknown the last time it erupted.



Mount Erebus blowing off a little steam. (National Oceanic and Atmospheric Administration)

Marie Byrd Land

The majority of the Antarctic Continent volcanoes are found in Marie Byrd Land. They include Andrus, Berlin, Murphy, Siple, Takahe, and Toney. The Andrus volcanoes are located in the Ames Range (75° 42′S 132° 20′W) of Marie Byrd Land and include three coalescing shield volcanoes. Mount Andrus (75° 48′S 132° 18′W) is located in the southern part of the Ames Range and was last active during the Holocene. Mount Kauffman is located in the northern part of Ames Range and in 1977 showed weak fumarolic activity.

The Berlin volcano is made of the two coalescing shield volcanoes of Mounts Berlin (76° 3′S 135° 52′W) and Moulton (76° 3′S 135° 8′W). These volcanoes are about 10 miles (16 km) apart and located close to the eastern coast of the Ross Sea. The two coalescing shield volcanoes of Mount Berlin include the Berlin Crater (west) and Merrem Peak (east) on its caldera rim. Mount Berlin is considered a young volcano with the potential for being active. The Berlin crater has a fumarolic ice tower characteristic of Antarctic and is the only place in West Antarctica with geothermal activity. Past eruptions at the Berlin volcano includes Brandenberger Bluff more than 2.5 mya, Merrem Peak active between more than 500,000 and about 150,000 years ago, and fumarolic activity from 25,000 years ago until present. Mount Moulton is a dormant volcano with its last eruption being unknown.

The Murphy volcano is a shield volcano located on the Pacific coast of Marie Byrd Land. Mount Murphy's (75° 18′S 100° 45′W) last eruption is estimated at about 8 mya during the Late Miocene (23–5 mya). A peak of Mount Murphy called "Sechrist Peak" (75° 23′S 111° 2′W) is suspected to have erupted around 900,000 years ago. Mount Siple (73° 26′S 126° 40′W) is shield volcano rising out of Siple Island. It last erupted in the Holocene, but has had plumes in 1988 and 2012. Another shield volcano in Marie Byrd Land is the Mount Takahe (76° 17′S 112° 5′W) that last erupted around 5,500 years ago. Toney Volcano (75° 48′S 115° 49′W) is a shield volcano that last erupted during the Holocene.

A mountain range called "Executive Committee Range" (76° 50′S 126° 6′W) consists of five major shield volcanoes, which are Mounts Sidley (77° 2′S 126° 6′W), Waesche (77° 10′S 126° 54′W), Hampton (76° 29′S 125° 48′W), Cumming (76° 40′S 125° 48′W), and Hartigan (76° 52′S 126° W). The Executive Committee Range is the largest Antarctic volcanic region at almost 500 miles (960 km) in length. Mount Sidley is the tallest Antarctica volcano standing at 14,058 ft. (4,285 m) and a dormant volcano with its last eruption being unknown. Mount Waesche is a dormant volcano that was last active in the Holocene. The Crary Mountains is another mountain range with volcanoes in Marie Byrd Land. Two volcanoes in this range are Mount Frakes (76° 48′S 117° 42′W) and Mount Steere (76° 42′S, 117° 48′W). Both of these are shield volcanoes with their last eruption being listed as uncertain. Mount Frakes at 12,057 ft. (3,675 m) has a higher elevation than Mount Steere at 11,673 ft. (3,558 m).

Victoria and Ellsworth Land Volcanoes

The volcanoes in Victoria Land include Mount Melbourne, the Royal Society, Pleiades, and two unnamed volcanoes. Mount Melbourne (74° 21′S 164° 42′E) is a stratovolcano and last erupted around 1750. It is currently in the fumarolic stage and the only active volcano in Victoria Land and the mainland of Antarctica. Mount Melbourne has shown weak fumarolic activity in 1972, 1983, and presently. It is a protected area and has been designated as "Antarctic Specially Protected Areas" (ASPA) No.118. The geothermal activity around Mount Melbourne heats the soil resulting in a unique habitat where small communities algae, moss, and lichen can grow. There is also a single invertebrate protozoan species found here.

The Royal Society Volcanoes are cinder cones and consist of more than 50 basaltic vents most of which are near the Koettlitz Glacier (78° 15′S 164° 15′E) in the Royal Society Mountain Range (78° 10′S 162° 40′E) with the tallest peak being Mount Lister at 13,200 ft. (4,025 m). The Royal Society Volcanoes show lava flow, but are listed as dormant volcanoes with their last eruption being uncertain, but suspected as occurring during the Holocene. The Pleiades Volcanoes (72° 40′S 165° 30′E) are made up of cinder cones, lava domes, and Mount Pleiones

(72° 45′S 165° 29′E), which is a small trachytic stratovolcano. Mount Pleiones last erupted between 1,000 and 3,000 years ago. The Talos Dome is suspected to have erupted around 1254. There are two unnamed volcanoes in Victoria Land. The first unnamed volcano (76° 49′ 48″S 163° E) is a submarine caldera volcano and is located about 80 miles northeast of Mount Erebus. The second unnamed volcano (73° 27′S 164° 34′ 48″E) is a scoria cone volcano. It is located 60 miles (100 km) north of Mount Melbourne. Both these volcanoes are considered dormant with their last eruption being unknown.

In Ellsworth Land, there are the Hudson Mountain Volcanoes, which are a group of cinder cones that form nunataks. These cinder cones sit on Teeters Nunatak (74° 12′S 100° 1′W), and Mounts Manthe (74° 47′S 99° 21′W) and Moses (74° 33′S 99° 11′W). All of these are stratovolcanoes. The Hudson Mountain Volcanoes are suspected to have erupted in 1985 based on satellite data. Offshore of Ellsworth Land is the ice-covered oceanic island named Peter I Island (68° 51′S 90° 35′W). Peter I Island is a volcanic island approximately 250 miles (400 km) off the Antarctic coast. It is about 11 miles (18 km) long and around 5 miles (8 km) wide. This shield volcano is considered active with the last eruption occurring within the past 10,000 years. A peak on Peter I Island is Lars Christensentoppen (68° 50′S 90° 37′W).

Antarctic Peninsula Volcanoes

On the Antarctic Peninsula, a group of 16 nunataks called the "Seal Nunataks" (65° 1′ 48″S 60° 3′W) emerge out of the Larsen-B portion of the Larsen Ice shelf. The Seal Nunataks are Larsen, Evensen, Murdoch, Dallman, Chistensen, Pollux, Donald, Akerlundh, Isla Robertson, Nunatak Oceana, Arctowski, Bruce, Gray, Castor, Bull, and Hertha. These nunataks are cinder cones and the remaining parts of a once large shield volcano. A number of these nunataks have shown recent fumarolic activity. In 1893, the Christensen Nunatak (65° 6′S 59° 31′W) was observed as fumarolic active and possibly having an eruption in the same year. In 1982, the Murdoch and Dallman volcano cones had fumarolic activity. The Christensen Nunatak is suspected to have been had fumarolic activity in 2004 and/or 2008. A notable Antarctic Peninsula volcano is the Paulet Volcano (63° 35′S 55° 47′W). The Paulet Volcano is a cinder cone volcano measuring less than a mile in diameter. It is an ice-free island because of geothermal activity. Another notable active Antarctic Peninsula volcano is Lindenberg Island (64° 55′S 59° 40′W).

Offshore Volcanoes in Antarctica

Offshore of Antarctica, there are several volcanoes, such as the South Shetland Islands, Balleny Islands, and Ross Island. The most active volcanic islands are Mount Erebus on Ross Island and Deception Island of the South Shetland Islands.

Other notable active island volcanoes are Buckle Island in the Balleny Islands and Penguin Island.

South Shetland Volcanoes

In the South Shetland Islands, there are a number of island volcanoes, such as the Bridgeman, Deception, and Penguin. Bridgeman Island is a small island of about 0.5 mile long in the South Shetland Islands. It is located 60 miles (100 km) off of the Antarctic Peninsula. The Bridgeman Island (62° 4′S 56° 44′W) volcano is a dormant stratovolcano with its last eruption being unknown. In 1821 and again in 1850, there were reports of fumarolic activity on Bridgeman Island. Deception Island (62° 58′S 60° 39′W) is a horseshoe-shaped island in the South Shetland Islands. It is an active submarine caldera with confirmed eruptions occurring in 1800, 1827, 1842, 1912, 1967, 1968, and 1970. There has been suspected eruptions in 1839, 1972, and 1987. The most recent eruption, in 1970, was characterized as a considerable underwater (phreatomarine) explosion with volcanic rock and lava fragments (called "tephra") spewed over the northern part of the island. Penguin Island (62° 6′S 57° 56′W) is a small island south of King George Island measuring just more than a mile in length and less than a mile in width. It is a stratovolcano that last eruption is suspected to have occurred in 1850.

Balleny Island Volcanoes

The Balleny Islands are chain of volcanic islands stretching almost 100 miles (160 km) off the coast of Victoria Land. Three main volcanoes are the three main islands of the Balleny Islands (66° 55′S 163° 45′E). These islands are Buckle, Sturge, and Young Islands. Buckle Island (66° 39′S 163° 3′E) is the middle island of the three. There are two craters on the island on the western and eastern parts. The western crater is dormant, while eastern crater is active. The last suspected or unconfirmed eruptions occurring on Buckle Island were in 1899 and 1939. Sturge Island (67° 25′S 164° 44′E) is a stratovolcano located about 16 miles (26 km) south of Buckle Island. The last eruption on Sturge Island is considered to be unknown, but there are reports of volcanic activity on Brown Peak on Sturge Island in 2001. Young Island (66° 17′S 162° 25′E) is a stratovolcano located 5 miles (8 km) north of Buckle Island. The last reported sighting of volcanic activity on the island was in 1839.

Ross Island

Ross Island is made up of four main volcanoes, which are Mounts Erebus, Bird, Terror, and Terra Nova. Mount Erebus (77° 31′S 167° 9′E) is a composite volcano and the largest on Ross Island. Its highest point is almost 12,500 ft. (3,800 km). Mount Erebus is the most active volcano in Antarctica. Since 1972, there have been recurring low-level volcanic eruptions called "strombolian eruptions" on the surface of the Mount Erebus Lava Lake. It is estimated that about six strombolian eruptions occur each day. During these volcanic eruptions, crystallized rocks, called "Erebus crystals," are spewed from the Erebus volcano as glassy encased projectiles, called "volcano bombs." There have been a number of volcanic eruptions over the years, such as in 1912, 1915, 1947, 1955, 1958, and 1963. In 2004, it was determined that the Mount Erebus Lava Lake was two Lava Lakes.

Mount Terror (77° 31′S 168° 32′E) is a dormant shield volcano about 20 miles (30 km) east of Mount Erebus. Its highest point is around 10,500 ft. (3,200 km). Mount Bird is dormant shield volcano that is located about 7 miles (11 km) south of Cape Bird. Its highest point is around 5,800 ft. (1,700 km). Mount Bird last erupted between 3.8 and 4.6 mya. Between Mount Erebus and Mount Terror is Mount Terra Nova (77° 31′S 167° 57′E) with an elevation of about 6,900 ft. (2,100 m). Mount Terra Nova is a dormant volcano that was last active in the Holocene.

Ross Sea Area

There are several volcanoes in the Ross Sea, such as Coulman Island and Mounts Discovery, Harcourt, Morning, and Overlord. The ice-covered Coulman Island (73° 29′S 169° 45′E) is made up of several connected shield volcanoes. The Coulman Island volcano has a volcanic crater that is almost 4 miles (5 km) wide and more than 2,300 ft. (700 m) deep and two significant vents. Mount Discovery (78° 22′S 165° 1′E) is a stratovolcano located at the top of the McMurdo Sound. West of Mount Discovery is another stratovolcano called Mount Morning (78° 31′S 163° 35′E). Both Mounts Discovery and Morning are dormant volcanoes with their last eruption being unknown. They are on the east of the Koettlitz Glacier of Victoria Land. Mount Harcourt (72° 18′S 170° 0′E) is a stratovolcano located on the Hallett Peninsula. Mount Overlord (73° 10′S 164° 36′E) is an extinct stratovolcano on the ice-covered Deception Plateau (73° 15′S 164° 50′E). The Mount Overlord volcano has a volcanic crater that is just more than 1 mile (1.6 km) wide. The last eruption of Mount Overlord was in the Miocene.

Andrew J. Hund

See also: East Antarctica, Transantarctic Mountains; Vinson Massif; West Antarctica

Further Reading

LeMasurier, W., and J. Thomson, eds. *Volcanoes of the Antarctic Plate and Southern Oceans.* Washington, DC: American Geophysical Union, 1990.

Vostok Station

The inland Russian Antarctic Vostok Station (78º 28′S 106º 48′E) was opened on December 16, 1957, during the USSR Second Complex Antarctic Expedition. The Soviets used sledge-tractor traverse (STT) to get to the site, which is more than 11,000 ft. (3,488 m) above sea level.

The station was set up under the Program of the International Geophysical Year 1957–1958 in the area of the earth's South Geomagnetic Pole. The maximum solar wind energy flux is registered at the South and North Geomagnetic Poles of the

In this February 5, 2012 photo provided by the Arctic and Antarctic Research Institute of St. Petersburg, Russian researchers at the Vostok station in Antarctica pose for a picture after reaching the subglacial lake Vostok. Scientists hold the sign reading "05.02.12, Vostok station, boreshaft 5gr, lake at depth 3769.3 metres." The Russian team reached the lake hidden under miles of Antarctic ice, a major scientific discovery that could provide clues in the search for life on other planets. (AP Photo/Arctic and Antarctic Research Institute Press Service) planet. The North Geomagnetic Pole is situated in the area of the north coast of Greenland and the south—in the vicinity of Vostok station. The indicated cosmophysical processes are coherent in both hemispheres and cause powerful perturbation in the earth's magnetosphere and ionosphere that seriously influence performance of communication equipment, satellite navigation, and efficiency of high-tension power lines and pipelines.

The geographical latitude and height above sea level determined a possibility of observation at this point of the minimal air temperatures ever recorded on the earth. The lowest officially recorded temperature ever was −128.6°F (−89.2°C) at the Russian Vostok Station on July 21, 1983. In 2010, remote temperatures collected from high ridge in the East Antarctic Plateau were −136°F (−93°C).

Vostok station was initially built of wooden panel board houses delivered to this region from Mirny Station by STT. The total route length of such traverses was 876 miles (1,410 km). In the second part of the 1970s, the service-housing space of the station was rebuilt to structures of prefabricated aluminum winterized panels resting on metal pile foundations. At present, there are two living and laboratory buildings, diesel–electric station space, bathhouse and garage, and the office-center. The station facilities include a drilling complex and several laboratory premises. Perspective plans of the Russian Antarctic Expedition (RAE) envisage construction of the new wintering complex at Vostok, meeting all modern requirements (including environmental) to self-contained facilities operating under the extreme climatic conditions ensuring progress in scientific studies.

All logistical supply of the station including fuel, consumables, spares and aggregates, engineering equipment, and food products that could be kept frozen were delivered to Vostok by traverses. Until the season 2007–2008, they were made by the route Mirny–Vostok–Mirny and in the same season along the route Progress–Vostok–Progress. From that season, the new traverse vehicles are used—transporters manufactured in Germany, which are extensively used by the other national Antarctic programs. Two such traverses are made during the season (November–December and January–February). At the time of the final traverse from Vostok Station, special scientific studies are made: determination of the ice sheet thickness and bedrock relief by means of radar profiling and seismic sounding and determination of ice flow rates and snow accumulation using high-precision satellite geodetic measurements.

Personnel of Vostok Station, scientific equipment, medical supplies, and food products that should be kept unfrozen were usually delivered to Vostok by aircraft. From December 1957, these flights were made from Mirny Station using ski-equipped aircraft Li-2, Il-12, and Il-14. From 1992 to 2003, the aviation support of Vostok Station was provided by aircraft LC-130 of the U.S. Antarctic Program from the U.S. Antarctic McMurdo Station. From December 2003 to present, this work is carried out by RAE personnel using aircraft DC-3 BT-67 *Turbobasler*.

About 10–12 flights are made from Progress Station in the summer season (late November–early February).

Vostok Station is currently equipped with all types of satellite and shortwave radio-communication means. Beginning from the season 2011–2012, receiving of two Russian TV programs was arranged, and in January 2013, equipment for the access of the station computer network to Internet via the geostationary communication satellite began operation.

Due to specific features of the air temperature regime, the air flights to Vostok Station have extremely strict time limitations (late November–early February). This fact determines the possibility of carrying out the programs of seasonal work and studies at the station. At present, seasonal activities at this station include ice sheet drilling operations, glaciological studies of the ice core and snow cover characteristics, study of the glacier drift dynamics and snow accumulation rate, microbiology, seismic and radio-echo sounding of the glacial strata, and the underlying surface and high-precision geodetic measurements. Research in the areas of meteorology, geomagnetism, study of the ionosphere and the ozonosphere, snow cover dynamics, and man physiology is carried out the year-round. Wintering personnel of the station consist of 12 people with 15–20 specialists added in the summer season.

In the 1960s, deep drilling of the ice sheet began at Vostok station with the aim of investigating temporal changes of Antarctic climate based on ice core data. Russian specialists developed unique technologies and engineering solutions for drilling super-deep boreholes in the ice cover, which were successfully applied in Antarctica at Vostok. In the 1990s, the paleoclimate changes that had occurred in the Antarctic for the past 420 kyr were reconstructed using data of ice core characteristics.

In 1994, a team of scientists of Russia, Great Britain, and the United States reported about the discovery of a large subglacial water body beneath Vostok Station with a water table equal to Lake Ladoga or Lake Ontario. Using seismic sounding and radio-echo profiling, characteristics of spatial variability of the glacier thickness, water layer, and bottom sediments of the subglacial Lake Vostok and its coastline configuration were obtained. Continuing ice sheet drilling from a horizon of 3,535 m made it possible to obtain an ice core, which was not of atmospheric origin comprising frozen lake water. On February 5, 2012, the drilling process was successfully finished, and the ecologically clean penetration to the subglacial Lake Vostok was made at a mark of 3,769.3 m. Then, by means of drilling, a fresh-frozen ice core was obtained from lake surface water, which rushed upward the borehole. Direct study of the water column of Lake Vostok and its bottom sediments is planned for the season 2014–2015. Specially designed engineering devices and technologies will be applied excluding contamination of relict water of the subglacial lake.

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See also: Antarctic Ice Sheet; Antarctic Programs and Research Stations/Bases; Ice Cap; Ice Sheet

Further Reading

Oswald, G., and G. Robin. "Lakes beneath the Antarctic Ice Sheet." *Nature* 245, no. 5423 (1973): 251–54.

Vuntut National Park of Canada

Established in 1995 as part of the Vuntut Gwich'in First Nation Final Land Claim Agreement, Vuntut National Park is 4,345 sq. km of wilderness in the northwest corner of the Yukon Territory in Canada on the border of Alaska. The Vuntut Gwich'in First Nation and Parks Canada cooperatively manage the park. Vuntut is a Gwich'in word meaning "among the lakes." The Vuntut Gwich'in, literally the "people of lakes" or also known as the "porcupine caribou people," have inhabited the Old Crow Flats and Porcupine River area that lie within the park for thousands of years. The land and the Porcupine caribou herd provided the Vuntut Gwich'in with food in days past, and also with shelter and clothing. The Vuntut Gwich'in traditional lifestyle was one of seasonal rounds of fishing in summer and fall, and collecting berries in the summer. Animals such as moose, muskrat, rabbit, and fowl were also part of their traditional diet. Twice a year, when the caribou migrated through the area, they would be harvested in large numbers. Remnants of the traditional caribou fences have been found within the park and constitute important cultural and archaeological sites.

The Old Crow Flats, a large wetland of small streams, peat bogs, and 2,000 shallow lakes, are found in the southern portion of the park. It was recognized in 1982 under the Ramsar Convention, an intergovernmental treaty, where member countries maintain their wetlands of international importance and plan for wise use of the land, because half a million birds use the flats annually to breed and grow before migrating south. The flats are also part of the migration route of the Porcupine caribou herd.

The northern portion of the park contains the British Mountains, and caribou use this as their calving grounds. Grizzly bears, wolves and wolverines, and muskoxen are found in this area. Because the area did not experience the glaciations during the Pleistocene Ice Age, thousands of fossils are preserved in the permafrost. Fossils of many animals found, such as the woolly mammoth, which are extinct today.

The area can have some of the coldest weather in the Yukon with −76°F (−60°C) in winter and up to 59°F (15°C) in the summer, although in recent winters, the temperatures have not been as cold. It is a dry Arctic climate with only 8–12 inches (20–30 cm) of precipitation annually, but the summers are becoming wetter.

Today there are no communities found within the park. The Vuntut Gwich'in still use the area for traditional purposes such as hunting, trapping, and fishing. Those wishing to visit the park must be totally self-sufficient as there are no developed trails or facilities within the park. Experienced backcountry visitors can enjoy hiking, winter ski touring, and canoeing the Old Crow River. The park is accessible only by air as there are no roads to or in the park. Old Crow, the Vuntut Gwich'in community of 300, is the most isolated and northern community in the Yukon.

Leslie McCartney

See also: Gwich'in; Tuktut Nogait National Park

Further Reading

Parks Canada. "Vuntut National Park of Canada." 2012. http://www.pc.gc.ca/pn-np/yt/vuntut/index.aspx. Accessed January 14, 2014.

Smith, Shirleen. *People of the Lakes: Stories of Our Van Tat Gwich'in Elders. Googwandak nakhwach'ànjòo Van Tat Gwich'in.* Edmonton: University of Alberta Press, 2009.

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Walrus

Walruses (*Odobenus rosmarus*) are the largest of all Arctic pinnipeds, the group of fin-footed mammals that include seals, sea lions, and walruses. The walrus is the only member of the family Odobenidae. They are restricted to the Arctic Ocean and adjacent seas and are full-time residents of the Arctic. The Latin name, *Odobenus rosmarus*, means "tooth-walking sea horse." There is only one species of walrus, but two subspecies are recognized: *Odobenus rosmarus rosmarus*, in the Atlantic, and *O. r. divergens*, in the Pacific. The status of the third subspecies, *O. r. laptevi*, from the Laptev Sea, has been uncertain and recently found not valid. The Pacific walruses basically constitute a large single population of about 200,000 animals and are distributed in the Bering and Chukchi Seas. The Atlantic walruses constitute separate and much smaller subpopulations distributed from eastern Canada, Greenland, Svalbard, Franz Joseph Land, to the Kara Sea. The Laptev population is now recognized as the westernmost population of the Pacific walrus.

Walruses are large and bulky animals with long, thick ivory tusks that may reach up to 1 m. Adults are easy to recognize by their prominent tusks, whiskers, and bulkiness. As an adaptation to frequent contact with ice and rocks, their skin is very thick, tough and wrinkled, and covered with fine hair. Skin color can vary from grayish to dull brown, chestnut, or sometimes reddish. Males are larger and heavier than females and have longer and heavier tusks. Males' average body length can reach about 138 inches (350 cm) and body mass up to about 3,700 pounds (1,700 kg), whereas females are about 110 inches (280 cm) and weigh about 1,700–2,200 pounds (800–1,000 kg). Walruses are relatively long lived, and their life span is about 40 years. Tusks are used as tools for hauling out, fighting with other walruses, and defending their territory.

Walruses are very social and gregarious animals and congregate on the ice in groups of up to 500 walruses. Groups are even larger when walruses congregate to rest at haul-out sites on sandy or rocky shores. During the summer, they mainly stay in shallow areas, while in the winter, they generally follow the pack ice. Male walruses prefer to stay during the summer in seasonally ice-free coastal, shallow (260 to 330 ft. [80 to 100 m deep]) areas, while females and calves prefer to remain in association with drifting ice as much as is possible, although occur in coastal areas as well. Seasonal changes in the sea ice cover allow walruses to exploit a wide area of the continental shelf during the year. However, recent reduction of summer sea

A walrus on the ice in the Arctic Ocean north of western Russia. *Odobenus rosmarus rosmarus*—the Atlantic subspecies of walrus. (National Oceanic and Atmospheric Administration)

ice especially in the Chukchi Sea has resulted in increased use of land haul-outs by adult females and young during ice-free periods, which may result in trampling and deaths as well as force walruses to conduct longer foraging trips and reduced access to preferred feeding grounds. Walruses are primary benthic feeding and forage mainly on bivalves, gastropods, worms, and sometimes crustaceans and other prey. Old males have been reported to be carnivores on ringed seals and birds. Walruses can create a negative pressure in their mouth, which allows them to suck the soft part of mollusks from their shells.

Females attain sexual maturity at the age of 6 years and males between 7 and 10 years; however, they usually do not participate in mating until they reach full body size at the age of 15 years. Walruses are polygynous and have more than one female mate at a time. Most calving occurs in April–June, after 15- to 16-month long pregnancy, and females give birth to a single 130-pound (60-kg) calf. Females care and nurse calves on the ice, which must be large enough to support their weight, and calves stay with their mother for about two years, by which time they learn foraging patterns.

The primary nonhuman predators of walruses are polar bears and killer whales, yet only younger walruses are vulnerable. The walrus has played a prominent role in the cultures of many indigenous Arctic people and has been hunted for its meat, fat, skin, tusks, and bone. During the nineteenth century and the early twentieth century, walruses were widely hunted causing a rapid drop of their populations all around the Arctic region. Their population has rebounded since then, though the populations of Atlantic and Laptev walruses remain fragmented and at low levels compared with the time before human interference. Nowadays, Pacific walrus hunting still remains vital to many indigenous people around Chukchi and Bering Seas.

Monika Kędra

See also: Arctic Fox; Arctic Ground Squirrel; Arctic Hare; Arctic Seabirds; Arctic Wolf; Bearded Seal; Beluga Whale; Bowhead Whale; Caribou; Dogs in the Arctic; Lemmings; Musk Oxen; Narwhal; Pacific Sleeper Shark; Polar Bear; Wolverine

Further Reading

Fay, F. “Odobenus rosmarus.” *Mammalian Species* 238 (1985): 1–7.

Jay, C, et al. “Walrus Areas of Use in the Chukchi Sea during Sparse Sea Ice Cover.” *Marine Ecology Progress Series* 468 (1985): 1–13.

Lindqvist, C., et al. “The Laptev Sea Walrus Odobenus Rosmarus Laptevi: An Enigma Revisited.” *Zoologica Scripta* 38 (2009): 113–27.

Sheffield, G., and J. Grebmeier. “Pacific Walrus (*Odobenus rosmarus divergens*): Differential Prey Digestion and Diet.” *Marine Mammal Science* 25, no. 4 (2009): 761–77.

Wandering Albatross

The wandering albatross (*Diomedea exulans*) is one of the largest birds in the world and has the largest wingspan. Modern DNA work has suggested that many populations traditionally treated as subspecies should be split off into their own species. Until the science is sorted out, the term “wandering albatross” is imprecise in that some scientific entities have endorsed these splits, while others have not.

The albatross was described by Carolus Linnaeus (1707–1778) in 1758 based on a specimen that had been collected in South Africa. The specific Latin name, *exulans*, turned out to be prescient, as the notion of exile nicely fit a species where individuals often stay at sea for up to a year at a time. As explorations of the subantarctic regions became regular, more and more breeding sites were discovered, including the following: the nominate form (South Georgia Island and the Kerguelen Islands), Gibson’s albatross (Auckland Islands), Tristan albatross (Tristan da Cunha Islands), Antipodean albatross (Antipodes Islands), and Amsterdam albatross (Amsterdam Islands). Although the Tristan and Amsterdam albatrosses have been designated as critically endangered, the other albatross enjoy more stable populations.

The wandering albatross is the most popularly cited of its genus, perhaps due to the number of impressive records it has achieved as a species. No organism on earth travels greater distances: albatrosses spend the majority of their lives in the air, even sleeping on the wing. Other than during the breeding season and while feeding, the birds never land. The wandering albatross also has the largest wingspan of any living bird; although adults average a bit more than 10 ft. from wing tip to wing tip, the largest verified measurement is 12 ft. 2 inches. In some populations (including the nominate form), the immature brown plumage is gradually replaced by a black-and-white plumage set off by pink feet and a large pink bill. In a few populations, the brown plumage is kept through the transition to adulthood.

Pairs bond for life and breed every other year. Parents take turns tending the nest and searching for food. During one such 12-day search, an albatross with a tracking device was measured to have flown nearly 4,000 miles (6,400 km). Feeding generally takes place at night, with food sources consisting of squid, fish, and shrimp. Albatross are opportunistic feeders and will occasionally follow ships hoping for scraps thrown overboard. It is felt that records of the wandering as well as several other species of subantarctic albatross in places as far flung as northern California may have followed such ships for thousands of miles.

The Maoris in New Zealand used the wandering albatross as a food source and to use their bones for tools. Although European sailors also used albatross bones to construct tools, they believed that birds that followed ships brought good luck. This was the background to Samuel Taylor Coleridge's famous poem *The Rime of the Ancient Mariner*, from which the idiom "having an albatross around one's neck" was derived.

Andrew J. Howe

See also: Agreement on the Conservation of Albatrosses and Petrels (ACAP); Arctic Loon; Arctic Redpoll; Arctic Seabirds; Arctic Skua; Arctic Tern; Common Raven; Gyrfalcon; Lapland Longspur; Red-Throated Loon; Rock Ptarmigan; Snow Bunting; Snow Goose; Snowy Owl; Sooty Albatross

Further Reading

Gotch, A. "Albatrosses, Fulmars, Shearwaters, and Petrels." In *Latin Names Explained: A Guide to the Scientific Classifications of Reptiles, Birds and Mammals.* New York: Facts on File, 1995, p. 191.

Parmelee, D. *Bird Island in Antarctic Waters.* Minneapolis: University of Minnesota Press, 1980.

Shirihai, H. "Great Albatrosses." *Antarctic Wildlife: The Birds and Mammals.* Helsinki, Finland: Alula Press, 2002.

Weddell #1 Antarctic Drifting Station

Even in the end of the twentieth century, there were regions on the earth where scientific studies were never carried out. One of them was located at the western periphery of a giant cyclonic water and ice gyre occupying the whole area of the Antarctic Weddell Sea. It adjoined directly the east coast of the Antarctic Peninsula, where even now no research station is located. So, the scientific community from the beginning of exploration of the sixth continent and the ambient ocean waters did not practically have any information on the ocean seabed relief and natural processes occurring in the water column, the ice cover, and the atmosphere in this Antarctic region. Appearance of satellite technologies to investigate the earth's surface state has increased our knowledge little. Traditional for marine studies, shipborne expeditions were difficult here due to solid thick ice cover with a large number of ice ridges and icebergs of different size.

The history of Antarctic studies knows one heroic example: the forced drift of the British ship *Endurance* with the expedition participants led by Ernest Shackleton (1874–1922), renowned polar explorer in 1914–1915. Due to strong compression of drifting ice in January 1915, the ship was crushed and sank, and the crew and polar expedition members had to land on the ice and continue the drift to the ice massif edge where they embarked the whaleboats. All participants to this polar tragedy reached the subantarctic island on their own and were later transported to Great Britain. However, participants of Shackleton's expedition did not make scientific studies in their ice camp.

The idea of an expedition to this unexplored area of the Antarctic appeared during the joint Soviet-German-U.S. studies under winter Antarctic conditions on board the Soviet R/V *Akademik Fedorov* and the German Polarstern in 1989. In 1990–1991, the scientific program and the logistical plan of the expedition were prepared. The method of creating a research station complex on drifting ice, which proved to be good in the Arctic and which was never before applied in the Antarctic, was chosen. Using the ship frozen into the ice massif as a scientific station was unreasonable from the economic viewpoint, and it did not allow advance studies of natural processes at meso- and microscales due to a significant influence of different physical fields caused by the ship itself on water, ice, and the atmosphere.

The scientific program was based on the studies in oceanography, dynamics, and physics of sea ice, meteorology, and hydrobiology. The station team comprised 15 Russians (one leader-radioman, three mechanics, one doctor, one cook, two oceanographers, two meteorologists, four ice researchers, and one hydrobiologist) and about the same number of Americans (one station manager, five helicopter pilots, one cook, one logistics manager, one meteorologist, one hydrobiologist, two ice researchers, and four oceanographers). Russia was represented by participants from the Arctic and Antarctic Research Institute of Roshydromet, Institute of Oceanography, and Institute of Medical-Biological Problems of the Russian Academy of Science, and the USA by participants from Columbia University, University of Washington, University of California, and U.S. Army Cold Regions Research and Engineering Laboratory.

On February 12, 1992, the drifting ice camp "Weddell-1" was opened in the southwestern Weddell Sea on the ice floe with a size of 2.5 × 1.6 km and the thickness of 59–165 inches (150–420 cm). All expedition cargos and station personnel were delivered to the place of operation by the Russian ship the *Akademik Fedorov*. The station team and the scientific laboratories were accommodated in Russian prefabricated panel houses and in U.S. tents. There were two diesel–electrical power stations with the European (220 v, 50 Hz) and the U.S. (115 v, 60 Hz) electrical power standards. The mess hall and the hotel for temporary personnel were accommodated in three inflatable rubber–cloth complexes applied by the

Russian Space Program in meeting the cosmonauts returning to the earth from space. The station transport consisted of one track bulldozer, three snowmobiles, and two helicopters "Bell-212." The station was equipped with modern satellite HF and VHF radio stations, medical block and galley, and also storehouses for the storage of warm and cold food products and station equipment. Fresh drinking and technical water was prepared from seawater by a compact distiller. A sauna-bath and shower cabins were built at the station, and heating of station premises was by kerosene stoves.

The station drift began on February 12, 1992, and ended on June 4, 1992. During this period, the total drift of the station was 466 miles (750 km), and the general drift was 434 miles (700 km) in the direction of 357°. It drifted along the continental slope of the western part of the Weddell Sea. The maximum daily drift of 25 km/day was recorded on May 24 and the minimum of 0.5 km/day on the February 27. The station was evacuated by the Russian vessel the *Akademik Fedorov* and the U.S. vessel the *Nathaniel Palmer*.

Based on the results of oceanographic studies carried out along the station drift route and a series of CTD sections (which measure electrical **C**onductivity, **T**emperature, and **D**epth [pressure]), made across this route by means of station helicopters, it was possible to determine peculiarities of the vertical thermohaline water structure and the nature of formation of cold bottom water masses, which influence significantly the water circulation of the whole global ocean. The process of their formation is connected with winter supercooling of surface waters over the continental shelf and their further sinking along the continental slope to near-bottom horizons onto the corresponding isopycnal surfaces. Using sensitive sensors, the stress and strain processes in the ice cover under the influence of ice compacting and diverging in the large-scale massif were investigated, and the physical values of these phenomena were determined by means of underwater measurements. The methods of underwater studies by divers and using the remote underwater device made it possible to measure the peculiarities of the bottom surface structure of surrounding ice floes and ice ridges and to determine the ice freezing and melting rates. Standard meteorological (eight times a day), special gradient observations and upper-air sounding by means of a tethered balloon in the surface layer of the atmosphere allowed us to determine the regularities of the autumn–winter meteorological regime, peculiarities of transformation and genesis of atmospheric cyclones in this region, and the character of thermodynamic processes of sea–air interaction through the ice cover. Investigation of the features of seasonal variability of bioproductivity of surface Antarctic waters in the wintertime showed a significant role of bottom ice surface in preservation of plankton at the cold time of the year when living organisms are actively concentrated in the capillaries formed at the bottom ice surface.

Experience of using drifting research stations, gained in the course of the Russian–U.S. experiment in the Antarctic, is unique and the only one up to present in the investigation of the earth's South Polar area.

Valery Lukin

See also: Arctic Ocean; Ice Core Climatic Data Proxies; Ice Core Collection and Preservation Issues; Ice Sheet; Ice Shelf

Further Reading

Gordon, A., and V. Lukin. "Ice Station Weddell #1." *Antarctic Journal of the US* XVII, no. 5 (1992), 97–99.

Gordon, A., and Ice Station Weddell Group of Principal Investigators and Chief Scientists. "Weddell Sea Exploration from Ice Station." *EOS Trans AGU* 74, no. 11 (1993): 121, 124–126.

Weddell Sea

The Weddell Sea is part of the Southern Ocean, the ocean that surrounds the continent of Antarctica. It also represents the southernmost extension of the Atlantic Ocean. Covering 1.1 million square miles (2.8 million sq. km), the sea is located between the Antarctic Peninsula in the west and Coats Land to the southeast, the Scotia Sea bordering it to the north at 60° S. The sea formed following the breakup of the supercontinent of Gondwanaland, a process started 160 mya. The Antarctic Peninsula, originally a volcanic arch, was the last point of contact between Antarctica and South America, a connection that severed with the opening of the Drake Passage 23 mya, leading to the establishment of the Circum Antarctic Current and Antarctic Ice Sheets. Though the British naval officer Edward Bransfield had entered the Weddell Sea in 1820, the water body is named after the British sealer and explorer James Weddell (1787–1834), who ventured into the area in 1823 in an exceptionally ice-free year, reaching the farthest south at the time (74° 15′S). First referred to as George IV Sea in honor of the British monarch, the sea was renamed Weddell Sea in 1900. The region is subject to the territorial claims of Argentina and Britain, as well as Chile, with claims overlapping around the Antarctic Peninsula.

The Weddell Sea is characterized by relatively heavy sea ice through most of the year and is highly influenced by the seasonal waxing and waning of sea ice, which increases from a minimum in early March to a maximum in September. Most of the Antarctic's perennial (multiyear) sea ice is found in the western Weddell Sea, where it attains a maximum thickness of approximately 2.5 m. By contrast, the eastern Weddell Sea is characterized by a much more dynamic seasonal ice regime and is predominantly ice free during summer. Its coastal zone in particular, extending approximately 50 km seaward, is characterized by a multitude of ice environments, including ice shelf, polynyas (ice-free areas year round), and pack ice. The ice cover is not rigid but dynamic due to the circular currents of the Weddell Gyre, which drives ice drift. The second largest ice shelf in the world, the Ronne-Filcher Ice Shelf (163,000 square miles [422,000 sq. km]) is situated in the region, alongside smaller shelves such as the Riiser-Larsen Ice Shelf. The recently (1980s–1990s) disintegrated Larsen-A and Prince Gustav Channel Ice Shelves were also located in the Weddell Sea along the Antarctic Peninsula.

Weddell Sea water depths are considerable, with a shelf break at 1,970 ft. (600 m) and depths averaging 14,400 ft. (4,400 m). From the Antarctic continent, the continental shelf passes into the 16,400 ft. (5,000 m) deep Weddell Basin until transiting into the shallower South Scotia Ridge—the boundary between the Weddell and the Scotia Seas to the north. Oceanographically, the sea can be divided into a southeastern area influenced by the Antarctic Current and a northwestern part dominated by the Weddell Gyre. Oceanographic circulation is generally clockwise for surface currents, which move southwestward from the Coats Land coast and northward toward the Antarctic Peninsula. The Weddell Sea is an important location for the formation of deep and bottom water crucial to the global ocean conveyor, which transports heat around the planet. Sea ice plays an important role in such deepwater formation, promoting seawater salinity and density through brine rejection. Of note is the regional formation of Antarctic Bottom Water, a cold and saline water mass rich in oxygen and nutrients, which flows northward along the seabed from the northern end of the Antarctic Peninsula toward lower latitudes.

The Weddell Sea is characterized by stark seasonal differences in biological productivity. Basic phytoplankton (algae) productivity of algae represents the fundamental food on which all other marine organisms rely. Phytoplankton is grazed by copepods and krill, which are in turn consumed by fish, invertebrates, marine mammals, and birds. Particles that sink from the production in surface waters represent food for deeper water and seabed organisms. During summer, the southern shelf waters of the Weddell Sea in the vicinity of the Filchner Ice Shelf are most productive relative to the central and southern parts. In winter, overall productivity is minimal due to the darkness of the Southern Hemisphere winter, which limits photosynthesis. Characteristic Weddell Sea fauna includes typical Antarctic animals such as birds (southern fulmar, Antarctic petrel, storm petrel, Adélie penguin), seals (crabeater, leopard, and Weddell), and whales (blue, minke, and fin), and abundant invertebrates. Prominent fish species found in the Weddell Sea are predominantly bottom dwellers such as Antarctic cod, dragonfish, and icefish.

Anna J. Pieńkowski

See also: Amundsen Sea; Bellingshausen Sea; Ross Sea

Further Reading

Bartsch, A. "Sea-Ice Algae of the Weddell Sea (Antarctica): Species Composition, Biomass and Ecophysiology of Selected Species." *Polar Research* 63 (1989): 110.

Muench, R., and A. Gordon. "Circulation and Transport of Water along the Western Weddell Sea Margin." *Journal of Geophysical Research* 100, no. C9 (1995), 18503–15.

Weddell Seal

The Weddell seal (*Leptonychotes weddellii*) is one of four phocid pinnipeds that lives exclusively in the Southern Hemisphere with breeding populations largely confined to the circumpolar fast ice and some pack ice habitats of Antarctica. Small populations also breed on South Georgia, the South Sandwich Islands, the South Shetland Islands, and the South Orkney Islands. The genus name is from the Greek *leptos*, small, slender, and *onux*, claw pus suffix *-otes*, denoting possession, which refers to small claws on hind flippers while the species is from *weddellii:* named after James Weddell, who commanded the British Sealing Expedition, 1822–1824, which penetrated to the head of the Weddell Sea. Weddell seals may grow up to about 11 ft. (3.3 m) in length and weigh up to 1,200 pounds (550 kg). Females may be slightly larger than males. They live up to about 22 years, and females mature sexually at about 3–6 years, males at about 7–8 years. Counting ice seal numbers is difficult, but a continent-wide estimate of Weddell seals is somewhere around 800,000.

Weddell seals have a large, heavy barrel-shaped body with a relatively small head, moderate snout, and no distinct neck. The incisors and canines are moderately sized and often greatly worn. The upper outer incisors and the canines are larger and procumbent for ice sawing, and the cheek teeth are blunt with a central prominent point on the molars with a smaller point behind. The seals maintain breathing holes in the fast ice using its teeth. The short pelage is typically dark, slightly lighter ventrally, mottled with large darker and lighter patches, with white patches predominant ventrally.

The Weddell seals give birth, mostly within colonies of up to 50 females, to their single pups from late September to early November depending on location. Pups nurse for periods of seven to eight weeks, to December. After the pups wean, females mate in the water with dominant males that defend underwater territories in fast-ice habitats. Adults molt from December to March. Weddell seals dive deeply, feeding primarily in the midwater regions of the water column at depths of around 330 to almost 1,000 ft. (100–300 m), and to about 2,000 ft. (600 m) for up to 82 min. They may also exhibit diurnal feeding patterns within two depth layers (0–520 ft. [0–160 m] and 1,100 to 1,500 [340–450 m]) as a response to vertically migrating prey. Fish (mainly Antarctic silverfish) including large Antarctic cod, followed by cephalopods and crustaceans, are the usual prey although there appears to be substantial geographic variability as well as considerable variability within areas and seasons.

Weddell seals primarily use fast-ice and nearby pack ice habitats close to the coast. Adult Weddell seals seem reluctant to leave the fast ice where they bred until March or April and then mostly remain within 30–60 miles (50–100 km) of their summer breeding colonies, although some seals move longer distances and spent long periods in heavy winter pack ice. In East Antarctica, they forage offshore within pack ice in winter for periods of up to 30 days, but return to the stable fast ice to haul out. There is no predictable migration in Weddell seals, and they often aggregate in larger groups in fast-ice habitats in early summer when breeding. They may form large colonies of many hundreds on inshore fast ice at this time, often in hummocked ice and near tide cracks. In pack ice, they are found usually singly on large smooth floes and haul out on beaches or fast ice during summer, usually singly or in small scattered groups, occasionally in close aggregations of up to 60. Single individuals are occasionally sighted at subantarctic islands and rarely on the southern fringes of Australia, New Zealand, and South America.

Threats

Although they were taken near a number of research stations to feed sled dogs from the 1950s through the early 1980s, and a small-scale experimental harvest was conducted in the 1980s, none are planned or likely to be considered. The distribution and abundance of Weddell seals will likely be negatively affected by changes in the extent, persistence, and type of annual sea ice as a result of climate change. Population size and distribution may be altered through changes in food web dynamics. The effects of changes in sea ice on Weddell seals foraging seems likely to be detrimental since they forage on species that are linked with the pack ice ecosystem.

Conservation Status

The Weddell seal is listed as lower risk, least concern on the IUCN Red List and is protected in its range under the Protocol on Environmental Protection to the Antarctic Treaty. It is also protected under the Convention for the Conservation of Antarctic Seals, Annex I of which provides for commercial harvests of limited numbers, as do the Convention on the Conservation of Antarctic Marine Living Resources, Article II.

Marthán Bester

See also: Antarctic Fur Seals; Bearded Seal; Crabeater Seal; Harp Seal; Hooded Seal; Leopard Seal; Polar Bear; Ribbon Seal; Ringed Seal; Ross Seal; Sealing and Antarctic Exploration; Southern Elephant Seal; Spotted Seal

Further Reading

Bester, M., and G. Hofmeyr. "Seals: Overview." In B. Riffenburgh, ed. *Encyclopedia of the Antarctic.* New York: Taylor and Francis Books, Inc., 2007, pp. 877–81.

Reeves, R., et al. "Weddell Seal." In *National Audubon Society Guide to Marine Mammals of the World.* New York: Alfred A. Knopf, Inc./Chanticleer Press, 2002, pp. 166–69.

Siniff, D., et al. "Projecting the Effects of Environmental Change on Antarctic Seals." *Antarctic Science* 20 (2008): 425–35.

Southwell, C., et al. "A Review of Data on Abundance, Trends in Abundance, Habitat Use and Diet of Ice-Breeding Seals in the Southern Ocean." *CCAMLR Science* 19 (2012): 49–74.

West Antarctica

West Antarctica is located on the Pacific Ocean side of the Transantarctic Mountains. The other side of the Transantarctic Mountains is East Antarctica. The Transantarctic Mountains (85° S 175° W) are an extensive collection of separately named mountain ranges stretching across the Antarctic continent. West Antarctica includes the Antarctic Peninsula, Ellsworth Land, Marie Byrd Land, and King Edward VII Land. Notable ice shelves are the Ross and Filchner–Ronne Ice Shelves, which are situated on opposite ends of the Transantarctic Mountains. Marginal Seas off West Antarctica are the Weddell, Bellinghausen, Amundson, and Ross. Significant offshore West Antarctica islands included Adelaide Island (67° 15′ S 68° 30′W), Alexander I Island (71° S 70° W), and Ross Island (77° 30′S 168° E).

The Antarctic Peninsula, Ellsworth Land, Marie Byrd Land, and King Edward VII Land are the four major geographic locations in West Antarctica. These areas correspond with the British Antarctic Territory (20° W and 80° W longitudes), Argentine Antarctica (25° W and 74° W), the Chilean Antarctic Territory (53° W and 90° W), an unclaimed territory in the Marie Byrd Land region (90° W and 150° W) longitudes, and Ross Dependency (150° W and 160° E) on the Pacific Ocean side of the Transantarctic Mountains.

Antarctic Peninsula

The Antarctic Peninsula (75° S 63° S) is about 1,200 miles (2,000 km) long extending from Prime Head (63° S) to roughly the Eklund Islands at the southwest end of George VI Sound. The Antarctic Peninsula is divided into two parts: the northern Graham Land and the southern Palmer Land. The Antarctic Peninsula is mainly a mountain range. The elevation of the mountains increases as range progresses from Graham to Palmer Lands. The landscape of the Antarctic Peninsula is characterized by coastal mountains, fjords, and islands. Fourteen countries have more than 30 permanent and seasonal stations and bases on the Antarctic Peninsula. The countries with stations are Argentina, Brazil, Chile, China, Ecuador, Peru, Poland, Russia, South Korea, Spain, Ukraine, the United Kingdom, the United States, and Uruguay.

The two seas on the Antarctic Peninsula are the Weddell and the Bellingshausen. The Weddell Sea is marginal sea of the Southern Ocean and covers

1,080,000 square miles (2,800,000 sq. km). This sea is located between the Antarctic Peninsula in the west and Coats Land to the southeast, the Scotia Sea bordering it to the north at 60° S. The Bellingshausen Sea located between the Antarctic Peninsula (west) and Amundsen Sea (east). The Bellingshausen Sea covers an area of more than 180,000 square miles (480,000 sq. km).

The northernmost part of Graham Land consists of 16 major islands. All of these islands are located outside of the Arctic Circle. In the Graham Land region, there are a number of coasts. On the Bellingshausen Sea (western) side of the coasts are Davis, Danco, Graham, Loubet, and Fallières. There are several islands along these coasts, such as Deception, Trinity, Biscoe, and Adelaide. On the Weddell Sea (eastern) side of Graham Land, the coasts are Nordenskjöld, Oscar II, Foyn, and Bowman. North of these coasts is the Trinity Peninsula (63° 37′S 58° 20′W) stretching to Prime Head (63° S). The Larsen Ice Shelf (67° 30′S 62° 30′W) is situated along the Oscar II, Foyn, Bowman, and Wilkins Coasts of Graham and Palmer Lands. The Larsen Ice Shelf covers an area about 19,000 square miles (48,600 sq. km).

Palmer Land (71° 30′S 65° W) is the southern portion of the Antarctic Peninsula. The border between Graham and Palmer Lands is Cape Jeremy (69° 24′S 68° 51′W) and east tip of Hollick-Kenyon Peninsula at Cape Agassiz (68 29′S 62° 56′W). Cape Jeremy neighbors the entrance to the George VI Sound. The southern border of Palmer Land is roughly 80° W bordering Ellsworth Land to the Carlson Inlet (78° S 78° 30′W) of the Ronne Ice Shelf. The Wordie Ice Shelf is on the southwestern coast of Palmer Land. In Palmer Land, there are a number of coasts. On the Bellingshausen Sea (western) side is the English Coast. Alexander I Island is the major island on this side of Palmer Land. The George VI Ice Shelf is the ice body that fills George VI Sound.

On the Weddell Sea (eastern) side, the Palmer Land coasts are Wilkins, Black, Lassiter, Orville, and Zumberge. There are two ice shelves running along the Palmer Land coast, which are the Larsen-D and Ronne Ice Shelves. Several inlets are found along the Weddell Sea side of Palmer Land, such the Hilton, Violante, and New Bedford. There are several mountains within Palmer Land, such as the Hauberg, Latady, Merrick, Seward Sweeney, and Scaife.

The Antarctica Peninsula has the least cold climate of Antarctica and thus is the most biological diverse place found in Antarctica. This area is where algae, moss, and lichen (e.g., old man's beard and *Bryoria* species) grow in the summer. The only two native vascular plants in Antarctica grow here, which are the Antarctic hair grasses (*Deschampsia antarctica*) and the Antarctic pearlworts (*Colobanthus quitensis*). It is also home to penguins (Adélie, chinstrap, emperor, and gentoo), flying seabirds (southern fulmar, petrels [cape, southern giant, snow, Wilson's storm], skuas [brown and south polar], kelp gull, Antarctic tern, and the imperial shag), seals (crabeaters, leopard, Weddell, and the south elephant), and sei whales. Marguerite

Bay on Dion Island is the only place emperor penguins breed in West Antarctica. The southernmost colony of gentoo penguins is found on Petermann Island. Lastly, the cryopelagic fish bald notothen lives in the below zero water of the peninsula.

Ellsworth Land

Ellsworth Land (75° 30′S 80° W) is predominately a high ice plateau that stretches between 103° 24′W and 79° 45′W. The borders of Ellsworth Land are Marie Byrd Land to the west, the western edge of Ronne Ice Shelf and the Ellsworth Mountains to the east, the Bellingshausen Sea to the north, and Palmer Land of the Antarctic Peninsula to the northeast. Ellsworth Land is part of the overlapping British Antarctic Territory of Eights (103° 24′W and 89° 35′W) and Bryan (89° 35′W and 79° 45′W) coasts and Chile Antarctic claims (84° W and 90° W). Within Ellsworth Land is a subglacial lake named Lake Ellsworth (79° S 91° W). Lake Ellsworth is named after Lincoln Ellsworth (1880–1951). This subglacial is just more than 6 miles (10 km) in length and estimated to be 490 ft. (150 m) deep. The area is named in honor of Lincoln Ellsworth's (1880–1951) father after he flew across the region on his transcontinental flight in 1935.

Inland are a number of mountain ranges, such as the Ellsworth, Jones (73° 32′S 94° 0′W), Behrendt (75° 20′S 72° 30′W), Walker (72° 13′S 99° 2′W), and the Hudson group of parasitic cones (stratovolcanoes). The Ellsworth Mountains has 6 of the 10 highest mountains in Antarctica. These mountains are Vinson, Tyree, Shinn, Craddock, Gardner, and Epperly. Mount Vinson (78° 35′S 85° 25′W) is commonly called Vinson Massif. Mount Vinson is a prominent feature of the southern portion of the Sentinel Range of the Ellsworth Mountains and is the tallest point in Antarctica. Vinson Massif reaches 16,050 ft. (4,892 m) making it the eighth most prominent peak in the world. It is located south of the Antarctic Peninsula near Ronne Ice Shelf and is 746 miles (1,200 km) away from the South Pole. The mountain is 13 miles (21 km) long and 8 miles (approx. 13 km) wide. Mount Tyree (78° 24′S 85° 51′W) is the second tallest point in Antarctica at 15,919 ft. (4,852 m) and is about 8 miles (13 km) from Vinson Massif. The third highest in Antarctica is Mount Shinn (78° 27′S 85° 46′W) at 15,292 ft. (4,661 m). Mounts Craddock (78° 38′S 85° 12′W) and Gardner (78° 23′S 86° 2′W) are the fourth and fifth tallest mountains in Antarctica at 15,255 ft. (4,650 m) and 15,049 ft. (4,587 m), respectively. Mount Epperly (78° 27′S 85° 51′W) is the eighth tallest in Antarctica at 14,301 ft. (4,359 m).

On the Bellingshausen Sea side of Ellsworth Land are the coasts of English, Bryan, and Eights. The English coast is situated between the northern point of the ice-covered Rydberg Peninsula (73° 10′S 79° 45′W) and the Buttress Nunataks (72° 22′S 66° 47′W) on the west coast of Palmer Land. Bryan Coast borders to the western side of the English coast. The Bryan Coast is sandwiched between English (east) and Eights coasts (west) and stretches between the Pfrogner Point (72° 37′S

89° 35′W) of Fletcher Peninsula and the northern point of the ice-covered Rydberg Peninsula. Within Bryan Coast is the Venable Ice Shelf (73° 3′S 87° 20′W). The Eights Coast is sandwiched between Bryan coast (east) of Ellsworth Land and Walgreen coast (west) of Marie Byrd Land. Eights Coast is located between Cape Waite (72° 42′S 103° 1′W) of King Peninsula and Pfrogner Point. Within Eights Coast is the Abbot Ice Shelf (72° 45′S 96° W) covering an area almost 10,500 square miles (27,000 sq. km). It is 250 miles (400 km) in length and about 40 miles (60 km) wide. A major feature of the Abbot Ice Shelf is the ice-covered Thurston Island situated off the Eights Coast. Separating Eights Coast and Thurston Island is the ice-covered Peacock Sound. Thurston Island is the third largest island in Antarctica at more than 130 miles (215 km) in length and more than 50 miles (90 km) in width. In the Peacock Sound lies Sherman Island. Other notable islands are Dendtler, Dustin, Farwell, Johnson, and McNamara.

Marie Byrd Land

Marie Byrd Land (80° S 120° W) is located between 158° W (west) and 103° 24′W (east). The borders of Marie Byrd Land are Ellsworth Land to the west, the Ross Ice Shelf and the Ross Sea to the east, and the Amundsen Sea to the south. Marie Byrd Land is located in the world's largest unclaimed Antarctic territory stretching from the South Pole (0° S) running along the 90° W and 150° W longitudes covering an area of 620,000 square miles (1,610,000 sq. km). Rear Admiral Richard Evelyn Byrd Jr. (1888–1957) named the region after his wife Marie Byrd in 1929.

There are five coastal areas within Marie Byrd Land, which are Walgreen, Bakutis, Hobbs, Ruppert, and Saunders. The Walgreen Coast (75° 30′S 107° W) is located between Cape Waite of King Peninsula and the ice-covered Cape Herlacher on the north tip of the Martin Peninsula. On the west of Walgreen Coast is the Bakutis Coast and Eights Coast on the east stretching from 103° 24′W (east) to 114° 12′W (west). The Bakutis Coast (74° 42′S 127° 5′W) is sandwiched between Walgreen (east) and Hobbs (west) Coasts stretching from 114° 12′W (east) to 127° 35′W (west). It is located between Cape Herlacher on the north tip of the Martin Peninsula and Dean Island located in the Getz Ice Shelf.

The Hobbs Coast (74° S 132° W) is sandwiched between Bakutis (east) and Ruppert (west) Coasts stretching from 127° 35′W (east) to 136° 50′W (west). It is located between Dean Island, which is surrounded by the Getz Ice Shelf, and Cape Burks of McDonald Heights in Hull Bay. The Ruppert Coast (75° 45′S 141° W) is located between Cape Burks of Hull Bay and Brennan Point of Block Bay stretching from 136°50′W (east) to 146° 31′W (west). This coast is bordered by the Hobbs (east) and Saunders (west) Coasts. The border between Ruppert and Saunders Coasts is Brennan Point of Block Bay. The Saunders Coast (77° 45′S 150° W) is sandwiched between Ruppert (east) and Shairase (west) Coasts from 146°

31′W (east) to 158° 1′W (west). Part of the Ruppert Coast is outside Marie Byrd Land. West of 150° W Marie Byrd Land is Ross Dependency, which is claimed by New Zealand.

There are a number of mountain ranges, such as the Clark, Crary, Ford, Fosdick, Haines, Horlick, Ickes, Kohler, Mackay, Usas, and Whitmore. A mountain range called "Executive Committee Range" (76° 50′S 126° 6′W) consists of five major shield volcanoes, which are Mounts Sidley (77° 2′S 126° 6′W), Waesche (77° 10′S 126° 54′W), Hampton (76° 29′S 125° 48′W), Cumming (76° 40′S 125° 48′W), and Hartigan (76° 52′S 126° W). The tallest volcano in Antarctic is Mount Sidley at 14,058 ft. (4,285 m). Another notable feature of Marie Byrd Land is Rockefeller Plateau. There are two U.S. research stations in Marie Byrd Land. One is a seasonal drilling station called "WAIS Divide" (79° 28′S 112° 4′W), while the other seasonal station is Byrd Station (80° S 119° W).

King Edward VII Land

King Edward VII Land (77° 40′S 155° W) is an ice-covered peninsula on the Ross Sea and is the smallest of the West Antarctic region. A notable feature of King Edward VII Land is the 85-mile (137-km) long and 50-mile (80-km) wide Swinburne Ice Shelf. West of 150° W King Edward VII Land is the New Zealand Ross Dependency territorial claim. The King Edward VII Peninsula borders of King Edward VII Land are Marie Byrd Land to the west and extends out into the Ross Sea and is located between Sulzberger Bay (77° S 152° W) and the Saunders Coast and the ice-covered Cape Colbeck (77° 7′S 158° 1′W) neighboring Okuma Bay on northeast side of the Ross Ice Shelf. The King Edward VII Peninsula is located on the Shirase Coast. The Shirase Coast (78° 30′S 156° W) is located on the eastern side of the Ross Ice Shelf and the Ross Sea. It is named after Lieutenant Nobu Shirase (1861–1946), in 1961. Lieutenant Nobu Shirase was the leader Japanese Expedition of 1910–1912.

Ice Shelves

In the West Antarctica, there are several significant ice shelves along the coast. These ice shelves are the Ronne–Filchner Larsen, Abbot, Getz, Sulzberger, and Ross. Ronne–Filchner Ice Shelf is the second largest in Antarctica (162,935 sq. miles [422,000 sq. km]) located at the head of the Weddell Sea. The thickness of the Ronne–Filchner Ice Shelf ice ranges from 500 to 650 ft. (150–200 m). Ronne–Filchner Ice Shelf is the combination of the Ronne and Filchner Ice Shelves. The Ronne Ice Shelf (78° 30′S 61° W) is larger of the two and located on the western side. The Filchner Ice Shelf (79° S 40° W) is on the eastern side. Located between the Ronne and the Filchner is Berkner Island (79° 30′S 47° 30′W). On the west side, the Ronne Ice Shelf is bordered by the Orville and Zumberge Coasts and Ellsworth Land.

The Larsen Ice Shelf (67° 30′S 62° 30′W) is situated on the eastern side of the Antarctic Peninsula along the Oscar II, Foyn, Bowman, and Wilkins Coasts. The ice shelf faces the Weddell Sea. The ice shelf is located between Cape Longing (64° 33′S 58° 50′W) on Longing Island and Hearst Island (69° 25′S 62° 10′W) off Palmer Land. The Larsen Ice Shelf covers an area of about 19,000 square miles (48,600 sq. km). The thickness of the Larsen Ice Shelf ice averages around 1,000 ft. (300 m).

The Abbot Ice Shelf (72° 45′S 96° W) is located on the Eights Coast (73° 30′S 96° W) of Ellsworth Land roughly between Cape Waite on King Peninsula and Phrogner Point on Fletcher Peninsula. The ice shelf covers an area of almost 10,500 square miles (27,000 sq. km). It is 250 miles (400 km) in length and about 40 miles (60 km) wide. A major feature of the Abbot Ice Shelf is the ice-covered Thurston Island situated off the Eights Coast. Separating Eights Coast and Thurston Island is the ice-covered Peacock Sound. Thurston Island is the third largest island in Antarctica at more than 130 miles (215 km) in length and more than 50 miles (90 km) in width. In the Peacock Sound lies Sherman Island. Other notable islands are Dendtler, Dustin, Farwell, Johnson, and McNamara.

The Getz Ice Shelf (74° 15′S 125° W) is located on the Bakutis and Hobbs Coasts of Marie Byrd Land roughly between Hull Bay and Cape Herlacher. Getz covers an area almost 13,000 square miles (32,810 sq. km) and stretches more than 300 miles (500 km) across the Antarctic coastline. The Getz Ice Shelf extends several miles into the sea and has a vertical face about 200 ft. (60 m). Several islands are embedded in or surrounded by the ice shelf, such as the Wright, Carney, Siple, Grant, and Shepard Islands. There is a bay and a gulf along the Getz Ice Shelf. Russell Bay is located between Carney Island and the northwest side of Siple Island off of the Getz Ice Shelf. Wrigley Gulf is on the opposite side of Siple Island and Russell Bay and in-between Grant Island. A notable feature of King Edward VII Land is the 85-mile (137-km) long and 50-mile (80-km) wide Swinburne Ice Shelf.

The world's largest floating ice shelf is the Ross Ice Shelf covering an area of 182,000 square miles (473,000 sq. km). Captain Ross had first named the Ice Shelf "Victoria Barrier" in honor of Queen Victoria and then later the "Great Ice Barrier." The ice shelf was later named in his honor. The Ross Ice Shelf is horseshoe shaped and about 500 miles (800 km) across and from the open sea inland is more than 350 miles (600 km) long. The ice cliff face above the water surface ranges from 50 to 150 ft. (15–50 m). The thickness of the Ross Ice Shelf ice ranges from 600 to 3,000 ft. (180–900 m). On the west side, the Ross Ice Shelf is bordered by Edward VII Peninsula, Shirase, Siple, and Gould coasts neighboring Marie Byrd Land. On the eastern side of the Ross Ice Shelf are the Queen Maud Mountains of the Transantarctic Mountains, Shackleton and Hillary coasts, and Ross Island.

Seas

The Bellingshausen Sea is located off of the Antarctic coast between the Antarctic Peninsula (west) and Amundsen Sea (east). On the western border is the western side of the Alexander Island (71° S 70° W), while the eastern border is Cape Flying Fish on Thurston Island. The southern border is the southern part of Peter I Island (68° 51′S 90° 35′W). The northern border is the Antarctic coast and includes the English, Bryan, and Eights Coasts. There are three major islands in the Bellingshausen Sea, which are Alexander I, Peter I, and Charcot. There are two significant bays in the Bellingshausen Sea, which are the Ronne Entrance and Marguerite. The George VI Ice Shelf fills in the George VI Sound with ice, making an ice bridge from Palmer Land to Alexander I Island.

The Amundsen Sea is located off of Marie Bird Land between an unnamed Sea (west) and Bellingshausen (east) Sea (72.5° S and 112° W). Just beyond the unnamed Sea is the Ross Sea. The western border is Cape Flying Fish (72° 3′S, 102° 20′W) on Thurston Island. The eastern border is Cape Dart (73° 7′ S 126° 9′ W) on Siple Island. There are two open bays on the Amundsen Sea coast, which are Russell Bay (73° 27′S 123° 54′W) and Pine Island Bay (74° 50′S 102° 40′W). There are two major ice formations that flow into Pine Island Bay, which are Pine Island and Thwaites Glacier. Pine Island Glacier (75° 10′S 100° W) is located near Cape Flying Fish, and Thwaites Glacier (75° 30′S 106° 45′W) extends into Pine Island Bay forming an ice spit or tongue about 30 miles (50 km) wide and is called "Thwaites Ice Tongue" (75° S 106° 50′W).

The Ross Sea is located off of the Antarctic coast and lies from the Edward VII Peninsula (west) to Victoria Land (east). The southern border is the Ross Ice Shelf. On the western border is the ice-covered McMurdo Sound (77° 30′S 165° E), which is adjacent to Ross Island. The eastern border is Roosevelt Island (79° 25′S 162° W) and Bay of Whales (78° 30′S 164° 20′W). The dominant feature of the Ross Sea is the Ross Ice Shelf, which is the world's largest floating ice sheet covering an area of 182,000 square miles (472,000 sq. km). The Ross Ice Shelf is horseshoe shaped and about 500 miles (800 m) across and from the open sea inland is more than 350 miles (600 km) long. The cliff face above the water surface ranges from 50 to 150 ft. (15–50 m).

Andrew J. Hund

See also: Antarctic Circle; Antarctic Ice Sheet; Antarctic Peninsula; East Antarctica; Transantarctic Mountains; Volcanoes in Antarctica

Further Reading

Rignot, E. "Changes in West Antarctic Ice Stream Dynamics Observed with ALOS PALSAR data." *Geophysical Research Letters* 35, no. 12 (2008): L12505.

Steig, E., et al. "Warming of the Antarctic Ice-Sheet Surface since the 1957 International Geophysical Year." *Nature* 457, no. 7228 (2009): 459–62.

Whaling and Antarctic Exploration

The naturalist William Speirs Bruce sailed to Antarctica with the Dundee Whaling Expedition in 1892–1893. He was given limited opportunities for research and never came within 6 miles (9.7 km) of land. The aim of the expedition was to hunt whales, preferably right whales, and the whalers had no interest in geographical discovery despite visiting a largely unknown area. The surprising thing about the Antarctic whaling industry is that not all whalers felt the same way and that two in particular (e.g., Carl Anton Larsen and Lars Christensen) were to make major contributions to geographical knowledge.

Whereas the sealers had a natural interest in the discovery of new land in their rapacious search for new beaches on which fur seals hauled out to breed, whalers had little interest in land except insofar as it afforded secure anchorages and sites for whaling stations. Even these became of reduced interest in the later pelagic phase of whaling, when ships were able to operate in the open ocean independently of any land base, and yet it was precisely during this period that the whaling industry's contribution to the knowledge of Antarctica was the greatest.

Japanese whalers on a ship off Antarctica clean an illegally killed whale in January 2000. Japan, Norway, and Iceland have repeatedly ignored the efforts of the International Whaling Commission to impose and enforce bans on commercial whaling. (AFP/Corbis)

The expedition of James Clark Ross (1839–1843) played a similar role for the whalers to that unwittingly performed by James Cook for the sealers. While Cook had reported numerous fur seals on South Georgia, Ross described seeing right whales in the Ross and Weddell Seas. Later in the nineteenth century, as right whales became increasingly scarce in the Northern Hemisphere, interest grew in Ross's report of a large Southern Hemisphere population close to Antarctica until, in the 1890s, several expeditions were sent South by whaling entrepreneurs to investigate whether the industry might be conducted there on an economically viable basis. In addition to Bruce's Dundee Whalers, Carl Anton Larsen led two expeditions to the Antarctic Peninsula (1892–1893 and 1893–1894) and Henrik Bull led one to the Ross Sea (1893–1895). None of these found right whales in any number, and indeed had the results of Eduard Dallmann's sealing and whaling voyage of 1873–1874 been more widely known, hopes might have been less sanguine about the prospects of finding any right whales at all close to Antarctica. Some mystery surrounds what whale species Ross himself saw. Since he had spent some time with northern whalers, he should certainly have been capable of distinguishing the slow-moving right whale from other less suitable species, and it is probable that the populations of Southern Hemisphere right whales were significantly reduced after his voyage by whaling in the breeding grounds close to South Africa and South America. In any case, just one whale was taken by these pioneering expeditions, though all reported seeing many fast-swimming rorqual whales. Aware of techniques developed by Svend Foyn to hunt rorquals off the Norwegian coast, Larsen saw enough of these during his two expeditions and as captain of *Antarctic* on Otto Nordenskjold's Swedish Antarctic Expedition (1901–1904) to set up the first whaling station on South Georgia in November 1904, backed by Argentine capital and equipped with ships and techniques specially designed to hunt the rorquals: blue, fin, humpback, sei, and minke whales in the descending order of size and desirability.

Larsen's initiative was followed soon afterward by the migration to the Antarctic of virtually the entire Norwegian whaling industry from its traditional whaling grounds off the coast of Finnmark, the northernmost county in Norway. What precipitated this move was not the decline in northern stocks of rorqual whales, as sometimes asserted, but legislation introduced by the Norwegian government banning whaling in this region in response to protests by Finnmark's fishermen who blamed falling catches on the reduced number of whales available to drive the fish inshore. Although other countries were to become involved in the southern whaling industry, Norwegians continued to play the most prominent role, particularly with regard to exploration.

The southern whaling industry became concentrated in two main centers: South Georgia with six shore stations and Deception Island in the South Shetlands, where one station operated in combination with a number of factory ships. From 1911 onward, factory ships began to extend their activities southward from Deception along the Antarctic Peninsula, benefiting from information supplied to them concerning numbers of whales and the availability of anchorages by the French explorer Jean-Baptiste Charcot. In return, Charcot received coal and help in repairing his ship. Indeed, the presence of the whaling industry at South Georgia and Deception Island provided support and a potential safety net for many exploring expeditions at this time, Sir Ernest Shackleton's *Endurance* expedition being the most notable example, though whalers on South Georgia also offered great assistance to Wilhelm Filchner (1911–1912) and, after Shackleton's death, to Frank Wild in 1922. Whaling ships ferried John Cope's expedition to Deception Island before landing him on the Danco Coast of the Antarctic Peninsula. Had it not been for the whalers, two members of his expedition might never have been recovered from their wintering site on Waterboat Point. The aviator Sir Hubert Wilkins was also to receive considerable assistance, with whaling vessels carrying his aircraft to and from Deception in the late 1920s.

Larsen's exploratory activities did not end once he had established the Compañia Argentina de Pesca whaling station at Grytviken, though his final contributions to Antarctic exploration were all made in connection with his whaling interests. In 1908, he searched for anchorages suitable for use by whalers along the coasts of South Georgia and the South Sandwich Islands, making the most detailed survey to date of the latter islands and only the second documented landing on Zavodovski Island. In 1923 and 1924, he led pioneering expeditions to the Ross Sea, where he was responsible for opening up an important new whaling ground.

Lars Christensen was the son of Christen Christensen, the owner of the steam whaler *Jason*, in which Larsen had made his first two Antarctic expeditions. By the 1920s, the southern whaling industry had begun to search for new stocks of whales outside the South Atlantic waters where it had originated. Larsen had demonstrated the potential of the Ross Sea, but to Lars Christensen, other regions appeared equally promising. In 1927, he sent one of his whale catchers, *Odd I*, to investigate the waters around Peter I Island. The results were disappointing; the island offered no potential anchorage, and very few whales were seen during the voyage from Deception. Realizing that he needed a more suitable ship, Christensen next purchased *Norvegia*, a small wooden-hulled whaling and sealing vessel, which he planned to use specifically for the purposes of exploration. An account of *Norvegia*'s four voyages together with Christensen's subsequent exploratory activities in *Thorshavn* is given under his name, while under Hjalmar Riiser-Larsen's name may be found a detailed description of *Norvegia*'s 1929–1930 voyage, during which Queen Maud Land was discovered. The apparent paradox of discoveries made at this time and by other whalers inspired by Christensen's example is that, with Petter Sørlle's invention of the stern slipway in 1922, a new generation of whaling ships came into use that was free from the need to operate in conjunction with any shore base because the ships were able to haul the whale carcasses on board for processing with minimal wastage. Why therefore should it have been at this time that Christensen and his colleagues attached such importance to making and reporting new land discoveries?

The answer lies in politics. For years, the largely Norwegian whalers had been obliged to pay dues and operate under restrictions imposed by the Falkland Islands Dependencies, a colonial administration established by Great Britain in 1908. Because they operated off islands and mainland in the most part discovered by British explorers, and because Great Britain's territorial claims were respected by the Norwegian government, the whalers found themselves paying increasingly higher licensing fees and observed legislation that became more restrictive as concern grew about diminishing whale stocks. Given that Norwegians had made many significant discoveries in the Antarctic, Christensen and his colleagues became especially disturbed when it became apparent that similar arrangements to those pertaining in the Falkland Islands Dependencies were to be extended to cover the Ross Sea and other new whaling grounds. Christensen's solution was simple: the whalers themselves must discover new land, which should then be claimed for Norway. This policy proved remarkably successful, both in what was achieved by Christensen's own ships but also in persuading other Norwegian whaling entrepreneurs to go out of their way to make new discoveries. In 1930–1931, the year following Riiser-Larsen's discovery of Queen Maud Land in *Norvegia*, R. K. Headland estimates that there were probably 300 whaling ships in Antarctic waters, the greatest number ever. Not surprisingly, this year was also unprecedented for the number of discoveries made by whalers, greatly extending knowledge of Antarctica's coastline between 14° and 69° E, which had previously been among the least known on the continent.

Providing oil, lubricants, glycerin (for nitroglycerin in explosives), margarine, and other essential products, whaling offered many fortunes and led to the establishment of great industrial concerns in Norway and Great Britain in particular. Christensen's farsightedness in linking whaling activities to geographical discoveries, which were then claimed on behalf of Norway, provoked in response the organization of expeditions on behalf of the British Empire and Germany. Indeed, in the heightened atmosphere of the years immediately preceding the outbreak of World War II, it was the capacity of the whaling industry to generate almost unimaginable sources of wealth that convinced previously skeptical national governments of the need to consolidate preexisting territorial claims in Antarctica and, where possible, to extend them through further expeditions. Thus, the influence of the whaling industry on Antarctic exploration was both direct, through discoveries made by the whalers, and indirect, through the responses these provoked in others. It is with good reason that the years between 1919 and 1942 have been referred to as the "Whaling Period" in Antarctic history. Certainly, no activity was more influential at this time.

William James Mills

See also: Gray's Beaked Whale; Humpback Whale; Long-Finned Pilot Whale; Southern Bottlenose Whale; Southern Right Whale

Further Reading

Aagaard, B. "Antarctic Whaling and Exploration." *Scottish Geographical Magazine* 45, no. 1 and no. 2 (1929): 23–34, 65–81.

Headland, R. "Geographical Discoveries in Antarctica by the Whaling Industry." In B.L. Basberg et al., eds. *Whaling and History: Perspectives on the Evolution of the Industry.* Sandefjord, Norway: Kommandør Chr. Christensens Hvalfangstmuseum, 1993, pp. 191–202.

Tønnessen, J., and A. Johnsen. *The History of Modern Whaling.* London: C. Hurst, 1982.

Whaling and Arctic Exploration

The relationship between whaling and exploration is long and complicated in the Arctic. Although whalers did on occasion discover major new whaling grounds, usually they were first reported by exploring expeditions. This was partly because explorers were able to take greater risks, and partly because their vessels tended to have greater ice-strengthening, but largely because it was the business of whalers to make a profit for their owners. Competition was intense, and no owner would thank an enterprising captain who missed whales for the slight possibility of discovering new whaling grounds. Yet significant discoveries were made by whalers. They also developed techniques for navigating through the ice, and many exploring expeditions made a point to employ experienced whalers as ice pilots.

Many cetacean species migrate seasonally between the lower latitudes, where they breed, and the polar regions, where the richest feeding grounds are found close to the ice. Whaling in the Atlantic was pioneered by the Basques of southwestern France and northern Spain who hunted the North Atlantic right whale (*Eubalaena glacialis*) in the Bay of Biscay. As stocks became depleted, they looked for new whaling grounds and followed the fishermen across the ocean to Labrador and Newfoundland, where a rich cod fishery had been reported in 1497 by John Cabot. By the late 1530s, Basque whaling was well established, with a tryworks erected onshore at Red Bay (Newfoundland). There, the preferred species was the bowhead (*Balaena mysticetus*) on account of its higher oil yield (5–10 more barrels per whale than right whales) and longer baleen plates. True Arctic whaling began as the whalers followed this species north each summer into Davis Strait with the retreating ice.

Beaked whale. (Brandon Southall/NMFS/OPR)

In 1607, Henry Hudson reported many whales off Svalbard. The first English and Dutch whaling fleets arrived in 1611 and 1612, respectively, followed soon afterward by French, Spanish, and Danish vessels. By 1614, the Dutch had established control in the north, compelling the English to look for new grounds to the south and west, resulting in a number of discoveries. English activity declined after 1619, when the Muscovy Company organized the last of its expeditions. Dutch whaling was initially shore based and then, increasingly, was conducted on the high seas after whale populations were hunted out in the fjords and close inshore. Beginning in 1670, whaling was chiefly carried out among the ice floes toward East Greenland and in the northern Barents Sea, where Cornelius Giles probably saw White Island and Cornelis Roule possibly Franz Josef Land.

As the so-called Greenland Fishery off Svalbard declined with the whale population, Dutch whalers began mounting regular expeditions to Davis Strait from the early eighteenth century. There, they were succeeded first by vessels from colonial America and then, after the Revolutionary War, from Great Britain. In 1763, William Christopher's report of whales in northern Hudson Bay led the Hudson's Bay Company to organize whaling expeditions until 1772; whaling was not resumed until 1866. Davis Strait, however, and Baffin Bay to its north had much larger stocks of whales, though the whalers appear not to have explored farther north than 71° N off West Greenland until the pioneering voyage by *Larkins* of Leith and *Elizabeth* of Hull in 1817, when the North Water and its large whale population were discovered at 77° N. This was a rare occasion in which a major whaling ground was discovered by the whalers themselves, who would undoubtedly have exploited it regardless of John Ross's expedition the following year. Ross's voyage indeed was organized following reports from whalers, including William Scoresby Jr., of unusually ice-free waters off Northeast Greenland, where Scoresby was to make significant discoveries in 1822 during another good ice year. The voyages of Ross and Edward Parry drew attention to waters farther west, particularly Pond Inlet (Baffin Island), where they reported many whales, and Lancaster Sound. Farther south, the whaler William Penny rediscovered Cumberland Bay and other inlets of southwest Baffin explored by John Davis in the 1580s but not visited since. In the Western Arctic, the American whaler Thomas Roys learned from those participating in Russian expeditions of whales being seen north of Bering Strait; his compatriots later explored the Beaufort Sea east to the Mackenzie Delta in the wake of expeditions searching for Sir John Franklin. Just as the presence of whalers in southern Baffin Bay had enabled Charles Francis Hall to rediscover Frobisher Bay in 1861, so Vilhjalmur Stefansson first learned of the blond Inuit of Victoria Island from whalers at Herschel Island. The existence of whaling stations established by Americans in regions claimed by Canada led that country to organize regular patrols of its Arctic territory, beginning with the expeditions of Albert Low and Joseph-Elzéar Bernier.

Whalers acquired their skills in ice navigation by dint of hard experience. The chief dangers facing vessels in ice were being struck by ice blocks during a storm or of being nipped and, in the worst case, crushed between floes. During storms, or when the pack ice was breaking up, ships would often seek shelter in the lee of large icebergs. They could also cut ice docks into floes, within which one or two ships might find respite while the pack as a mass forced up pressure ridges as it was compressed against land and fast ice. The whalers developed various techniques to make their way through pack ice when this was impossible by sail power alone. During warping, a hawser was fixed to ice in front of the ship and hauled in by the capstan. During tracking, the crew used hawsers to pull the boat in a manner analogous to towing a canal barge. Vessels might also be towed by the ship's boats. This knowledge was passed down within the whaling community and was not published until 1820 in the second volume of William Scoresby's *An Account of the Arctic Regions.*

William James Mills

See also: Beluga Whale; Bowhead Whale; Humpback Whale; Narwhal; Orca; Walrus

Further Reading

Bockstoce, J. *Whales, Ice, and Men: The History of Whaling in the Western Arctic.* Seattle: University of Washington, 1986.

Ross, W. *Arctic Whalers, Icy Seas: Narratives of the Davis Strait Whale Fishery.* Toronto: Irwin, 1985.

Whaling Fleet Disaster of 1871

During the summer of 1871, the whaling fleet was following the migration of the bowhead whales in the Bering Strait of northern Alaska. The whaling fleet consisted of 40 vessels. By August, the whaling fleet had traveled as far north as Point Belcher (70° 47′N 159° 39′E), close to Wainwright, Alaska. At the same time, in Siberia, cold and warm air masses had come together and stalled. The resulting weather condition was a stationary front. The Siberian stationary high front had descended on the region and remained for several days, resulting in the normal wind patterns being stalled. This stationary front resulted in an early and sudden freeze-over, and pack ice swiftly pushed from Siberia toward the Alaskan coast. Thirty-three of the vessels were caught in the cold front just south of Point Franklin. Within two weeks, the accumulation of ice had trapped these vessels entombing them in the pack ice in a line that stretched around 60 miles (97 km).

The more than 1,200 crew members on the trapped vessels abandoned their ships. The crew members set out on the icy waters and brutal Arctic conditions in small whaling boats with a three months' supply of food. The marooned crew members traveled approximately 70 miles (110 km) to the seven vessels that had escaped being stranded in the ice and were rescued. The seven vessels were the *Europa*, *Arctic*, *Progress*, *Lagoda*, *Daniel Webster*, *Midas*, and *Chance*. These vessels dumped their summer catch and whaling equipment to make room for the sailors. The vessels and 1,200 rescued sailors returned Honolulu, Hawaii.

Thirty-two of the thirty-three vessels were abandoned and ultimately lost. After the breakup of the ice, only one vessel could be salvaged (e.g., *Minerva*). The local Inupiat salvaged some of the ships' wood and were presumed to have burned at least three vessels (e.g., *Bark Concordia*, *Ship Gay Head*, and *Ship Florida*). Three vessels were known to have been crushed by the ice. These were the *Bark Roman* (September 7, 1871), the *Bark Awashonks* (September 8, 1971), and the *Bark Comet* (September 2, 1871). One sailor wintered on the *Bark Massachusetts*.

The whaling fleet catch was a total loss, which was valued at more than $1.5 million (approx. US $26.3 million [2012]). The majority (22 vessels) of the wrecked vessels were from New Bedford, Massachusetts; others were from Edgartown, Massachusetts; New London, Connecticut; San Francisco, California; and Honolulu, Hawaii. This whaling disaster was a significant blow to the whaling industry, which was waning.

Andrew J. Hund

See also: Eskimo Coast Disaster of 1885; Lost Patrol; Thule Air Base, Greenland, B52G Stratofortress Crash of 1968

Further Reading

Baker, J. *The Great Whaling Disaster of 1871.* Greensboro, NC: Morgan Reynolds Publishing., 2007.

Nichols, P. *Final Voyage: A Story of Arctic Disaster and One Fateful Whaling Season.* New York: Putnam, 2009.

Wolverine

The wolverine (*Gulo gulo*), is a carnivore of the Mustelidae family inhabiting the boreal area of the Northern Hemisphere. It was first described in the scientific literature in 1517 by the Polish scholar Matthias of Miechów in Cracow. Modern taxonomy maintains that a clear separation occurs between two populations, where the Eurasian represents the nominotypical *Gulo gulo gulo*, while the North American wolverines form the distinct subspecies *G. g. luscus.* Further subspecies described from Kenai Peninsula in Alaska and from Kamchatka are nowadays usually not considered valid.

The English name wolverine is probably an old (first known in 1574) irregular diminutive of the word "wolf." It is sometimes also called "quick hatch" in Canadian English, which is an East Cree (*kwikkwâhaketsh*) borrowing. The Canadian French name *carcajou* is borrowed from an Algonquian name for the animal, the Mi'kmaq *kwi'kwaju* ("evil spirit"). In Swedish and Norwegian, it is known as *järv*, which is an ancient word meaning "the brown one." The German name *Vielfrass* "heavy eater" (actually a folk etymology; it is probably an Old Norse borrowing, *fjeldfross* "mountain cat") was spread in northern Europe through the medieval fur trade and has survived in the literature until today. The Finns call it *ahma*, meaning "glutton," and the North Sámi *geatki*, Lule Sámi *gierkke*, Ume Sámi *gädhgee*, South Sámi *gierhkie*, Inari Sámi *ketki*, and Kildin Sámi *k'ētt'k*, while the Russians call it *rosomakha* (*росомаха*), which is borrowed from a Finno-Ugric word meaning "fat belly." In south Siberian Turkic, it is known as *kunu* derived from a verb for "stealing." Also its scientific name *gulo* "glutton" was given to it because of its reputation of being a voracious eater. Its pungent odor produced by its anal scent glands has given it several local names (e.g. skunk bear) in North America.

The wolverine inhabits a variety of habitats within the boreal zone of the Northern Hemisphere. The contemporary distribution covers Alaska, Canada (population estimated between 15,000 and 20,000), and as a rare species in the states of Wyoming, Idaho, and Montana, although occasional sightings have been recorded recently from places like California and Michigan. Small numbers are also to be found on the islands of Banks, Victoria (Kitlineq), Baffin (Qikiqtaaluk), Ellesmere (Umingmak Nuna), and Little Cornwallis of the Canadian Arctic Archipelago. It is a true subarctic species in Europe known from northern Sweden (population 600), mountainous parts of northern and south-central Norway (350), boreal zones of Finland (150), and in the tundra and forest zones of northern Russian Federation (with the highest population in the Komi Republic) eastward toward Mongolia, Siberia, and Kamchatka. It is also distributed in the Altai Mountains of northernmost Xinjiang, as well as in Inner Mongolia, Heilongjiang, Jilin, and Liaoning in China. The total population in China is estimated at fewer than 400. Historically, it has been found more south also in the European continent.

The mostly solitary wolverines are opportunistic feeders that live on reindeer, but in the forest areas also on roe deer and wapitis. They also feed on hares, rodents, and larger birds. Berries and fungi seem to be part of their diet too. The North European wolverines are said to be more active hunters than their North American relatives. Mating season is from May to August with a peak in June. Implantation of the embryos is delayed, most births taking place in February–March of the following year. They get one to five cubs.

It has always been hunted because of its skin, which has been used for clothing details. A few Paleolithic depictions on bones (for instance, the 12,500-year-old engraved drawing on a bone from the cave of Les Eyzies), and as a cave painting in Cueva de los Casares in southwestern Europe, indicate that the wolverine was of importance early in human history. Especially in the sixteenth and seventeenth centuries, their pelts were on demand in the fur trade, when large numbers were killed in Russia and the skins were sold on the international market. Already in 1635, the city of Turinsk in Siberia made the wolverine a symbol on its coat of arms indicating its importance within the fur trade. Wolverine skins were shipped from northern Russia to the Hanseatic city of Lübeck or transported by land to the city of Danzig. However, changes in fashion and price reduction in the eighteenth century decreased the demand on the market. It continued to be a game for indigenous hunters in Siberia, Russia, Scandinavia, and North America until recently, and the pelts were and are used locally. Legal hunting occurs in Alaska, Canada, and Russia. The pelts are still used for a trim on parkas and mittens. Also in Kamchatka, pelts of the wolverine remain popular among the indigenous population.

Earlier more vital populations in, for instance, northern Fennoscandia have been reduced to a small number, although an increase has been noticed the past few decades. As a predator on domestic reindeer and sheep, it has continued to be hunted, and although protected in many areas, it is still killed by poachers.

Its use as food has been of lesser importance. There are only a few records of various northern people, like the Sámi, who were sometimes eating them. During severe food shortage also, Siberian peoples could eat its meat. When food was scarce, Native Americans in the subarctic region, for instance, the Igloolik in Nunavut, used the meat of the wolverine too. Koyukon Indians in Alaska regarded the meat as taboo and did not even give it to the dogs. According to old Scandinavian sources, fat of wolverine was used as a remedy, and also other parts of the animal (teeth, claws) were used in folk therapy.

Its shyness has contributed many rumors about its way of life. The wolverine is a common trickster in the subarctic and Arctic Native American mythology. Among the Innu in Canada, the wolverine is regarded as the creator of the world. It is a common figure in many animal tales from the Athabaskan and Algonquin speakers of Canada and Alaska. Also Itelmen and Koryaks in Kamchatka have legendary tales about the wolverine. The month of February is named after the wolverine in the South Sámi language, *gierhkiengarres* "the month when the wolverine is hard."

Captured wolverine cubs are easily tamed and people living in the North have sometimes brought them home and kept them as pets. They have never been especially common in zoological gardens, although several northern and central European zoos currently keep them and some have been successful in breeding them. It is also kept in a few North American zoos.

Ingvar Svanberg

See also: Arctic Fox; Arctic Ground Squirrel; Arctic Hare; Arctic Seabirds; Arctic Wolf; Caribou; Dogs in the Arctic; Lemmings; Musk Oxen; Polar Bear; Walrus

Further Reading

Blomquist, L., and H. Larsson. "Breeding the Wolverine Gulo gulo in Scandinavian Zoos." *International* Zoo *Yearbook* 29 (1990): 156–63.

Copeland, J., and J. Whitman. "Wolverine (*Gulo gulo*)." In G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, eds. *Wild Mammals of North America: Biology, Management, and Economics.* Baltimore: Johns Hopkins University Press, 2003.

Haglund, B. *Järv och varg.* Stockholm, Sweden: Norstedt, 1965.

Inman, R. M., A. J. Magoun, J. Persson, and J. Mattisson. "The Wolverine's Niche: Linking Reproductive Chronology, Caching, Competition, and Climate." *Journal of Mammalogy* 93 (2012): 634–44.

Woolly Mammoths

The woolly mammoth (*Mammuthus primigenius*) is one of the best studied extinct prehistoric mammals that lived during the past ice age on earth. Woolly mammoths coexisted with early humans, and they have inspired both awe and romance into the study of everything from the sociology of cooperative hunting activities of early prehistoric cultures to the chemistry of climate change for advancing human knowledge toward survival during the next major climate event. Although the remains of woolly mammoths had been known about for thousands of years in Asia, it was not until the seventeenth century (1796) that the woolly mammoth was officially identified as an extinct mammal species by Europeans. Because the carcasses of woolly mammoths are found as relatively intact frozen organic specimens rather than as petrified (stone) artifacts, the remains can be studied extensively using modern scientific methods such as stable isotope analysis. Several frozen woolly mammoth carcasses have been found in Alaska and Siberia including the carcass of a 10,000-year-old female woolly mammoth found among Russia's Novosibirsk Islands believed to contain intact woolly mammoth blood. This finding caused increased excitement about finding functional cells and increasing the odds, hopes, and controversy of the creation of a living clone of the woolly mammoth.

The closest species to the woolly mammoth that is still alive today is the Asian elephant, *Elephas maximus.* If the woolly mammoth roamed today, it would look like a very hairy elephant with a domed head, fatty hump on its back, longer trunk, longer curved tusks that point toward each other, much smaller ears, and a smaller tail covered with long coarse hairs. The woolly mammoth was just one of the last in a line of elephants known as "mammoths" described by the extinct genus: *Mammuthus.* The complete biological classification of the woolly mammoth includes (1) kingdom: Animalia; (2) phylum: Chordata; (3) class: Mammalia; (4) order: Proboscidea; (5) family: Elephantidae; (6) genus: *Mammuthus*; and (7) species: *M. primigenius* (*Mammuthus primigenius*). *M. primigenius* was the youngest of the extinct genus *Mammuthus* and was believed to diverge from the steppe mammoth, *Mammuthus trogontherii*, about 200,000 years ago. People sometimes confuse mammoths with the mastodons from the more primitive genus *Mammut*, which appeared approximately 20–25 mya mistakenly called "mastodons." Mastodons evolved and disappeared as a separate taxonomic family and different evolutionary pathway.

In terms of size, the woolly mammoth was about the same size as an African elephant. Mature male woolly mammoths stood between 9 and 11 ft. tall and could weigh up to eight tons (8,000 pounds). Mature female woolly mammoths stood between 8.5 and 9.5 ft. tall and weighed less, approximately 4,000–6,000 pounds (1,800–2,700 kg). When baby woolly mammoths were born, they weighed approximately 200 pounds. The woolly mammoth was well adapted to live in the Arctic tundra during the past ice age. Woolly mammoths had approximately 4 inches of fat under their skin that provided insulation against cold temperatures. In addition, all parts of their bodies were covered in a wool-like fur that comprised two layers, an outer covering of longer guard hairs and a shorter woolly undercoat. The coats of woolly mammoths were very similar to musk oxen, and they likely molted (shed their fur) in spring like other mammals. The color of the woolly mammoth fur varied from light to dark, and research studies revealed that mammoths with light-colored coats were genetically rare because they would need two copies of the recessive gene (Mc1r allele). The coarse guard hairs on the upper part of the body of the mammoth grew up to a foot long. The hairs grew up to 35 inches (89 cm) long on the flank and underside on the mammoth. The shorter slightly curly undercoat grew approximately 3 inches long. The hairs on the domed head of the mammoth were short, but longer on the underside and the sides of the trunk of the mammoth. The tail was extended by very coarse hairs up to 2 ft. long, which were thicker than the guard hairs. It is likely that the woolly mammoth molted seasonally and that the heaviest fur was shed during spring. Since mammoth carcasses were more likely to be preserved during autumn, it is possible that only the winter coat has been preserved in frozen specimens. Comparison between the overhairs of woolly mammoths and modern elephants shows that they did not differ much although mammoths had numerous glands in their skin, which secreted oils into their hair, which improved insulation, repelled water, and likely provided the fur with a glossy sheen.

Other genetic adaptations to the cold weather included small ears and a small tail, which prevented them from freezing. The smaller area of the ears and tail reduced heat loss in these organs and prevented the formation of frostbite. The ears of the woolly mammoth were far smaller than those of modern elephants ranging in size from approximately 15 inches long to 9 inches across (38–23 cm) in comparison with approximately 3.5 ft. (1 m) long and 2.5 ft. (0.75 m) across for the African elephant. The tail of the woolly mammoth contained only 21 vertebrae (bones) in comparison with approximately 28–33 vertebrae in the tails of modern elephants. The length of the tail was extended up to approximately 2 ft. by very thick and coarse hairs. The tail could function as a fly swatter, just as in modern elephants. Woolly mammoths also had broad flaps of skin under their tails, which covered the anus, a feature common to modern elephants as well.

The word "proboscis" from which the order name of "Proboscidea" is derived means long flexible snout, and the mature male woolly mammoth could have a snout up to about 17 ft. long (5.2 m). Woolly mammoths also had very long curved tusks that were used for protection, interspecies dominance, and digging for food. The largest known male tusk found is 14 ft. long and weighs approximately 200 pounds. About one-fourth the length of the tusk grew inside the skull of the woolly mammoth. The tusks grew spirally in opposite directions continuing to grow in a curved pattern until the opposite tusk tips pointed toward each other. The tusks grew anywhere from 1 to 6 inches each year depending on the age of the mammoth, and tusk growth occurred more slowly on older adults. Both males and females had tusks, but the female tusk was much smaller in comparison at approximately 5.5 ft. long (1.7 m) and weighing about 20 pounds (9 kg). The typical weight of an adult male tusk was approximately 100 pounds (45 kg). The tusks of males were much larger than females, thus serving also as a secondary sexual characteristic to fend off sexual competitors and attract potential mates. At approximately six months old, baby mammoths developed very small milk tusks that were only a few centimeters long, which were later replaced by a new tusk. It has been discovered that woolly mammoth mothers in the far north prehistoric Alaska and Yukon Territories may have nursed their babies for up to three winters, according to a recent study where fossil teeth were analyzed. It is believed that extended lactation was a northern adaptation to ensure survival of the babies during long, dark Arctic winters when it was difficult to find food. The woolly mammoth also had four very large molar teeth that could grow back up to six times during their lifetime. Mammoths used their molar teeth to grind grasses, sedges, and other vegetation that they could find as a food source for survival in a harsh climate. Further investigation and analysis of the contents in the intestinal track of some adult woolly mammoth carcasses that have been found revealed that they even ate the poop of other mammoths. Woolly mammoths needed a varied diet to support their growth, like modern elephants. An adult male weighing 6,000 pounds (2,700 kg) would need approximately 400 pounds (180 kg) of vegetation each day and may have foraged up to 20 hours every day. Woolly mammoths could live as long as 60 years, especially if they had a good source of food as well as a healthy set of tusks and molars.

Scientists were able to determine that the woolly mammoth existed from 200,000 to 4,000 years ago, largely becoming extinct during the end of the Pleistocene, 10,000 years ago. Isolated populations of woolly mammoths were known to survive on Wrangel Island, Alaska, until 4,000 years ago, but these animals were considered dwarfs in comparison based on their smaller size. Dwarfism is known to be a trait of some species that have lived in isolation for several generations. People were able to learn much about the behavior and appearance of woolly mammoths based on the research of many scientists over the years who have examined ancient artifacts, prehistoric cave drawings, and frozen woolly mammoths found in Siberia and Alaska. Cultures had known of the remains of woolly mammoths long before Europeans began to discover, classify, and examine them using science and the scientific method. Early humans hunted the woolly mammoth, and it can be argued that the mammoth hunt played an essential role in teaching people about the importance of cooperation, leadership, teamwork, and nonconflict for survival. These lessons were especially important during the Paleolithic where major changes in both the geography and climate of earth were respected and known to have a direct impact on human society and the ways of life. Currently, there are four theories that are being used to explain the reason for the extinction of woolly mammoths approximately 11,000 years ago: (1) dramatic climate change that affected food source; (2) overhunting by humans; (3) extended lactation due to climate change; (4) new diseases introduced by humans and animals who crossed the Bering Strait, and (5) Meteorite impact. The most commonly accepted theory for the extinction of the woolly mammoth is climate change. As Arctic ice has continued to melt at an exponential rate in comparison with previous years, more woolly mammoths are being discovered including the first ever recorded ginger-colored baby woolly mammoth.

Karen Knaus

See also: Woolly Mammoths, Baby; Yukaghir Mammoth

Further Reading

Fisher, D., A. Tikhonov, P. Kosintsev, A. Rountrey, B. Buigues, and J. Van Der Plicht. "Anatomy, Death, and Preservation of a Woolly Mammoth (*Mammuthus primigenius*) Calf, Yamal Peninsula, Northwest Siberia." *Quaternary International* 255 (2012): 94.

O'Harra, D. "Woolly Mammoths Nursed Babies through Long Winters—And It May Have Wiped Them Out." *Alaska Dispatch*, 2010. http://www.alaskadispatch.com/article/woolly-mammoths-nursed-babies-through-long-winters-and-it-may-have-wiped-them-out.

Salsberg, C. *Resurrecting the Woolly Mammoth: Science, Law, Ethics, Politics, and Religion.* Stanford, CA: Stanford Technology Law Review, 2000.

Workman, C., L. Dalen, S. Vartanyan, B. Shapiro, P. Kosintsev, A. Sher, A. Gotherstrom, and I. Barnes. "Population-Level Genotyping of Coat Colour Polymorphism in Woolly Mammoth (*Mammuthus primigenius*)." *Quaternary Science Reviews* 30, nos. 17–18 (2010): 2304.

Woolly Mammoths, Baby

Among a number of adult woolly mammoths found in Arctic regions, baby mammoths have also been discovered. The first known woolly mammoth juvenile was retrieved from a stream named "Dima" located near the Russian town of Magadan. Likely, the baby was named "Dima" after the stream in which it was found. Scientists were able to determine the juvenile was between six months and one year when it died. By examining Dima's body and the contents of its stomach, they were also able to determine that shortly before Dima died, it must have stumbled behind the herd, hurt his leg, fallen into a pit of water and mud where he later drowned, and froze in the ice.

"Lyuba," a baby female mammoth, was discovered by a Siberian reindeer herder on the banks of the Yuribei River in May 2007. Lyuba was just one month old when she died about 40,000 years ago. Although her woolly coat was gone when she was discovered, her skin and internal organs were immaculately preserved. Scientists identified milk in Lyaba's stomach as well as fecal matter in her intestines, which they think she may have been eaten to promote the development of intestinal microbes necessary for digestion of vegetation, similar to other elephants.

An isotope analysis of the contents of the stomachs and intestines of other baby woolly mammoths found in Yukon, Canada, showed that babies nursed for at least three years and were weaned and gradually shifted to a diet of plants from the age of two to three years. Other studies of preserved mammoth calves revealed that they were all born during spring and summer. Examination of the teeth of baby woolly mammoths found in far northern Arctic regions indicated prolonged periods of nursing in comparison with modern elephants, which some believe was a direct result of climate change.

The carcass of a baby mammoth is examined in the Arctic city of Salekhard in July 2007. (NTV, Russian Television Channel/AP Photo)

The woolly mammoth was well adapted to live in harsh Arctic climates, but the threat of warming temperatures may have led to increased migration to farther northern regions where a higher risk of predator attacks and greater difficulty in obtaining food was experienced, especially during the longer periods of winter darkness at higher latitudes. Ironically, as we experience the threat of global warming and climate change, more baby mammoths are being discovered in Arctic regions including Yuka, who was found along the Laptev Sea located on the coast of the Arctic Ocean, the first recorded ginger-colored baby woolly mammoth.

Karen Knaus

See also: Woolly Mammoths; Yukaghir Mammoth

Further Reading

Gross, L. "Reading the Evolutionary History of the Woolly Mammoth in Its Mitochondrial Genome." *PLoS Biology* 4, no. 3 (2006): e74.

Guthrie, R. *Frozen Fauna of the Mammoth Steppe.* Chicago: University of Chicago Press, 1990.

Pfizenmayer, E. *Siberian Man and Mammoth.* London: Blackie and Son, 1939.

Sutcliffe, A. *On the Track of the Ice Age Mammals.* Cambridge, MA: Harvard University Press, 1985.

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Y

Yana River. *See* Khatanga, Lena, and Yana Rivers

Yenisey River. *See* Ob, Pechora, and Yenisey Rivers

Yukaghir

The Yukaghir (sometimes spelled Yukagir) live in the coldest part of the inhabited world where the temperature plummets below −76°F (−60°C). At present, there are two larger communities (Tundra and Kolyma Yukaghir) left, living hundreds of kilometers apart from each other in the northeastern part of the Republic of Sakha (Yakutia), Russia.

The present population estimate for the Yukaghir is about 1,600. The Northern or Tundra Yukaghir inhabit the forest-tundra and tundra zone, being concentrated mainly in Andryushkino Village on the Alazeya River (197 Yukaghir in 2002). This is a multinational and multilingual village where Eveny and Yakuts are more numerous than Yukaghir who constitute less than a quarter of the local population. Most Southern or Kolyma Yukaghir live over 400 kilometers further south in Nelemnoe Village, which is situated on a tributary of the Kolyma River called Yasachnaya. This is the most compact Yukaghir settlement where more than half of the population identifies itself as Yukaghir (181 out of 281 in 2002). Smaller numbers of Yukaghir are scattered in various other settlements all over northeastern Siberia; a considerable number also lives in the regional center Yakutsk (136 Yukaghir in 2002).

The ethnonym "Yukaghir" is probably derived from the Eveny language, meaning "frozen people." When speaking in Yukaghir, the Kolyma Yukaghir call themselves *odul* and the Tundra Yukaghir *wadul*, both meaning "strong." The common Yukaghir identity in the two communities is weak despite the efforts of Yukaghir activists to promote it.

Language

The Kolyma and Tundra Yukaghir languages are mutually incomprehensible. Most linguists describe two Yukaghir languages as a genetically isolated language group while some affiliate these languages with the Uralic family. Today, these are spoken, or passively known, by the eldest members of the communities, making it one of the most endangered languages in the region. In the census of 2010, more than 300 Yukaghir declared that they had some command of Yukaghir (treated as one language in the census). Nevertheless, the situation varies greatly in different regions in terms of the actual command and the usage. While around 60 Tundra Yukaghir in the Andryushkino tundra use to some extent their ancestral language, only a few elderly people in the Upper Kolyma region are fluent in Kolyma Yukaghir. Tundra Yukaghir has slightly better survived because the language is spoken in reindeer herding families living in remote areas. In all, the language shift has been more or less complete as today the vast majority of the Yukaghir speak Russian as their first language. Although Kolyma Yukaghir knew Russian already in the nineteenth century, it became dominant language in the 1960s because of the systematic Sovietization, mainly through the boarding school system. In some other areas, the first language used is Yakut (e.g., Andryushkino), which is the largest regional language. In the older polyglot generation, there are Yukaghir who know several languages including Eveny and Chukchi. The Yukaghir languages are taught as a foreign language in Nelemnoe and Andryushkino. Although the school lessons seem to reinforce the sense of ethnic belonging, they do not turn the youth into Yukaghir-speakers.

History and Subsistence

Historians argue that the Yukaghir ancestors inhabited the present-day Yakutia earlier than other ethnic groups we know today in the region. In the seventeenth century, the Yukaghir populated the vast areas from the Lena River in the west to the Anadyr River in the east, probably numbering around 5,000. From the seventeenth until the early twentieth century, their number and territory underwent one of the quickest declines among the Siberian indigenous peoples (compare with the Enets). This took place because of various factors. On the one hand, neighboring ethnic groups, Eveny and Yakut, came to the area and assimilated the Yukaghir already before the Russian colonization. On the other hand, Russian Cossacks put on colonial pressure, especially through taxation, which led to frequent periods of famine, and by using Yukaghir as auxiliary soldiers in their war campaigns against other indigenous groups (especially Chukchi). In addition, smallpox and measles that Russians brought with themselves killed numerous indigenous families in the region.

Over the past centuries, different Yukaghir groups developed diverse subsistence patterns. The Southern Yukaghir remained hunters and fishermen whose only domestic animal was dog, also used as a draft animal. The main game in the region was elk and wild reindeer; hunting fur animals like sables was important in trade and tax relations with Russians. The Northern Yukaghir adopted from the Eveny small-scale reindeer herding, which offered extensive mobility for fishing and hunting, especially for wild reindeer. As almost every indigenous reindeer herder, hunter, or fisherman in the Soviet Union, the Yukaghir were forced into collective farms in the 1930s. Since then they had to fulfill plans by hunting a set number of sables in the forest or to increase the production of reindeer meat in the tundra. From the 1960s onward, Yukaghir worked in the multiethnic state farms as wage workers. Since the 1990s, with the collapse of the Soviet economic regime based on subsidies and centralized distribution of necessities, many Yukaghir have been forced to return to a subsistence-based way of life. As a result, most men in Nelemnoe are engaged in hunting for big game like elk to feed their families. Women work in the villages, for example, as teachers or other state-paid workers. Like among many other Siberian groups, there has been a nominal growth of Yukaghir population during the past decades. This refers to the fact that even if a person is of mixed ethnic background, it is profitable to be indigenous because of various subsidies and privileges (e.g., fishing and hunting).

Religion

The Yukaghir living in the forest and tundra are animists who attribute particular importance to human–animal relations. Forest hunters attribute great significance to the spirits who are said to own the game animals. If hunters behave according to the proper rules, the spirits are expected to give the prey animals as food to the hunters. Like many other Siberian hunting cultures, Yukaghir follow special prescriptions after killing a bear who is believed to occupy a particular place among animals and spirits. Using some deceptive techniques, the hunters demonstrate that the bear should not blame them for its death; otherwise the bear might seek revenge. Although since the 1970s there are no practicing shamans anymore among the Yukaghir, due to the negative impact of the Orthodox Church's and Soviet state's policies, shamanic abilities are said to be manifested in ordinary people. At the same time, the dead shamans are today known to be as extremely dangerous agents who should not even be talked about (e.g., in the eighteenth century, their bodies were cut into pieces and used as amulets in a kin group). Between the eighteenth and early twentieth centuries, Russian Orthodox missionaries managed to introduce some elements of Christianity like appealing to Jesus or saints or carrying neck crosses without altering much the earlier structural understanding of the spirit realm.

Laur Vallikivi

See also: Chukchi; Dolgans; Enets; Eskimos; Evenks; Evens; Eyak; Inuit; Ket; Khanty; Koryak; Mansi; Nenets; Nganasan; Sami; Selkup

Further Reading

Nikolaeva, I., and T. Mayer. "Online Documentation of Kolyma Yukaghir." Suomalais-Ugrilainen Seura (Finno-Ugrian Society, Société Finno-Ougrienne), 2004.

Vaba, L. "The Yukaghirs." In *The Red Book of the Peoples of the Russian Empire.* NGO Red Book, 1991. http://www.eki.ee/books/redbook/introduction.shtml.

Yukaghir Mammoth

Scientists have been able to learn many things about frozen animals that have been found in Arctic regions. For example, in 2002, a frozen elderly adult male woolly mammoth that lived in the Arctic tundra approximately 22,000 years ago was found in a Siberian village known as Yukaghir. The frozen mammoth found was later named the "Yukaghir mammoth." Arctic permafrost preserved the head, tusks, front legs, stomach, and intestinal tract of the animal that contained both digested and undigested food artifacts. Contents of the mammoth's stomach and poop found in the intestinal tract have been studied by scientists including paleoecologists and other mammoth experts. Some of the results of their studies were published and shared in an article with a comical and perhaps sarcastic title involving a play of words, "Mammoth Mystery: A Mammoth Waste of Time" by Peter Tyson on the Public Broadcasting System NOVA ScienceNow Web site.

Mammoth experts were able to examine the mammoth's very large bones and tusks to determine that it stood more than 9 ft. tall and weighed between 4,000 and 5,000 pounds (1,800–2,300 kg) when it roamed the Arctic tundra 22 millennia ago. In addition, research investigations on the feces or poop of the mammal revealed information about its diet, habitat, and climate. The majority components of the mammoth's diet included grasses, sedges, and rushes that come from the Poaceae family of true grasses, which are flowering plants. A scientific method for determining the age of carbon-containing specimens known as "radiocarbon dating" was used to analyze the plants found in the mammoth poop and confirmed that they came from the Pleistocene. The Pleistocene ice age was an important period of time involving extremely cold weather conditions where the earth experienced repeated glaciations (repeated times of being frozen over), that took place between 2,588,000 and 11,700 years ago. The woolly mammoth and other extinct mega fauna such as the giant sloth, *Megatherium*, giant polar bear, *Ursus maritimus tyrannus*, saber-toothed cat, and *Smilodon* lived on the earth during the Pleistocene.

Some other plant materials found in the dung of the mammoth included grass seeds, willow leaves, twigs, shrubs, moss, sage pollen, pond algae, and dung-inhabiting fungus. It is quite likely that the extreme weather conditions experienced by the Yukaghir mammoth between growing seasons in the Arctic tundra led them to eat waste of other mammoths to supplement their diet with nutrients for survival. The scientists discovered fruit bodies in the fungus that are present only in poop that has been exposed to air for approximately one week. In addition, the scientists found no bile acids in the poop. The absence of bile acids in feces occurs only in certain mammals including, elephants, hyraxes, and manatees. These two scientific facts (i.e., presence of fruit bodies in poop fungus and no bile acids in the poop) allowed scientists to infer that the Yukaghir mammoth most likely ate week-old poop from another mammoth.

The research team was unable to determine exactly what caused the death of the Yukaghir woolly mammoth, but their large molar teeth were extremely worn down, which provided further evidence that they were malnourished. In their 2008 paper, the scientists wrote, "the start of the growing season might have come too late for this animal. Lying down in a sheltered hollow, he died, and became covered with a thick mud layer that . . . subsequently froze and preserved part of him." People from all walks of life continue to be fascinated with stories and facts of survival in Arctic regions especially during extreme weather conditions including the last ice age on earth.

Karen Knaus

See also: Woolly Mammoths; Woolly Mammoths, Baby

Further Reading

Tyson, P. *Mammoth Mystery: A Mammoth Waste of Time.* Published by PBS on the NOVA ScienceNow website, 2008.

van Geel, B., et al. "The Ecological Implications of a Yakutian Mammoth's Last Meal." *Quaternary Research* 69 (2008): 361–76, University of Amsterdam.

Zurita, E., A. Carlini, G. Scillato-Yané, and E. Tonni. "Mamíferos extintos del Cuaternario de la Provincia del Chaco (Argentina) y su relación con aquéllos del este de la región pampeana y de Chile." *Revista geológica de Chile* 31, no. 1 (2004): 65–87.

Yukon River

The Yukon River Watershed is one of 12 major river systems that organize Alaska's 3,000 rivers. The majestic Yukon River is a key geographic, economic, and cultural feature of the Arctic and subarctic Northwest America. In the past, the Yukon River boasted the largest stocks of migrating runs of Chinook (king), Coho (silver), and Chum (pink) salmon in the world. The source of Alaska's largest river is in British Columbia, Canada; it bisects Canada's Yukon Territory and Alaska before emptying an estimated 1.9 million gallons of water per second into the Bering Sea, south of Norton Sound, at the Yukon-Kuskokwin Delta. The Yukon's drainage is approximately 321,500 square miles, and it drains about one-third of Alaska, including major rivers such as the Tanana and Koyukuk. The Great River as it is called in the Athabaskan language is roughly 1,980 miles long with many rural communities scattered along its shores. For the king salmon, the Yukon is one of the longest fish migrations in the world. As the longest river in Alaska and the Yukon Territory, it served as a principal means of transportation during the early part of the twentieth century and remains a major transportation corridor for interior Alaskans, Canadians, and tourists.

There is a long-standing relationship between the Athabaskan, Inupiaq, and Yup'ik people living along the Yukon and the river's salmon. Hunter-gatherers along the river have been harvesting king salmon for more than 8,000 years. The salmon fishery has been important to the ecological integrity and cultural traditions; even today, human activity along the river continues to focus around salmon. The river flows through parklands and refuges in both Alaska and Canada traversing diverse ecosystems such as boreal forest and tundra. There are no dams along the river and only one car ferry at Dawson City, Canada. There are now a total of four vehicle bridges: one crossing the Alaska Highway; one crossing the Klondike Highway; one crossing the Dalton Highway; and one crossing the Whitehorse.

The Yukon is the fifth largest river in North America and the third largest in the United States. While generally considered pristine, the Yukon has had a legacy of pollution from mining and military development. As the extraction and processing of metals, coal, oil, and natural gas increases, water quality is at risk for degradation by contaminant release into the watershed. Several tribal organizations along the river work to sustain the Yukon River salmon fishing in partnership with state, provincial, and international treaties and laws. The Yukon River Inter-Tribal Watershed Council is a cooperative network of First Nations and tribes in Alaska and Canada whose goal is to maintain the river as a source of drinking water and healthy salmon, and to monitor governmental agencies' management of the river.

Today, pollution enters the river also by global transport from other regions, especially Asia with its recent energy and economic development. Industrially created persistent organic chemicals and metals like lead and mercury are being reported both in Arctic water and related food sources, such as salmon.

Yukon River communities tend to be on the north side of the Yukon River, and residents typically live a subsistence lifestyle while maintaining traditional, cultural, and spiritual values. People along the river use fish wheels and set nets to harvest the salmon. In the 1990s, the use of drift nets increased on the lower Yukon, and coupled with climate change and stock management mistakes, returning king salmon harvest decreased on the Upper Yukon in both Alaska and Canada.

As commercial fishing groups increased their political pressure on management, salmon declines continued. The number of fish and the quality of those fish continue to decline. Currently, the Yukon River fishery is caught in the middle between politics and science, as regulators are tasked with managing a complex social, economic, and ecological system. Having lost key fisheries in the lower latitudes, the Yukon River, with its cultural and spiritual connection to the people and the land, has become a focus of understanding how to maintain a resilient system during rapid environmental and economic change. Besides commercial downriver interests and upper river subsistence users, there are multiple political stakeholders.

The U.S. and Canadian governments are tasked by various laws and treaties since the Yukon River runs through state, provincial, and national lands. The salmon cross many jurisdictional boundaries that even use different definitions of fisheries. The Yukon River Salmon Agreement was added to the Pacific Salmon Treaty after 17 years of negotiation. The Yukon River, which has sustained many Arctic people for thousands of years, is seriously threatened.

Lawrence K. Duffy

See also: Arctic Salmon; Colville River; Gwich'in

Further Reading

Hinck, Jo Ellen, et al. "Environmental Contaminants in Fish and Their Associated Risk to Piscivorous Wildlife in the Yukon River Basin, Alaska." *Archives of Environmental Contamination and Toxicology* 51, no. 4 (2006): 661–72.

O'Neill, D. "The Fall of the Yukon Kings." In *Arctic Voices: Resistance and the Tipping Point.* New York: Seven Stories Press, 2012, pp 142–64.

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Zackenberg Research Station

The Zackenberg Research Station (74° 30′N 20° 30′W) is situated in the central Northeast Greenland. The station is located near a small 1,500 ft. (450 m) runway built to facilitate transport to the station. It consists of six wooden houses with a total area of 2,900 sq. ft. (275 sq. m). The houses hold mess and kitchen; different laboratories; offices for scientists, for monitoring program staff, and for logisticians; bathing facilities; and storage room for provisions and bedrooms for the staff. Visiting scientists and staff staying at the station for shorter periods are accommodated in insulated tents, Weatherhaven shelters.

A new accommodation building and a house with garage, workshop, and room for generators are added to the station later. Transport to/from Zackenberg is carried out by chartered short takeoff landing aircrafts via island. The terrestrial monitoring and research area comprises the 198 square miles (512 sq. km) drainage basin of the Zackenbergelven River, while marine monitoring is carried out in the adjoining fjord Young Sound. The study area is mountainous with several peaks reaching 3,300–4,600 ft. (1,000–1,400 m). The lowland consists of a 1.25–1.86 mile (2–3 km) wide valley with the 88-foot (27-m) deep lake Store Sø situated about 10 miles (15 km) from the station. To the west, the valley penetrates to the AP Olsen Land Ice Cap. The Zackenberg area is divided by a fault zone separating areas with Cretaceous and Tertiary sandstones topped by basalts above 2,000 ft. (600 m) above sea level to the east from Caledonian gneissic and granite bedrock to the west. The plant communities consist of Dryas heath, Cassiope heath, Salix snowbed, grassland, and fen. Vegetation covers approximately 80 percent of the area below 980 ft. (300 m) above sea level. The climate is High Arctic with an average annual temperature of 18°F (−7.8°C) and a precipitation of around 1 inch (2.61 cm), whereof approximately 85 percent is solid. Permafrost reaches down to 980 ft. (300 m), and the annual maximum depth of the active layer varies between 40 and 90 cm in most years. During the 1930s, trappers used the area, mainly for Arctic fox pelts. The Danish Peary Land Expeditions (1947–1950) and the British North Greenland Expedition (1952–1954) have used the fine conditions at Zackenberg as base.

When the Danish Polar Center was established in 1989, the establishment of a permanent monitoring and research facility in High Arctic Greenland became a core target. Most of High Arctic areas in Greenland are protected within the National Park of North and East Greenland, which is classified as a Man and Biosphere

Reserve with specific obligations for monitoring and research. In 1991, an expedition was organized to survey the area for suitable sites for a research station. The expedition pointed at the Zackenberg valley as the most appropriate site. The station was built and was active in 1995. The basic idea is to carry out long-term monitoring research at drainage basin scale covering both physical and biological aspects of ecology to track trends and causes to changes. The monitoring is carried out by Zackenberg Ecological Research Operations; it is organized in coordinated elements: ClimateBasis, GeoBasis, BioBasis, and MarineBasis. An annual report including collected basic data and summaries of ongoing research is published. A summary of research results is published in *Advances in Ecological Research* Vol. 40 (2008).

Bent Hasholt

See also: Arctic and Antarctic Research Institute (AARI); Greenland; Weddell #1 Antarctic Drifting Station

Further Reading

Andersson, T., J. Böcher, B. Fredskild, B. H. Jakobsen, H. Meltofte, G. S. Mogensen, and B. Muus. *Rapport om muligheden for placering af en naturvidenskabelig forskningsstation ved Zackenberg, Nationalparken i Nord- og Østgrønland.* Copenhagen, Denmark: University of Copenhagen and Danish Polar Center, 1991, p. 48.

Høye, T., and D. Sikes. "Arctic Entomology in the 21st century." *Canadian Entomology* 145 (2013): 125–30.

Zhongshan (Sun Yat-sen) Station

One of China's two permanent research stations in Antarctica, located on the Larsemann Hills of Princess Elizabeth Land (East Antarctica, in the Australian-claimed sector) at 69º 22′S 76º 22′E, is named after the British-educated revolutionary considered to be the father of modern China.

Scientists at the station conduct research all year-round in, among others, the fields of meteorology (including the study of the ionosphere and of upper atmosphere physics), geomagnetism, sea ice, and seismology. In addition, during the summer season, research is also conducted on geology, biology, medicine, marine science, polar physics, glaciology, and the environment. The station is also active in the fields of lake deposits, and ozone and ultraviolet radiation observation.

The station was opened on February 26, 1989, by the Fifth Chinese Antarctic Research Expedition (CHINARE), in an area located within the Antarctic Circle and along the southeast coast of Prydz Bay, where the polar night lasts 58 days and temperatures drop up to −33.6ºC. Two other research stations are located nearby: Australia's Law Base and Russia's Progress Station. It consists of 15 buildings, with a total area of 29,000 sq. ft. (2,700 sq. m) providing accommodation (two living quarters), office space, and research and recreation facilities, together with sewage and a rubbish treatment system. Seven special observation huts cater to the different scientific programs conducted. The station's capacity is 60 personnel in the summer and 25 in the winter, with 14 vehicles at their disposal. Electrical supply comes from four diesel generators, and medical facilities allow small surgical procedures to be carried out. Communications rely on two 1.6 kw single sideband transmitter and full-waveband receiver sets, plus a maritime satellite terminal.

The scientific equipment available includes biological and geological laboratories, a meteorological observation field, and rooms devoted to solid tide observation, and seismic and geomagnetic absolute value observation. One of the buildings serves as an upper atmospheric physics observatory.

The Zhongshan Station is managed by the Polar Research Institute of China, the research arm of the Chinese Arctic and Antarctic Administration, under the State Oceanic Administration of China.

Zhongshan is the Mandarin Chinese pronunciation of Sun Yat-sen (1866–1925), considered to be the father of modern China. Trained as a doctor in Hong Kong, where he converted to Christianity, he decided to devote his life to the overthrow of the Manchu dynasty, traveling and living all over the world to raise funds and promote this cause. The 1911 Revolution resulted in the establishment of the Republic of China, with Sun Yat-sen briefly serving as its first president in the year after.

Alex Calvo

See also: Antarctic Programs and Research Stations/Bases

Further Reading

China Oceanic Information Network. "Zhongshan Station." http://www.coi.gov.cn/english/eoverview/ejd/jde.htm. Accessed February 14, 2013.

Chinese Arctic and Antarctic Administration. "Chinese Antarctic Zhongshan Station." http://www.chinare.gov.cn/en0/index.php?pid=stationsandst=zhongshan. Accessed February 14, 2013.

Dong, S. *Sun Yat-sen: The Man Who Changed China.* Hong Kong: Form Asia Books Limited, 2003.

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APPENDIX I: GLACIERS AROUND THE WORLD

Biafo Glacier is a retreating mountain glacier located in Pakistan (35° 41′N 75° 55′E). It stretches 39 miles (63 km) and is joined by the Hispar Glacier, which is 30 miles (49 km) in length resulting in the largest nonpolar region glacial system.

Furtwängler Glacier is a small retreating mountain glacier located near the summit of Mount Kilimanjaro in Tanzania (3° 4′S 37° 21′E). It covers an area of about 15 acres (6 hectares) and is 20 ft. thick (6 m).

Hubbard Glacier is an advancing glacier located in Alaska (60° 18′N 139° 22′W) stretching 76 miles (122 km) inland from Disenchantment Bay.

Jostedalsbreen Glacier is a retreating mountain glacier located in Norway (61° 42′N 6° 55′E). It is continental Europe's largest glacier covering an area of 188 square miles (487 sq. m) and 37 miles (60 km) in length.

Lambert Glacier is located in East Antarctica and is the world's largest and longest glacier. The glacier is 250 miles (400 km) in length and 60 miles (100 km) in width. The depth of the glacier is just more than 8,200 ft. (2,500 m) in some parts.

Pasterze Glacier is a retreating mountain glacier located in Austria (47° 5′N 12°43′E). It covers an area of 7.2 square miles (18.5 sq. m) and 8.4 miles (5.3 km) in length.

Perito Moreno Glacier is an advancing glacier located in Argentina (50° 29′S 73° 3′W) close to Los Glaciares National Park. It measures 19 miles (30 km) in length. It is part of the world's third largest freshwater reserve known as the Southern Patagonia Ice Field. The Southern Patagonia Ice Field is fed by 48 glaciers one of which is the Perito Moreno.

Siachen Glacier is a retreating glacier located in the Karakoram Range of the Himalaya Mountains (35° 25′N 77° 6′E) in the disputed Pakistan and Indian regions of Kashmir on the Indian side. The Karakoram is commonly called the "Third Pole." Siachen Glacier stretches 43 miles (70 km) making it the world's second-longest glacier outside of the polar regions.

Six Principal Toes of the Columbia Icefield are located in the Canada Rockies (52° 9′N 117° 18′W). The six toes are the Athabasca, Castleguard, Columbia, Dome, Stutfield, and Saskatchewan Glaciers.

Vatnajökull Glacier is a retreating ice cap located in Iceland (64° 24′N 16° 48′W). It covers an area of 3,100 square miles (8,100 sq. km) and has an average thickness of 1,300 ft. (400 m).

Andrew J. Hund

Appendix 2: Select Listing of Arctic Polar Expeditions

1496	Grigorii Istoma explores White Sea region
1497	D. Zaytsev and D. Ralev explore White Sea region following Grigorii Istoma's route
1553	Englishman Richard Chancellor explores White Sea region for Northeast Passage
1575–1577	Englishman Martin Frobisher explores for Northeast Passage and reaches Baffin Island
1579	**Danish Expedition**—John Allday fails to reach Greenland
1586–1588	**Northwest Passage Expedition**—Englishman John Davis explores Davis Strait-Baffin Bay region
1596–1597	Willem Barentsz leads Dutch expedition to locate Northwest Passage and discovers Spitsbergen
1605–1607	**Hans Køning Expeditions**—Three expeditions led by John Cunningham, Godske Lindenov, and Carsten Richardson seek to reestablish contact with the lost Norse colonies in Greenland
1610	K. Kurochkin leads expedition to the Yenesei River region
1610–1611	**Henry Hudson's Expedition**—Henry Hudson explores Hudson Bay region
1612–1613	**British Button Expedition**—Thomas Button explores Hudson Bay region for Northwest Passage
1615–1616	**William Baffin and Robert Bylot's Expeditions**—William Baffin and Robert Bylot explore the Davis Strait-Baffin Bay region
1619–1620	**Danish Expedition**—Jens Munk explores Hudson Bay region where all but three members of the expedition die; Danish government gives up looking for the Northwest Passage
1631	**Luke Foxe Expedition**—Luke Foxe explores Hudson Bay region for Northwest Passage

1631–1632	**Thomas James Expedition**—Thomas James concludes that Hudson Bay was not the Northwest Passage
1686–1687	**Bezvestnaya Expedition**—Explores the Taymyr Peninsula coast
1733–1743	Great Northern Expedition (or Second Kamchatka expedition)—Vitus Bering explores the North American coast
1715–1719	**James Knight's Expedition**—James Knight searches for Northwest Passages; all members of the expedition perish
1818	**Royal Navy Expedition**—David Buchan explores icepack
1818	**Royal Navy Expedition (or Ross First Arctic Expedition)**—John Ross explores Northwest Passage
1819	**Royal Navy Expedition**—William Edward Parry explores Northwest Passage
1827	**First Norwegian Expedition**—Baltazar M. Keilhau leads expedition
1827	**Royal Navy Expedition**—William Edward Parry explores Spitsbergen and reaches 82° 45′N
1829–1833	**Royal Navy Expedition**—John Ross explores Northwest Passage
1838–1840	**La Recherche Expedition**—Explores North Atlantic and Scandinavian Islands
1845	**Franklin's Lost Expedition**—John Franklin searches for Northwest Passage
1848	**Rae–Richardson Arctic Expedition**—John Richardson and John Rae search for Franklin (overland)
1850	**McClure Arctic Expedition**—Robert McClure searches for Franklin
1850–1851	**First Grinnell Expedition**—Edwin De Haven searches for Franklin
1852	**Edward Augustus Inglefield Expedition**—Inglefield searches for Franklin
1853–1855	**Second Grinnell Expedition**—Elisha Kent Kane searches for Franklin
1857–1859	**McClintock Arctic Expedition**—Francis Leopold M'Clintock searches for Franklin
1860–1861	**Isaac Israel Hayes Expedition**—Isaac Hayes's Farthest North expedition makes a disputed claim of reaching 81° 35′N

1860–1862	**Charles Francis Hall First Expedition**—Charles Hall searches for Franklin
1864–1869	**Charles Francis Hall Second Expedition**—Charles Hall's second search for Franklin
1868	**First German North Polar Expedition**—Carl Koldewey explores Eastern Greenland coast
1869–1870	**Second German North Polar Expedition**—Carl Koldewey's further exploration of Arctic region
1871–1873	**Polaris Expedition (or Charles Francis Hall Third Expedition)**—Charles Francis Hall's third scientific expedition ends in mutiny and the death of Hall
1872–1874	**Austro-Hungarian North Pole Expedition**—Karl Weyprecht discovers Franz-Josef Land
1875–1876	**British Arctic Expedition**—George Nares leads expedition trying to reach the North Pole
1878–1879	**Vega Expedition**—Adolf Erik Nordenskiöld searches for the Northeast Passage and becomes first to circumnavigate Eurasia
1879–1882	**USS *Jeannette* Expedition**—George De Long and George Melville search for the overdue Vega Expedition of Nordenskiöld
1881–1884	**Lady Franklin Bay Expedition (or International Polar Expedition)**—Adolphus Greely leads scientific and farthest North expedition
1888–1889	**Norwegian Expedition**—Fridtjof Nansen leads the first successful east to west inland ice crossing of the Greenland; Nordenskiöld had failed in 1883, and Peary had failed in 1886
1891–1892	**Peary Expedition to Greenland**—Robert Edwin Peary Sr. seeks to determine whether Greenland was an island
1893–1896	**Norwegian Expedition**—Fridtjof Nansen and Hjalmar Johansen attempt to reach the North Pole
1897	**S. A. Andrée's Arctic Balloon Expedition**—Salomon August Andrée's attempt to use an air balloon to reach the North Pole ends in the deaths of three crew members
1903–1906	**Amundsen's "Gjøa" Expedition**—Roald Amundsen becomes the first to cross the Northwest Passage
1905–1906	**North Pole Expedition**—Robert Peary's expedition claims to have reached 87° 06′N (disputed)

1906–1908	**Danmark Expedition**—Ludvig Mylius-Erichsen charts Greenland coast; expedition ends in the death of crew
1909–1912	**Alabama Expedition**—Ejnar Mikkelsen explores Northeast Greenland to recover bodies of the Danish crew from the Danmark Expedition
1908–1909	**Robert Peary Final Expedition**—Robert Peary claims to have reached the North Pole (disputed)
1910–1915	**Russian Arctic Ocean Hydrographic Expedition**—Explores for Northeast Passage
1912	**First Thule Expedition**—Knud Rasmussen and Peter Freuchen explore North Greenland
1912–1915	**Brusilov Expedition**—Georgy Brusilov explores Northeast Passage; expedition ends in tragedy
1913–1918	**Canadian Arctic Expedition**—Vilhjalmur Stefansson leads scientific expedition
1916–1919	**Second Thule Expedition**—Knud Rasmussen and Peter Freuchen explore North Greenland for the second time
1918–1925	**Northwest Passage Expedition**—Roald Amundsen crosses the Northwest Passage
1919	**Third Thule Expedition**—Knud Rasmussen leads a third exploration of Greenland
1919–1920	**Fourth Thule Expedition**—Knud Rasmussen leads a fourth exploration of Greenland
1921–1924	**Fifth Thule Expedition**—Knud Rasmussen leads a fifth exploration of Greenland
1926	**Byrd and Bennett North Pole Fly Over**—Richard E. Byrd and Floyd Bennett claim to have flown over the North Pole (disputed)
1926	**Norge Expedition**—Roald Amundsen, Umberto Nobile, and Lincoln Ellsworth make the first confirmed North Pole overflight
1930	**Bratvaag Expedition**—Expedition finds the remains of the Salomon August Andrée expedition of 1897
1931	**Sixth Thule Expedition**—Knud Rasmussen leads a sixth exploration of Greenland
1938–present	**Soviet and Russian Manned Drifting Ice Stations**—Called North Pole with 40 different drifting stations

1952–1954	**British North Greenland Expedition**—James Simpson leads scientific expedition
1994–1996	**Arctic Environmental Research Expedition**—Kenji Yoshikawa leads expedition
2007	**Arktika 2007**—Russian submersible reaches North Pole ocean floor
2008	**Marine Live-Ice Automobile Expedition (MLAE)**—Arctic vehicle expeditions explore various regions (later expeditions are launched in 2009, 2011, and 2013)

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Appendix 3: Select Listing of Antarctic Polar Expeditions

1675	Anthony de la Roché discovers Antarctic Convergence
1734–1737:	**First French Antarctica Expedition**—Yves-Joseph de Kerguelen-Trémarec and Jean Guillaume Bruguière search for Terra Australis
1772–1775:	Captain James Cook searches for Terra Australis and crosses the Antarctic Circle to 71° 10′S (furthest south)
1819–1821:	Fabian Gottlieb von Bellingshausen discovers Fimbul Ice Shelf
1820:	Edward Bransfield makes first recorded sighting of Antarctic Peninsula
1821:	John Davis sets foot on Antarctica (disputed claim)
1823–1824:	James Weddell discovers Weddell Sea and reaches furthest south of 74°15′S
1830–1833:	**Southern Ocean Expedition**—John Biscoe circumnavigates Antarctica and goes ashore on Anvers Island
1837–1840:	**Second French Antarctica Expedition**—Jules Dumont d'Urville discovers Adelie Land and goes ashore on the Geologie Archipelago
1838–1842:	**United States Exploring Expedition**—Charles Wilkes discovers Shackleton Ice Shelf (called at the time "Termination Barrier")
1839–1843:	**First British National Antarctic Expedition**—James Clark Ross discovers Victoria Land and Ross Sea region (e.g., Ross Ice Shelf (called the "Victoria Barrier" at the time) and Mounts Erebus and Terror) and reaches furthest south of 78° 10′S
1892–1893:	**First Norwegian Expedition**—Carl Anton Larsen (the first person to ski in Antarctica) discovers Larsen Ice Shelf, the Foyn Coast, King Oscar Land, and Robertson Island

1893–1895:	**Right Whale Expedition**—Henrik Johan Bull and Carsten Borchgrevink (Norwegian) and New Zealander Alexander von Tunzelmann are the first confirmed people to set foot on Antarctica at Cape Adare (this occurs in 1895, 74 years after John Davis is said to have landed in Antarctica)
1897–1899:	**Belgian Antarctic Expedition**—Adrien de Gerlache leads first expedition to overwinter in Antarctica
1898–1900:	**Southern Cross Expedition**—Carsten Borchgrevink overwinters in Antarctica and reaches furthest south of 78° 50′S
1901–1903:	**Gauss Expedition (or First German Antarctic Expedition)**—Erich von Drygalski leads a scientific expedition to Heard Island
1901–1904:	**Swedish Antarctic Expedition**—Otto Nordenskjöld and Carl Anton Larsen lead scientific expedition of the Antarctic Peninsula
1901–1904:	**Discovery Expedition (or the British National Antarctic Expedition of 1901–1904)**—Robert Falcon Scott leads scientific expedition of the Ross Sea region and reached furthest south of 82° 17′S
1902–1904:	**Scottish National Antarctic Expedition**—William Speirs Bruce leads Antarctic scientific expedition
1903–1905:	**Third French Antarctic Expedition**—Jean-Baptiste Charcot explores the west coast of Graham Land
1907–1909:	**Nimrod Expedition (or the British Antarctic Expedition of 1907–1909)**—Ernest Shackleton reaches farthest south 88° 23′S and the South Magnetic Pole
1910–1912:	**Japanese Antarctic Expedition**—Nobu Shirase explores the Ross Sea region
1910–1912:	**Roald Amundsen's South Pole Expedition**—Roald Amundsen reaches the geographic South Pole (90° S) on December 14, 1911
1910–1913:	**Terra Nova Expedition (or British Antarctic Expedition)**—Robert Falcon Scott reaches the geographic South Pole (90° S) on January 17, 1912, 33 days after Roald Amundsen's party. All members of this party died on the return trip.
1911–1913:	**Second German Antarctic Expedition**—Wilhelm Filchner explores the Weddell Sea and discovers the Luitpold Coast and the Filchner-Ronne Ice Shelf

1911–1914:	**Australasian Antarctic Expedition**—Douglas Mawson charts 2,000 miles of Antarctic coastline
1914–1916:	**Endurance Expedition (or Imperial Trans-Antarctic Expedition)**—Ernest Shackleton fails in his attempt to make a 1,800-mile (2,900 km) journey across the Antarctic continent from the Weddell Sea to the Ross Sea
1914–1917:	**Ross Sea Party**—Aeneas Mackintosh and the Ross Sea party lay out a supply line for Endurance Expedition
1920–1922:	**British Graham Land Expedition**—John Lachlan Cope leads an expedition to Graham Land
1921–1922:	**Shackleton–Rowett Expedition**—The last expedition of the Heroic Age of Antarctic Exploration, it had the vague goals of exploring, surveying, and mapping the Antarctic coastline (Ernest Shackleton died of heart failure during the expedition)
1929–1931:	**British Australian and New Zealand Antarctic Research Expedition (BANZARE)**—Douglas Mawson leads scientific and political expedition (claiming Antarctic land) over two Austral summers
1928–1930:	**First Expedition of Richard Evelyn Byrd**—Richard Evelyn Byrd constructs a base camp on Ross Ice Shelf called "Little America" and conducts scientific expeditions by various means (e.g., snowshoe, sledge, snowmobile, and airplane)
1933–1935:	**Second Expedition of Richard Evelyn Byrd**—In 1934, Byrd spends five months alone in meteorological station
1933–1939:	Lincoln Ellsworth leads an aircraft expedition that covers 2,500 miles of Antarctica
1934–1937:	**British Graham Land Expedition**—John Riddoch Rymill leads a geophysical exploration of Graham Land
1938:	**Third German Antarctic Expedition**—Alfred Ritscher leads an expedition that claims New Swabia or Neuschwabenland for Nazi Germany
1939–1941:	**Third Expedition of Richard Evelyn Byrd (or United States Antarctic Service Expedition)**—Byrd's third scientific expedition
1943–1945:	**Operation Tabarin**—James Marr leads a British military operation to build the first base on Antarctica and establish a permanent British presence in Antarctica

1946–1946	**Operation Highjump**—Richard Evelyn Byrd leads a large U.S. military exploration and training expedition to Antarctic
1947	**First Chilean Antarctic Expedition**—Federico Guesalaga Toro conducts a Chilean government/military expedition to reinforce Chile's territorial claims against British claims and to establish Base General Bernardo O'Higgins Riquelme
1947–1948	**Operation Windmill**—Gerald Ketchum leads a second U.S. military exploration and training for Antarctic Expedition
1947–1948	**Ronne Antarctic Research Expedition**—Finn Ronne leads an expedition to the Weddell Sea region
1949–1952	Norwegian British Swedish Antarctic Expedition—John Giaever leads the first Antarctic expedition comprising a team of international scientists
1955–1956	**Operation Deep Freeze**—Richard Evelyn Byrd sets up three U.S. Antarctic bases at Bay of Whales, McMurdo Sound, and the South Pole
1955–1957	**First Soviet Antarctic Expedition**—Mikhail Somov establishes Soviet base Mirny and makes scientific observations. *Note:* Soviet Antarctic Expeditions occurred each year from 1955 to 1992 for a total of 36 Soviet Antarctic Expeditions named in numeric order.
1956–1958	**Commonwealth Trans-Antarctic Expedition**—Vivian Fuchs leads first overland crossing of Antarctica through the South Pole
1957–1958	**New Zealand Geological Survey Antarctic Expedition**—Expedition explores Ross Dependency. *Note:* This was the first of three New Zealand Geological Survey Antarctic Expeditions, with others occurring in 1958–1959 and 1969–1970.
1957–1958	**Luncke Expedition**—Bernhard Luncke leads Norwegian scientific and aerial photography expedition
1962	**Vostok Traverse**—A four-month 1,900-mile (3,000 km) trek across Antarctica by Australian National Antarctic Research Expeditions (ANARE)
1965	**Operation 90**—Colonel D. Jorge Leal leads the first Argentine expedition to the South Pole, where 10 Argentine

	soldiers become the first and only soldiers to perform military land maneuvers in Antarctica, which is forbidden under the Antarctic Treaty of 1959
1981–1982	**First Indian Expedition to Antarctica**—Dr. Sayed Zahoor Qasim leads an Indian exploration of Antarctica
1984–1985	**First Uruguayan Antarctic Expedition**—Antarkos I—Lieutenant Colonel Omar Porciúncula leads an expedition to establish a permanent base in Antarctica
1987–1988	**First Bulgarian Antarctic Expedition**—Establishes the Sofia University Refuge (now called the St. Kliment Ohridski Base)
1992–1993	**Antarctic Environmental Research Expedition**—Scientific expedition is led by Kenji Yoshikawa
2004–2005	**Chilean South Pole Expedition**—Exploration by the Chilean Navy
2007–2009	**Norwegian-U.S. Scientific Traverse of East Antarctica**—Scientific expedition studies climate change and includes two East Antarctica overland treks (one from Troll Station to the South Pole [2007/2008] and a second from the South Pole to Troll Station by an alternative route [2008/2009])
2011	Norwegian Christian Eide is the fastest person to go from the ocean (Hercules Inlet) to the Geographic South Pole. This unsupported journey takes 24 days and one hour.
2012:	Felicity Aston is the first women as well as the first person to solo ski across Antarctica. Her trek lasted 59 days and she skied 1,084 miles (1,744 km).
2013−2014	Expedition named "Spirit of Mawson," led by Professor Chris Turney, is designed to draw world attention to the effects of climate change on sea ice. His expedition was abandoned after the Russian vessel became ensnared in sea ice.

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Appendix 4: Northwest Passage Expeditions

John Cabot: 1497, 1498
Martin Frobisher: 1576, 1577, 1578
John Davis: 1585, 1586, 1587
Henry Hudson: 1607, 1608, 1609, 1610
Thomas Button: 1610–1611
William Baffin and Robert Bylot: 1615–1616
Jens Munk: 1619–1620
Luke Foxe: 1631
Thomas James: 1631–1632
James Knight: 1715–1719
Christopher Middleton: 1741–1742
William Moor: 1746–1747
Samuel Hearne: 1770–1772
James Cook: 1776–1780
Alexander Mackenzie: 1789
John Ross: 1818
William Edward Parry: 1819–1825
John Ross and James Clark Ross: 1829–1833
John Franklin: 1819–1822 and 1845–1848
Robert McClure: 1850–1854
Roald Amundsen: 1903–1906

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Select Bibliography

Books

Alexander, C. *The Endurance: Shackleton's Legendary Antarctic Expedition.* New York: Knopf, 1998.

Alexander, C. *Mrs. Chippy's Last Expedition: The Remarkable Journal of Shackleton's Polar-Bound Cat.* New York: Harper Perennial, 1999.

Amundsen, R. "*The North West Passage"; Being the Record of a Voyage of Exploration of the Ship "Gjöa" 1903–1907.* E.P. Dutton and Company, New York, 1908.

Amundsen, R. *The South Pole: An Account of the Norwegian Antarctic Expedition in the "Fram", 1910–12*. Edinburgh: Birlinn Ltd, 2003.

Arnesen, L., and A. Bancroft. *No Horizon Is So Far: Two Women and Their Extraordinary Journey across Antarctica*. New York: Da Capo Press, 2003.

Bargagli, R. *Antarctic Ecosystems: Environmental Contamination, Climate Change, and Human Impact.* New York: Springer, 2004.

Barrett, A. *Weird and Tragic Shores: The Story of Charles Francis Hall, Explorer.* New York: Modern Library, 2000.

Barry, R., and T. Gan. *The Global Cryosphere: Past, Present and Future*. Cambridge: Cambridge University Press, 2011.

Behredt, C. *Innocents on the Ice: A Memoir of Antarctic Exploration, 1957*. Boulder: University Press of Colorado, 1999.

Berton, P. *The Arctic Grail: The Quest for the Northwest Passage and the North Pole, 1818–1909.* Guilford, CT: The Lyons Press, 2000.

Bickel, L. *Mawson's Will: The Greatest Polar Survival Story Ever Written*. New York: Steerforth, 2000.

Bickel, L. *Shackletons Forgotten Men: The Untold Tale of an Antarctic Tragedy.* London: Pimlico, 2001.

Cherry-Garrard, A. *The Worst Journey in the World*. London: Constable and Co. Ltd., 1922.

Clancy, R. J., Manning, and H. Brolsma. *Mapping Antarctica: A Five Hundred Year Record of Discovery.* New York: Springer Praxis Books, 2013.

Committee on Principles of Environmental Stewardship for the Exploration and Study of Subglacial Environments, Polar Research Board, Division on Earth and Life Studies and National Research Council. *Exploration of Antarctic Subglacial Aquatic Environments: Environmental and Scientific Stewardship*. Washington, DC: National Academies Press, 2007.

Cook, J. *Blue Whale: Vanishing Leviathan*. New York: Dodd Mead and Co., 1973.

Cookman, S. *Ice Blink, The Tragic Fate of Sir John Franklin's Lost Polar Expedition.* New York: John Wiley and Sons, 2000.

Crane, D. *Scott of the Antarctic: A Life of Courage and Tragedy.* New York: Knopf, 2006.

Cyriax, R. *Sir John Franklin's Last Arctic Expedition.* London: Methuen and Company, Ltd., 1939.

Davis, N. *Aurora Watcher's Handbook.* Fairbanks: University of Alaska Press, 1992.

Dease, P. *From Barrow to Boothia*. Montreal: McGill-Queen's University Press, 2002

Ehrlich, G. *This Cold Heaven: Seven Seasons in Greenland*. New York: Vintage, 2003.

Emmerson, C. *The Future History of the Arctic.* New York: Public Affairs, 2010.

Fiennes, R. *Captain Scott.* London: Hodder Paperbacks, 2004.

Fiennes, R. *Mind over Matter: The Epic Crossing of the Antarctic Continent.* New York: Delacorte Press, 1994.

Flegg, J., E. Hosking, and D. Hosking. *Poles Apart: The Natural Worlds of the Arctic and Antarctic.* Brattleboro, VT: Stephen Greene Press, 1990.

Fleming, F. *Ninety Degrees North: The Quest for the North Pole by Fergus Fleming.* New York: Grove Press, 2003.

Florindo, F., and M. Siegert. *Antarctic Climate Evolution: Developments in Earth and Environmental Sciences*. Vol. 8. Elmont, NY: Elsevier Science, 2008.

George, D. *Glaciers*. Chicago: Regensteiner, 1986.

Green, C. *Polar Lands*. London: Boldley Head Ltd, 1984.

Harper, K. *Give Me My Father's Body: The Life of Minik, the New York Eskimo*. New York: Washington Square Press, 2001.

Hayes, D. *Historical Atlas of the Arctic.* Seattle: University of Washington Press, 2003.

Hempleman-Adams, D. *Walking on Thin Ice: In Pursuit of the North Pole.* London: Orion Publishing, 1999.

Henson, M. *A Negro Explorer at the North Pole*. Montpelier, VT: Invisible Cities Press, 2001.

Joyner, C., and E. Theis. *Eagle Over the Ice: The U.S. in the Antarctic.* Hanover, NH: University Press of New England, 1997.

Kerry, K., and G. Hempel. *Antarctic Ecosystems: Ecological Change and Conservation*. New York: Springer, 2012.

Kolbert, E., and F. Spufford. *The Ends of the Earth: An Anthology of the Finest Writing on the Arctic and the Antarctic.* New York: Bloomsbury, 2007.

Lambert, K. *Hell with a Capital H—an Epic Story of Antarctic Survival.* London: Pimlico, 2002.

Lansing, A. *Endurance: Shackleton's Incredible Voyage*. New York: Basic Books, 1999.

Larson, E. *An Empire of Ice: Scott, Shackleton, and the Heroic Age of Antarctic Science.* New Haven, CT: Yale University Press, 2011.

Legler, G. *On the Ice: An Intimate Portrait of Life at McMurdo Station, Antarctica.* Minneapolis: Milkweed Editions, 2005.

Levere, T. *Science and the Canadian Arctic: A Century of Exploration, 1818–1918.* Cambridge: Cambridge University Press, 2004.

Lewis, J. *The Mammoth Book of Antarctic Journeys*. New York: Running Press, 2012.

Loomis, C., and A. Barrett. *Weird and Tragic Shores: The Story of Charles Francis Hall, Explorer.* New York: Modern Library Exploration, 2000.

Lopez, B. *Arctic Dreams*. New York: Vintage, 2001.

MacPhee, R. *Race to the End: Amundsen, Scott, and the Attainment of the South Pole.* New York: Sterling Innovation, 2010.

Malaurie, J. *Ultima Thule: Explorers and Natives in the Polar North.* New York: W. W. Norton & Company, 2003.

Maurice, E. *The Last Gentleman Adventurer: Coming of Age in the Arctic*. Boston: Houghton Mifflin Harcourt, 2005.

Mawson, D. *Home of the Blizzard: A True Story of Antarctic Survival.* 3rd ed. Edinburgh: Birlinn Ltd., 2000.

McClintock, F. *A Narrative of the Discovery of the Fate of Sir John Franklin and His Companions: The Voyage of the "Fox" in the Arctic Seas*. Cambridge: Cambridge University Press, 2012.

McGoogan, K. *Fatal Passage: The True Story of John Rae, the Arctic Hero Time Forgot.* New York: Carroll & Graf, 2002.

McKinlay, W. *Karluk, The Great Untold Story of Arctic Exploration.* New York: St. Martin's Press, 1976.

McNair, M. *On Thin Ice: A Woman's Journey to the North Pole*. Nevis, MN: North Winds, 1999.

Murdoch, W., and W. Bruce. *From Edinburgh to the Antarctic: An Artist's Notes and Sketches during the Dundee Antarctic Expedition of 1892–1893*. Cambridge: Cambridge University Press, 2012.

Nansen, F. *Farthest North: The Epic Adventure of a Visionary Explorer, by Fridtjof Nansen*. Abridged ed. New York: Modern Library, 1999.

Nansen, F., and Lieut. Johansen. *Farthest North: Being the Record of a Voyage of Exploration of the Ship Fram 1893–96, and of a Fifteen months' Sleigh Journey by Dr. Nansen and Lieut. Johansen with an Appendix by Otto Sverdrup, Captain of the Fram.* 2 vols. London: Newnes, 1898.

Niven, J. *The Ice Master: The Doomed 1913 Voyage of the Karluk.* New York: Hyperion, 2001.

Nordenskiöld, A. E., and A. Leslie. *The Voyage of the Vega round Asia and Europe; with a Historical Review of Previous Journeys along the North Coast of the Old World, by A.E. Nordenkiöld, tr. by Alexander Leslie, with Five Steel Portraits, Numerous Maps, and Illustrations*. New York: Macmillan and Co., 1882.

Oliver, R., R. James, and J. Jago, eds. *Antarctic Earth Science (Fourth International Symposium).* Cambridge: Cambridge University Press, 2011.

Parry, W. E. *Journal of a Voyage for the Discovery of a North-West Passage from the Atlantic to the Pacific: Performed in the Years, 1819–20, in His Majesty's Ships Hecla and Griper, under the Orders of William Edward Parry; with an Appendix Containing the Scientific and Other Observations*. London: John Murray, 1821.

Philbrick, N. *Sea of Glory: America's Voyage of Discovery, the U.S. Exploring Expedition, 1838–1842*. New York: Viking, 2003.

Piantadosi, C. *The Biology of Human Survival: Life and Death in Extreme Environments.* Oxford: Oxford University Press, 2003.

Pielou, E. C. *A Naturalist's Guide to the Arctic*. Chicago: University of Chicago Press, 1995.

Preston, D. *First Rate Tragedy: Robert Falcon Scott and the Race to the South Pole.* New York: Mariner Books, 1999.

Roberts, D. *Alone on the Ice: The Greatest Survival Story in the History of Exploration*. New York: W. W. Norton and Company, 2013.

Roberts, P. *The European Antarctic: Science and Strategy in Scandinavia and the British Empire.* London: Palgrave Macmillan, 2011.

Riby, R. *Unknown Shore: The Lost History of England's Arctic Colony*. New York: Holt Paperbacks, 2002.

Rothblum, E., J. Weinstock, and J. Morris. *Women in the Antarctic.* London: Routledge, 1998.

Savage, C. *Aurora: The Mysterious Northern Lights.* Richmond Hill, Ontario, Canada: Firefly Books, 2001.

Siegert, M., M. Kennicutt II, and R. Bindschadler, eds. *Antarctic Subglacial Aquatic Environments*. Washington, DC: American Geophysical Union, 2011.

Shackleton, E. *The Heart of the Antarctic: Being the Story of the British Antarctic Expedition, 1907–1909.* New York: Carroll & Graf, 1999.

Shackleton, E. *South: The Endurance Expedition.* New York: Penguin, 1999.

Smith, M. *Tom Crean: Unsung Hero of the Scott and Shackleton Antarctic Expeditions*. Seattle: Mountaineers Books, 2002.

Strycker, N. *Among Penguins: A Bird Man in Antarctica.* Corvallis: Oregon State University Press, 2011.

Stump, E. *The Roof at the Bottom of the World: Discovering the Transantarctic Mountains.* New Haven, CT: Yale University Press, 2011.

Tin, T., D. Liggett, P. Maher, and M. Lamers. *Antarctic Futures: Human Engagement with the Antarctic Environment.* New York: Springer, 2013.

Vicuna, F. *Antarctic Mineral Exploitation: The Emerging Legal Framework.* Studies in Polar Research. Cambridge: Cambridge University Press, 2009.

Wade, F., R. Black, F. Ronne, P. Siple, A. Court, L. Warner, C. Passel, P. Knowles, D. Stewart, and E. Lockhart. "Reports on Scientific Results of the United States Antarctic Service Expedition, 1939–1941." *Proceedings of the American Philosophical Society* 89, no. 1. Philadelphia: The American Philosophical Society, 1945.

Watson, N., and J. Ussher. *Still Life: Inside the Antarctic Huts of Scott and Shackleton*. London: Murdoch Books, 2012.

Williams, G. *Voyages of Delusion: The Quest for the Northwest Passage.* New Haven, CT: Yale University Press, 2003.

Willis, C. *Ice: Stories of Survival from Polar Exploration*. New York: Da Capo Press, 1999.

Wilson, D. *The Lost Photographs of Captain Scott: Unseen Images from the Legendary Antarctic Expedition*. Boston: Little, Brown and Company, 2011.

Woodman, D. *Unravelling the Franklin Mystery: Inuit Testimony*. McGill-Queen's Native and Northern Series (Book 5). Montreal: McGill-Queens University Press, 1991.

Worsley, F. *Shackleton's Boat Journey.* New York: W. W. Norton & Company, 1998.

Zotikov, I. *The Antarctic Subglacial Lake Vostok: Glaciology, Biology and Planetology*. New York: Springer Praxis Books/Geophysical Sciences, 2006.

Web Pages

Alfred-Wegener Institute for Polar and Marine Research (AWI). http://www.awi-bremerhaven.de/

Antarctica New Zealand. http://antarcticanz.govt.nz/

Antarctic Heritage Trust. http://www.heritage-antarctica.org/aht.htm?CFID=137319813&CFTOKEN=75515147

Antarctic Institute of Argentina. http://www.dna.gov.ar/

Antarctic Institute of Chile (INACH). http://www.inach.cl/

Antarctic Institute of Ecuador (INAE). http://www.inae.gob.ec/

Antarctic Institute of Uruguay. http://www.iau.gub.uy/

Antarctic Treaty Secretariat. http://www.ats.aq/

Arctic and Antarctic Research Institute (AARI), Russia. http://www.aari.nw.ru/default_en.asp

Arctic Biodiversity Data Service (ABDS): Linguistics. http://www.abds.is/explore-indicies-networks/linguistics

Arctic Indigenous Languages. http://www.arcticlanguages.com

Association of Polar Early Career Scientists (APECS). http://www.scar.org/information/apecs.html

Australian Antarctic Division (AAD). http://www.antarctica.gov.au/

Belgian Polar Platform. http://www.belspo.be/belspo/BePoles/index_en.stm

British Antarctic Survey (BAS). http://www.antarctica.ac.uk/

Byrd Polar Research Center (BPRC), Ohio, USA. http://www-bprc.mps.ohio-state.edu/

Canada's First Peoples: The Inuit. http://firstpeoplesofcanada.com/fp_groups/fp_inuit1.html

Canadian Polar Commission. http://www.polarcom.gc.ca/

Canadian Polar Continental Shelf Project (PCSP). http://www.nrcan.gc.ca/the-north/polar-continental-shelf-program/polar-shelf/10003

Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). http://www.ccamlr.org/

Committee for Environmental Protection of the Antarctic Treaty (CEP). http://www.cep.aq/

Council of Managers of National Antarctic Programs (COMNAP). http://www.comnap.aq/

Institute for Marine and Antarctic Studies, Tasmania. http://www.imas.utas.edu.au/

Institute of Arctic and Alpine Research (INSTAAR). http://instaar.colorado.edu/

Integrating Climate and Ecosystem Dynamics (ICED) project. http://www.antarctica.ac.uk/Resources/BSD/ICED/

International Centre for Reindeer Husbandry. http://icr.arcticportal.org/

International Polar Foundation. http://www.polarfoundation.org/

Italian National Antarctic Research Programme (PNRA). http://www.pnra.it/

National Institute of Polar Research in Japan (NIPR). http://www.nipr.ac.jp/

National Snow & Ice Data Center (NSIDC). http://nsidc.org/

Norwegian Polar Institute (NPI). http://npweb.npolar.no/

Office of Polar Programs (OPP). http://www.nsf.gov/dir/index.jsp?org=OPP

Paleoenvironmental Arctic Sciences (PARCS). http://www.ncdc.noaa.gov/paleo/parcs/index.html
Scientific Committee on Oceanic Research (SCOR). http://www.jhu.edu/~scor/
Scott Polar Research Institute (SPRI). http://www.spri.cam.ac.uk/
South African National Antarctic Programme (SANAP). http://www.sanap.ac.za/ /
Survey of Living Conditions in the Arctic (SLiCA). http://www.arcticlivingconditions.org
Swedish Polar Research Secretariat. http://www.polar.se/english/
Teachers Experiencing Antarctica and the Arctic (TEA). http://tea.armadaproject.org/
Tuktu and Nogak Project: Inuit Quajimatajatuqangit. http://aulak.polarnet.ca/tuktu/main.html
U.S. Permafrost Association. http://www.uspermafrost.org/
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