SEA SURFACE TEMPERATURES

See **SATELLITE REMOTE SENSING OF SEA SURFACE TEMPERATURES**

SEA TURTLES

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Introduction

There are seven living species of sea turtles that include six representatives from the family Cheloniidae and one from the family Dermochelyidae. These, along with two other extinct families, Toxochelyidae and Prostegidae, had all evolved by the early Cretaceous, more than 100 Ma (million years ago). Today the cheloniids are represented by the loggerhead turtle (*Caretta caretta*), the green turtle *Chelonia mydas*, the hawksbill turtle (*Eretmochelys imbricata*), the flatback turtle (*Natator depressus*), and two congeneric turtles, the Kemp's ridley turtle (*Lepidochelys kempii*) and the olive ridley turtle *(Lepidochelys olivacea*). The only remaining member of the dermochelyid family is the largest of all the living turtles, the leatherback turtle (*Dermochelys coriacea*).

Sea turtles evolved from a terrestrial ancestor, and like all reptiles, use lungs to breathe air. Nevertheless, a sea turtle spends virtually its entire life in the water and, not surprisingly, has several extreme adaptations for an aquatic existence. The rear limbs of all sea turtles are relatively short and broadly flattened flippers. In the water, these are used as paddles or rudders to steer the turtle's movements whereas on land they are used to push the turtle forward and to scoop out the cup shaped nesting chamber in the sand (**Figure 1**). The front limbs are highly modified structures that have taken the appearance of a wing. Internally the front limbs have a shortened radius and ulna (forearm bones) and greatly elongated digits that provide the support for the flattened, blade-like wing structure. Functionally the front flippers are nearly identical to bird wings, providing a lift-based propulsion system that is not seen in other turtles.

Other special adaptations help sea turtles live in the marine environment. All marine turtles are well suited for diving, with specialized features in their blood, lungs, and heart that enable them to stay submerged comfortably for periods from 20 min to more than an hour. Since everything they eat and drink comes from the ocean, their kidneys are designed to minimize salt uptake and conserve water and they have highly developed glands in their heads that concentrate and excrete salt in the form of tears.

Despite all their adaptations and highly specialized mechanisms for life in the ocean, sea turtles are inescapably tied to land at some stage of their life. Turtles, like all other reptiles, have amniotic eggs which contain protective membranes that allow for complete embryonic development within the protected environment of the egg. This great advancement in evolution provided many advantages for reptiles over their predecessors: fish and amphibians. However, turtle eggs must develop in a terrestrial environment. Thus, in order to reproduce, female sea turtles need to emerge from the water and come ashore to lay eggs. All seven species lay their eggs on sandy beaches in warmer tropical and subtropical regions of the world.

Eggs are deposited on the beach in nest chambers, which can be as deep as 1 m below the sand surface. The adult female crawls on land, excavates a chamber into which it lays 50–130 eggs, and returns to the water after covering the new nest. Eggs usually take 50–70 days to fully develop and produce hatchlings that clamber to the beach surface at night. The length of the incubation primarily is influenced by the prevailing temperature of the nest during development; warmer temperatures hasten the hatchlings' development rates.

Nest temperature also plays a key role in determining the sex of hatchlings. Sea turtles share with other reptiles a phenomenon known as temperature-dependent sex determination (TSD). In sea turtles, warmer nest temperatures produce females, whereas cooler temperatures generate males. More specifically, it appears that there is a crucial period in the middle trimester of incubation during which

Figure 1 Leatherback digging nest.

temperature acts on the sex-determining mechanism in the developing embryo. Temperatures of $>30°C$ generate female sea turtles, and temperatures cooler than 29°C produce males. There is a pivotal range between these temperatures that can produce either sex. During rainy periods it is very common to have nests that are exclusively male, whereas a sunny dry climate tends to produce many nests of all females. Extended periods of extreme weather can produce an extremely skewed sex ratio for an entire beach over an entire nesting season. It is of much concern that global warming trends could have drastic effects on reptiles for which a balanced sex ratio totally depends on temperature.

During a single nesting season an individual female nests several different times, emerging from the water to lay eggs at roughly two-week intervals. Thus a female's reproductive output can total sometimes more than 1000 eggs by the end of the nesting season. However, once finished, most individuals do not return to nest again for several years. There is much variation in the measured intervals of return, between 1 and 9 years, before subsequent nesting bouts. Alternatively, males may mate at a much more frequent rate. Mating occurs in the water, and has been observed in some areas, usually near the nesting beaches. However, timing and location of mating is not known for many nesting populations, and is virtually unknown for some species.

Sea turtles have evolved a life history strategy that includes long-lived adults, a high reproductive potential, and high mortality as hatchlings or juveniles. As adults they have few predators with the exception of some of the larger sharks and crocodilians. Age to reproductive maturity is estimated at 8–20 years depending on the species and feeding conditions. Their eating habits include herbivores, like the green and black turtle, carnivores like the ridley turtles that eat crustaceans, and even spongivores, like the hawksbill. Almost all sea turtle hatchlings have a pelagic dispersal phase which is poorly documented and understood. Juveniles and adults congregate in feeding areas after the hatchling has attained a certain size. All sea turtles are currently listed in Appendix I of the Convention on International Trade in Endangered Species of Flora or Fauna (CITES Convention) and all species except the flatback (*Natator depressus*) from Australia, are also listed as threatened or endangered by the World Conservation Union (IUCN). Historically populations of sea turtles have declined worldwide over the past 20 years due to loss of nesting beach habitat, harvest of their eggs due to natural predation or human consumption, and the extensive adult mortality brought about by fishing pressure from the expansion of shrimp and drift net or long-line ocean fisheries.

General Sea Turtle Biology

The first fossil turtles appear in the Upper Triassic (210–223 Ma) and the sea turtles of today are descendants of that lineage. The current species of the family Cheloniidae evolved about 2–6 Ma and the sole representative of the Dermochelyidae family is estimated to have evolved about 20 Ma. All sea turtles are characterized by an anapsid skull, in which the region behind the eye socket is completely covered by bone without any openings, and the presence of a bony upper shell (carapace) and a similar bony lower shell (plastron). In all of the cheloniids the carapace and plastron consist of paired bony plates, in contrast to the sole Dermochelyid which has no evident bony plates in the leathery carapace and plastron, but instead interlocking cartilaginous osteoderms.

Like all reptiles, sea turtles have indeterminate growth, i.e., they continue to grow throughout their entire lifetime, which is estimated to be 40–70 years. Growth rates are often rapid in early life stages depending on amount of food available and environmental conditions, but diminish greatly after sexual maturity. As turtles get very old, growth probably becomes negligible. Sea turtles can grow to be quite large; and the leatherback is by far the largest, with most adults ranging between 300 and 500 kg with lengths of over 2 m. The cheloniid turtles are all smaller ranging from the smallest, the Kemp's and olive ridleys, to the flatback, which may weigh as much as 350 kg.

Sea turtles can not retract their necks or limbs into their shell like other turtle species and have evolved highly specialized paddle-like, hind limbs and wing-like front limbs with reduced nails on the

Figure 2 Single nail on fore-flipper of a juvenile loggerhead.

forelimbs limited to one or two claw-like growths (**Figure 2**) that are designed to facilitate clasping of the carapace on the female by the male during copulation. Fertilization is internal and sea turtles lay terrestrial nests on sandy beaches in the tropics and subtropics. Adults migrate from feeding areas to nesting beaches at intervals of 1–9 years, distances ranging from hundreds to thousands of nautical kilometers, to lay nests on land. Nest behavior can be solitary or aggregate in phenomena called an 'Arribada' where up to 75 000–350 000 female turtles will emerge to nest on one beach over a period of three to five consecutive evenings (**Figure 3**). Egg clutches of 50–200 eggs are buried in the sand at 20–40 cm below the surface. The nests are unattended and hatch 45–70 days later into hatchlings that average 15–30 g in weight. The sex of a hatchling sea turtle is determined by the temperature at which the nest is incubated (temperature dependent sex determination) during the middle trimester of development (critical period). For most sea turtles, temperatures above 29.5°C result in the development of a female whereas those eggs incubated at temperatures below 29°C become males. Sea turtles lay cleidoic eggs which are 2–6 cm in diameter and have a typical leathery inorganic shell constructed by the shell gland in the oviduct of the laying females. Nesting is seasonal and controlled by photoperiod cues integrated by the pineal gland and also influenced by the level of nutrition and fat stores available.

Sea turtle physiology is well adapted for deep and shallow diving that can average from 15 min to 2 hours in length. Their tissues contain high levels of respiratory pigments like myoglobin as a reserve oxygen store during the breath hold/dive. Respiratory tidal volumes are quite large (2–6 liters per breath) and allow for rapid washout of carbon dioxide and oxygen uptake during the brief periods spent on the surface breathing (**Figure 4**). Thus in a normal one hour period a sea turtle may spend 50 min under the water and only 10 min at the surface breathing and operating entirely aerobically and accrue no oxygen debt. Cardiovascular adaptations include counter current heat exchangers in the flippers to reduce or enhance heat exchange with the surrounding water. Control of the vascular tree is

Figure 3 Olive ridley arribada at Nancite Costa Rica.

much higher than the level of arterioles and can permit almost complete restriction of blood flow to all tissues but the heart, brain, central nervous system, and kidney during the deepest dives. They also have evolved temperature and pressure adapted enzymes that will operate well at both the surface and at extreme depths. Leatherbacks are the deepest diving sea turtles; dives of over 750 m in depth have been recorded.

All sea turtles have lacrimal salt glands (**Figure 5**) and reptilian kidneys with short loops of Henle to regulate ion and water levels. Lacrimal salt glands allow sea turtles to drink sea water from birth and maintain water balance despite the high levels of inorganic salts in both their marine diet and the salty ocean water they drink. Diets range from: plant materials like sea grass, *thallasia* and algae for herbivores like the green and black sea turtles; crabs and crustaceans for the ridley turtles; sponges for the loggerhead; and jellyfish and other Cniderians are the sole diet of leatherbacks.

Dermochelyidae (1 genera, 1 species)

The genus *Dermochelys*: *Dermochelys coriacea* (Linne') the leatherback turtle Leatherbacks are

Figure 4 Leatherback breathing at surface.

Figure 5 Clear salt gland secretion from base of eye.

Figure 6 Leatherback osteoderm with ridges on carapace.

the largest (up to 600 kg as adults) and most ancient of the sea turtles diverging from the other turtle families in the Cretaceous. About 20 Ma *Dermochelys* evolved to a body form very similar to that seen today. Their shell consists of cartilaginous osteoderms and they do not have the characteristic laminae and plates found in the plastron and carapace of other sea turtles. The leatherback shell is streamlined with seven cartilaginous narrow ridges on the carapace and five ridges on the plastron that direct water flow in a laminar manner over their entire body (**Figure 6**). The appearance is a distinctive black with white spots, a smooth, scaleless carapace skin and a white smooth-skinned plastron. The head has two saber tooth like projections on the upper beak that overlap the front of the lower beak and serve to pierce the air bladder of floating cniderians that are a large component of their diet when available. Their nesting distribution is worldwide with colonies in Africa, Islands across the Caribbean, Florida, Pacific Mexico, the Pacific and Caribbean coastlines of Central America, South America, Malaysia, New Guinea, and Sri Lanka. Remarkably they are found in subpolar oceans at surface water temperatures of 7–10°C while maintaining a core body temperature above 20°C.

Leatherbacks are pelagic and remain in the open ocean throughout their life feeding on soft-bodied invertebrates such as cniderians, ctenophores, and salps. Average adult females weigh about 300 kg and may take only 8–10 years to attain that size after emerging from their nests at about 24 g. Sex is determined by TSD with a pivotal temperature of 29.5°C. They build a simple cup shaped body pit and lay the largest eggs, about the size of a tennis ball, in clutches of 60–110 yolked eggs. Unlike other sea turtles leatherbacks also deposit 30–60 smaller yolkless eggs that are infertile and only contain albumins. These yolkless eggs tend to be laid late in the nesting process and are primarily on the top of the clutch and may serve as a reservoir for air when hatchlings emerge and congregate prior to the frenzied digging to emerge from their nest chamber.

Unlike other sea turtles leatherbacks crawl on their wrists while on land, rotating both front flippers simultaneously and pushing with both rear flippers in unison. This contrasts with the alternating right to left front and rear flipper crawls of the Cheloniidae. In the ocean their enlarged paddle-like front flippers generate enormous thrust providing excellent propulsion and allowing leatherbacks to migrate an average of 70 km per day when leaving the nesting beaches. Leatherback migrations from Central American beaches are along narrow 'corridors' that are about 100 km wide (**Figure 7**). These oceanic migratory corridors provide important insights into the complex reproductive behavior of these animals. Genetic studies have demonstrated

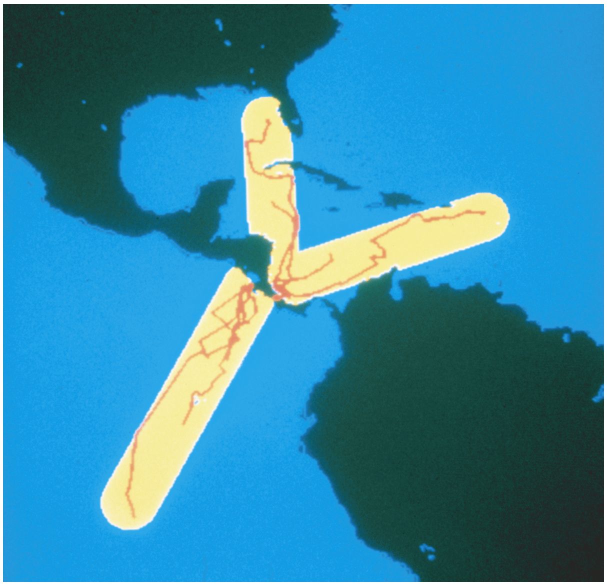

Figure 7 Leatherback migration corridors.

Figure 8 Green turtle.

that there is excellent gene flow across all the ocean basins with a strong natal homing and distinct genetic haplotypes in different nesting populations.

Cheloniidae (5 genera, 6 species, 1 race)

The genus *Chelonia*: *Chelonia mydas* (Linne') the green turtle and *Chelonia mydas agassizi* (Bocourt) the black turtle The genus *Chelonia* contains only one living species the green turtle *Chelonia mydas mydas* (Linne') that also has a Pacific–Mexican population that is considered by some researchers as a subspecies or race, the Pacific green turtle or black turtle, *Chelonia mydas agassizi* (Bocourt). The green turtle (**Figure 8**) actually has a brownish colored carapace and scales on the legs, with a yellowish plastron and has one pair of prefrontal head scales with four pairs of lateral laminae. The name 'green turtle' comes from the large greenish fat deposit found under the carapace which is highly desired for the cooking of turtle soup. The black turtle (**Figure 9**) is distinguished by the dark black color of both the carapace and plastron in the adult form. This subspecies or race is found only along the Pacific coastline of Mexico and extends in smaller populations along the Pacific Central American coastline to Panama. *Chelonia* are herbivorous; the green turtle eats marine algae and other marine plants of the genera *Zostera, Thallassina, Enhaus, Posidonia,* and *Halodule* and is readily found in the Caribbean in eel-grass (*Zostera*) beds, whereas black turtles rely heavily on red algae and other submerged vegetation. These turtles live in the shallow shoals along the equatorial coastlines as far North as New England in the Atlantic and San Diego in the Pacific and as far south as the Cape of Good Hope in the Atlantic and Chile in the Pacific. The main breeding rookeries include the Coast of Central America, many islands in the West Indies, Ascension Island, Bermuda, the Florida Coast, islands off Sarawak (Malaysia), Vera Cruz coastline in Mexico (center for black turtles), and islands off the coast of Australia. Adult females emerge on sandy beaches at night to construct nests in which they lay 75–200 golf ball-sized leathery eggs. The eggs in these covered nests develop unattended and the young emerge 45–60 days latter. The sex of the hatchlings is determined by the temperature at which the eggs are incubated during the third trimester of development called TSD. Temperatures above 29°C tend to produce all female hatchlings whereas those below 29°C produce males. The hatchlings have a high mortality in the first year and spend a pelagic period before reappearing in juvenile/adult feeding grounds, such as the reefs off Bermuda, the Azores, and Heron Island in the Pacific. As adults they average 150–300 kg with straight line carapace lengths of 65–90 cm. Black turtles tend to be smaller than green turtles. Genetic studies have shown a strong natal homing of the females to the beaches where they were hatched with significant gene flow between rookeries probably due to mating with males from different natal beaches found on common feeding grounds.

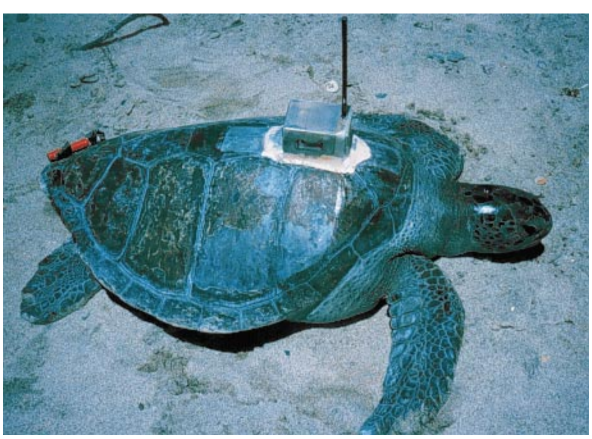

Figure 9 Black turtle (with transmitter).

The genus *Lepidochelys*: *Lepidochelys kempii* (Garman) the Kemp's ridley, *Lepidochelys olivacea* (Eschsholtz) the olive ridley The Kemp's or Atlantic Ridley and the olive or Pacific Ridley turtles are the two distinct species of this genus. The Kemp's ridley (**Figure 10**) is the rarest of the sea turtles whereas the olive ridley is the most abundant. Anatomically ridleys are the smallest sea turtles. Adult Kemp's usually have five pairs of grey-colored coastal scutes and olive ridleys have 5–9 olive-colored pairs. The adults have a straight line carapace length of 55–70 cm and weigh on average

Figure 10 Juvenile Kemp's ridley.

100–200 kg. Both species have an interesting reproductive behavior in that they have communal nesting called 'arribadas' (Spanish for arrival). There are a number of arribada beaches where females come out by the thousands on sandy beaches 2–6 km long on three or four successive evenings once a month during the nesting seasons. A percentage of the total population are solitary nesters that emerge on other nearby beaches or on arribada beaches on nights other than the arribadas. These solitary nesters have a very high hatching success of their individual nests (about 80%). It is unknown what proportion of the total population of females nest in this solitary manner and what role they play in the contribution of new recruits into the reproductive adult numbers. Arribadas in Gahirmatha, India have been described with 100 000 turtles emerging in one night to nest communally only inches apart. Many nests are dug up by successive nesting females in the same or subsequent nights of the arribada. The hatching success of these arribada nests is about 4–8% which is the lowest among all sea turtles. Kemp's ridley turtles have arribadas on only one nesting beach in the world, Rancho Nuevo (Caribbean), Mexico. Historically Kemp's arribadas were estimated at 20 000–40 000 female turtles per night in the 1950s, but recent arribadas average only 300–400 individuals per night. This dramatic decline has been attributed to the numbers of adults and juveniles killed in the shrimping nets of the fisheries in the Gulf of Mexico and the American Atlantic coastline. These genera feed primarily on crustaceans, crabs and shrimp, and as a result have been in direct competition with these well-developed fisheries for many years and have suffered dire consequences. Olive ridleys have arribada beaches in Pacific Mexico, Nicaragua, Costa Rica, and along the Bay of Bengal in India. Very little is known about the ocean life of these sea turtle species and it is believed that after hatching they also spend 1–4 years in a pelagic phase associated with floating *Sargassum* and then reappear in the coastal estuaries and neretic zones worldwide at a straight carapace length of about 20–30 cm. Although Kemp's ridley turtles feed primarily on crabs in inshore areas, olive ridley turtles have a more varied diet that includes salps (*Mettcalfina*), jellyfish, fish, benthic invertebrates, mollusks, crabs, shrimp and bryozoans. This more varied diet may account for the different deep ocean and nearshore habitats in which the olive ridleys are found.

The genus *Eretmochelys*: *Eretmochelys imbricata* (Linne'), the hawksbill This species is the most sought after sea turtle for the beauty of the carapace. Historically eyeglass frames and hair combs were made from the carapace of hawksbills. The head is distinguished by a narrow, elongated snout-like mouth and jaw that resembles the beak of a raptor (**Figure 11**). They have four pairs of thick laminae and 11 peripheral bones in the carapace. They tend to be more solitary in their nesting behavior than the other sea turtles but this may be due to their reduced populations. Other than the kemp's ridley turtles they tend to be the smallest turtles averaging 75–150 kg as adults. They are common residents of coral reefs worldwide and appear as juveniles at about 20–25 cm straight length carapace after a pelagic developmental phase in the floating *Sargassum*. What is impressive about the adults is that their diet is 90% sponges. This is one of the few spongivorous animals and electron micrographs of their gastrointestinal tract has shown the microvilli with millions of silica spicules imbedded in the tissue. Tunicates, sea anemone, bryozoans, coelenterates, mollusks, and marine plants have also been found to be important components of the hawksbill diet.

Figure 11 Raptor-like beak of hawksbill.

Hawksbills have the largest clutch size of any of the chelonids averaging 130 eggs per nest. They also lay the smallest eggs with a mean diameter of 37.8 mm and mean average weight of 26.6 g. This results in the smallest hatchling of all sea turtles with an average weight of 14.8 g. Other than possibly the olive ridley turtle they have the lowest clutch frequency of only 2.74 clutches per nesting season. Hawksbills also tend to be the quickest to construct their nest when out on a nesting beach; they spend only about 45 min to complete the process whereas other turtles take between one to two hours.

Habitats include shallow costal waters and they are readily found on muddy bottoms or on coral reefs. The genetic structure of Atlantic and Pacific populations indicate that hawksbills like other sea turtles have strong natal homing and form distinct nesting populations. They also have TSD and hatchlings also have a pelagic phase before appearing in coastal waters and feeding grounds at about the size of a dinner plate.

Cuba has requested that these turtles be upgraded to CITES Appendix II status which would allow farming of 'local resident populations.' Genetic studies, however, have conclusively demonstrated that these Cuban populations are not local and include turtles from other regions of the Caribbean. These kinds of controversies will increase as human pressures for turtle products, competition for the same food resources such as shrimp, incidental capture due to longline fishing practices, and beach alteration and use by humans increases.

The genus *Caretta*: *Caretta caretta* (Linne'): the loggerhead turtle The loggerhead, like olive ridley turtles, are distinguished by two pairs of prefrontal scales, three enlarged poreless inframarginal laminae, and more than four pairs of lateral laminae. They have a beak like snout that is very broad and not narrow like the hawksbill and they have the largest and broadest head and jaw of the chelonids (**Figure 12**). They nest throughout the Atlantic, Caribbean, Central America, South America, Mediterranean, West Africa, South Africa, through the Indian Ocean, Australia, Eastern and Western Pacific Coastlines.

Figure 12 Broad head of juvenile loggerhead.

Loggerheads are primarily carnivorous but have a varied diet that includes crabs (including horseshoe crabs), mollusks, tube worms, sea pens, fish, vegetation, sea pansies, whip corals, sea anenomies, and barnacles and shrimp. Their habitats appear to be quite diverse and they will shift between deeper continental shelf areas and up into shallow river estuaries and lagoons. This sea turtle is the only turtle that has large resident and nesting populations across the North American coastline from Virginia to Florida and the nesting rookeries in Georgia and Florida are currently doing well despite severe human pressures.

Loggerheads that nest on islands near Japan have been shown to develop and grow to adult size along the Mexican coastline and then migrate 10 000 km across the Pacific to nest. Genetic studies have confirmed that the Baja Mexico haplotypes are the same as the female adults nesting on these Japanese islands confirming strong natal homing in this genus. Loggerheads make a simple nest at night and lay about 100–120 golf ball-sized eggs. The hatchlings spend a pelagic phase and reappear at 25–30 cm straight carapace length in coastal bays, estuaries and lagoons as well as along the continental shelf and open oceans (**Figure 13**). The orientation and homing of loggerhead hatchlings has been extensively studied and it has been demonstrated that these turtles can detect the direction and intensity of magnetic fields and magnetic inclination angles. This ability together with the use of olfactory cues and chemical imprinting on olfactory cues from natal beaches may account for the natal homing ability of all sea turtles.

Figure 13 Juvenile loggerhead turtle.

The genus *Natator*: *Natator depressus* the flatback This genus has a very limited distribution and is only found in the waters off Australia yet it appears that populations are not endangered at this time. Their nesting beaches are primarily in northern and south-central Queensland. Most of the nesting beaches are quite remote which has protected this species from severe impact by humans. Apart from the Kemp's ridley this is the only sea turtle to nest in significant numbers during the daytime. It is thought that nighttime nesting has evolved as a behavior to reduce predation and detection but there may also be thermoregulatory considerations. During the daytime in the tropics and subtropics both radiant heat loads from the sun and thermal heat loads from the hot sands may significantly heat the turtles past their critical thermal tolerance. In fact, a number of daytime-nesting flatbacks may die due to overheating if the females do not time their emergence and return to the water to coincide closely with the high tides. If individuals are stranded on the nesting beach when the tides are low and the females must traverse long expanses of beach to emerge or return to the sea during hot and sunny daylight hours, there is a higher potential to overheat and die. On the other hand green turtles in the French Frigate Shoals area of the Pacific are known to emerge on beaches or remain exposed during daylight in shallow tidal lagoons during nonnesting periods and appear to heat up to either aid in digestion or destroy ectoparasites.

Flatback turtles are characterized by a compressed appearance and profile of the carapace with fairly thin and oily scutes. Flatbacks are also distinguished by four pairs of laminae on the carapace and the rim of the shell tends to coil upwards toward the rear. Flatbacks have a head that is very similar to the Kemp's ridley with the exception of a pair of preocular scales between the maxilla and prefrontal scales on the head. These turtles tend to be the largest chelonid, weighing up to 400 kg as adults, and lay the second largest egg with diameters of about 51.5 mm weighing about 51.5 g, smaller only than the leatherback which has a mean egg diameter of 53.4 mm and mean egg weights of 75.9 g. Flatbacks have the smallest clutch size of the chelonids, laying a mean of 53 eggs per clutch, and will lay about three clutches per nesting season. There is only one readily accessible nesting beach for this species at Mon Repos in Queensland, Australia. Other isolated rookeries like Crab Island are found along the Gulf of Carpentaria and Great Barrier Reef.

It is believed that flatbacks may be the only sea turtle that does not have an extended pelagic period in the open ocean. Hatchlings and juveniles spend the early posthatchling stage in shallow, protected coastal waters on the north-eastern Australian continental shelf and Gulf of Carpentaria. Their juvenile and adult diet is poorly known but appears to include snails, soft corals, mollusks, bryozoans, and sea pens.

See also

International Organizations. Sandy Beaches, Biology of.

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SEABIRD CONSERVATION

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Introduction

Conservation is the preservation and protection of plants, animals, communities, or ecosystems; for marine birds, this means preserving and protecting them in all of their diverse habitats, at all times of the year. Conservation implies some form of management, even if the management is limited to leaving the system alone, or monitoring it, without intervention or human disturbance. The appropriate degree of management is often controversial. Some argue that we should merely protect seabirds and their nesting habitats from further human influences, leaving them alone to survive or to perish. For many species, however, this solution is not practical because they do not live on remote islands, in