SALINITY

See **SATELLITE MEASUREMENTS OF SALINITY. WATER TYPES AND WATER MASSES.**

SALMON FISHERIES

Atlantic

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Introduction

Migrating animals, concentrated in space and time, represent readily harvestable resources that have a long history of exploitation by humans. The anadromous Atlantic salmon (*Salmo salar*) is no exception. Cave paintings and stone carvings dating back 25 000 years from the Dordogne region of France confirm its long association with, and importance to, humans. Throughout its range in the North Atlantic, the Atlantic salmon has been and continues to, be exploited by a variety of gear in rivers, lakes, estuaries, and the sea, providing employment and recreation, and generating considerable economic benefits, often in remote rural areas. The Atlantic salmon also has cultural, ceremonial, and symbolic significance, but it is difficult to ascribe a value to these important facets of the resource. Throughout the history of exploitation of Atlantic salmon by humans, there have been many changes in the nature and scale of the fisheries.

Description of the Salmon Fisheries

Although it is a matter of conjecture, the most ancient method of harvesting Atlantic salmon was probably by hand in rivers where adults returning to spawn may well have been an important component of the diet prior to the development of agriculture and techniques for animal husbandry. Apart from the use of clubs or stones, the spear or harpoon was probably the first fishing gear used for salmon. The snare, hook, and dip net probably followed. The earliest method of harvesting salmon in quantity was probably the fishing weir. Spears, hooks, nets, and weirs thought to have been used for catching salmon at least 8000 years ago have been discovered in Sweden. In eastern Canada, the first harvesting of Atlantic salmon is thought to have started about 8800 BC when Amerindians arrived in the area. The spear was the preferred implement.

Documentary evidence of the use of salmon weirs is available from the eleventh century. The Battle of Clontarf in Ireland in 1014 was known as the Battle of the Salmon Weir. Use of weirs and nets (probably hand nets, seine, and gill nets) by North American Indians was documented in the sixteenth century. The seine net is known to have been used for catching salmon in Scotland and Ireland in the seventeenth century and probably much earlier than that. Amerindians practiced a primitive form of angling. Angling for salmon as a hobby is known from at least the seventeenth century in some countries, although it was introduced to Norway only in the nineteenth century.

While a considerable variety of types of salmon fishing gear has been developed, on comparison they appear to be based on a few basic methods of capture, which have been categorized under four general headings: fixed gears or traps (e.g., bag nets, stake nets, set gill nets); floating gears (e.g., longlines and drift nets); seine or draft nets; and rod and line (using a variety of artificial flies, baits, and lures).

There have been many improvements to these fishing methods over the period of their deployment. One of the most significant has been the development of synthetic twines that made the gear (including recreational fishing gear) easier to handle and less visible.

Salmon fisheries are often categorized as 'recreational' and 'commercial' to distinguish between sport fishing with rod and line and fishing with other gears with the intention of selling the harvest. However, the distinction is sometimes blurred. For example: 'recreational' licenses may be issued to fish for salmon with gill nets for local consumption purposes in Greenland; in some countries the sale of rod-caught salmon is permitted; and rod-and-line fisheries may be let or sold for considerable sums of money. For the purposes of this article, recreational

fisheries are considered to be sport fisheries using rod and line and a variety of artificial flies, baits, and lures; commercial fisheries are those fisheries conducted with a variety of other gears where the intention is to sell the harvest. A third category, 'subsistence fisheries', is conducted with the intention of using the harvest of salmon for consumption by the local community; for example, the fisheries by native people in Canada, Finland and Greenland. Salmon fishing may also be conducted for research purposes, in some cases using methods that would ordinarily be prohibited.

Some countries have only recreational fisheries. For example, all netting of salmon was prohibited in Spain and the salmon fishery was dedicated entirely to recreational fishing in 1942 following the Civil War, during which the salmon populations had been heavily exploited for food. Similarly, in the United States all commercial exploitation of Atlantic salmon ceased in 1948. Other countries have a mixture of commercial and recreational fisheries (e.g., Norway, United Kingdom, Ireland, France, Iceland, and Russia). In Iceland there is no coastal netting and commercial fisheries are conducted in only two rivers in the south of the island (A. Isaksson, personal communication). Canada had a major commercial fishery, but management measures introduced since the mid-1960s have progressively reduced the fishery and in 2000 no commercial licenses were issued, with the effect that the Canadian salmon fishery is now recreational and subsistence in nature. In Russia, the fisheries were mainly commercial and angling for salmon was prohibited in all but three rivers, where it was strictly controlled by restrictions on the number of licenses issued. However, since the mid-1980s, recreational fisheries have developed in the rivers of the Kola peninsula and are popular with foreign anglers. Greenland and the Faroe Islands have only one and five salmon rivers, respectively, so the opportunities for recreational fishing are limited and fishing has mainly been either commercial or subsistence in Greenland, and commercial or research in the Faroe Islands.

Salmon fisheries have been described as single or mixed stock on the basis of whether they exploit a significant number of salmon from one or from more than one river stock, respectively. Some mixed stock fisheries may exploit salmon originating in different countries. Mixed stock fisheries have also been referred to as interception fisheries and the term is often applied specifically to the Greenland and Faroes fisheries. However, prior to the closure of the commercial fisheries in Newfoundland and Labrador in Canada, there was concern about the harvest of US fish by this fishery. Similarly, in the North-East Atlantic area there are harvests in the fisheries of one country of salmon originating in the rivers of another country (**Table 1**). Thus, many salmon fisheries are interceptory in nature, but these interceptions have declined in recent years as a result of international agreements in the North Atlantic Salmon Conservation Organization (NASCO), national or regional regulations, economic factors and other reasons.

The terms 'home water' and 'distant water' are also used in relation to salmon fisheries. Since 1983,

Table 1 Origin of salmon caught in home water fisheries in the North-east Atlantic in 1992

	Catch by country									
Origin of stock	*Russia*	*Finland*	*Norway*	*Sweden*	*England and Wales*	*Scotland*	*Northern Ireland*	*Ireland*	*France*	*Iceland*
Wild										
Russia	100%	–	+	–	–	–	–	–	–	–
Finland	–	99%	+	–	–	–	–	–	–	–
Norway	–	+	75%	6%	–	–	–	+	–	–
Sweden	–	–	1%	46%	–	–	–	–	–	–
England and Wales	–	–	–	–	62%	+	+	10%	–	–
Scotland	–	–	–	–	38%	95%	3%	5%	–	–
Northern Ireland	–	–	–	–	+	+	92%	5%	–	–
Ireland	–	–	–	–	+	+	+	80%	–	–
France	–	–	–	–	+	+	+	+	100%	–
Iceland	–	–	–	–	–	–	–	–	–	28%
Reared										
Escapees	–	< 1%	23%	2%	–	5%	1%	–	–	–
Ranched	–	–	1%	46%[a]	–	–	3%	< 1%	–	72%

Source: Report of the ICES Advisory Committee on Fishery Management 1994. NASCO Council document CNL(94)13.

[a]Fish released for mitigation purposes and not expected to contribute to spawning.

+, Catches thought to occur but contribution not estimated.

–, Catches occur rarely or not at all.

with the implementation of the Convention for the Conservation of Salmon in the North Atlantic Ocean, which prohibits fishing beyond areas of fisheries' jurisdiction, all salmon fisheries are in effect home water fisheries. The term home water fishery is therefore more correctly used to indicate fisheries within the jurisdiction of the state of origin of the salmon (i.e., in the country in whose rivers the salmon originated), as opposed to distant water fisheries, which harvest salmon outside the jurisdiction of the state of origin.

The Resource

Limits on production during the freshwater phase of the life cycle constrain the abundance of Atlantic salmon and result in catches that are low compared to those of Pacific salmon and pelagic marine fish species such as herring and mackerel.

A wide range of factors has already affected this freshwater production capacity, including urbanization, land drainage, overgrazing, forestry practices, infrastructure developments, water abstraction, sewage and industrial effluents, hydroelectricity generation, and the introduction of nonindigenous species. Many salmon rivers were damaged as a result of the Industrial Revolution. For example, in Canada, there has been a net loss of productive capacity of salmon of 16% since 1870, and in the state of Maine, USA, about two-thirds of the historic salmon habitat had been lost by the mid-1980s. Early attempts at enhancement through stocking programs date to the middle of the nineteenth century. These stocking programs continue and in 1999 more than 30 million Atlantic salmon eggs and juveniles were stocked in rivers around the North Atlantic. With the decline of many heavy industries there have been improvements in salmon habitat and in England and Wales, for example, there are now more salmon-producing rivers than there were 150 years ago. Much progress has also been made in recent years in improving fish passage facilities at dams. The effects of the Industrial Revolution are, however, still being felt today, through the continuing problem of acidification of rivers and lakes, for example. As the human population continues to increase, pressures on salmon habitat from domestic, industrial, and agricultural demands will increase.

Catch statistics compiled for the North Atlantic region by the International Council for the Exploration of the Sea (ICES) are available for the period from 1960, during which the total reported catch has ranged from approximately 2200 tonnes in 1999 to approximately 12 500 tonnes in 1973 (**Figure 1**).

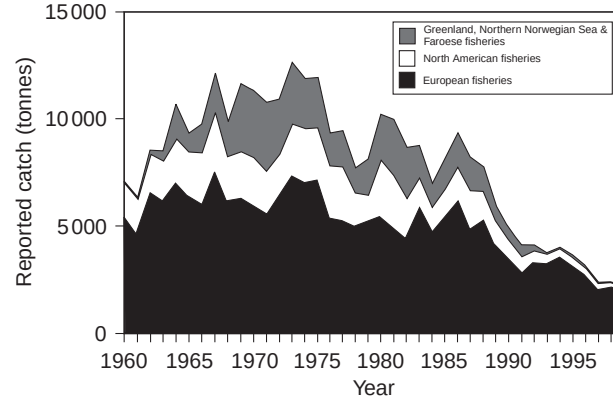

Figure 1 Reported catch of Atlantic salmon (tonnes) from the North Atlantic area, 1960–1999.

The mean reported catch in tonnes by country for each of the four decades 1960–69 to 1990–99 is shown in **Table 2**. There has been a steady decline in the total reported North Atlantic catch of salmon since the early 1970s. **Figure 2** shows for four major states of origin that there is some degree of synchronicity in the trend in catches over the 40-year period from 1960 when expressed as the percentage difference from the long-term mean reported catch. While catches in all four countries were above or close to the 40-year mean in the period from the 1960s to the late 1980s, the last decade of the twentieth century was characterized by below-average catches. Although some of the reduction in catches was the result of the introduction of management measures, which have reduced fishing effort, the abundance of both European and North American Atlantic salmon stocks has declined since the 1970s, particularly the multi-sea-winter components. This decline in abundance appears to be related to reduced survival at sea.

In addition to the reported catches illustrated in **Figure 1**, catches may go unreported for a variety of reasons. These include the absence of a requirement for statistics to be collected; suppression of information thought to be unfavorable; and illegal fishing. Estimates of unreported catch for the North Atlantic region for the period from 1987 have ranged between approximately 800 and 3200 tonnes, or 29–51% of the reported catch. Illegal fishing appears to be a particular problem in some countries. Associated with all forms of fishing gear is mortality generated directly or indirectly by the gear but which is not included in reported catches. This mortality may be associated with predation, discards, and escape from the gear. For salmon fishing gear the contribution of most sources of this

Table 2 Mean reported catch (in tonnes) by country during the four decades 1960–1969 to 1990–1999

Country	*1960–1969*	*1970–1979*	*1980–1989*	*1990–1999*
Canada	2053	2142	1638	395
Denmark	138	491	152	1
England and Wales	325	384	370	224
Faroe Islands	64	152	606	47
Finland	—	42	54	57
France	—	14	23	13
Germany	2	3	—	—
Greenland	773	1300	816	119
Iceland	131	197	176	138
Ireland	1329	1676	1263	616
Northern Ireland	291	174	114	82
Norway	1822	1745	1453	840
Russia	690	559	520	158
Scotland	1684	1437	1058	468
Spain	36	27	21	8
St. Pierre and Miquelon	—	—	3	2
Sweden	50	39	35	34
USA	1	2	3	1

Notes: (1) The catch for Iceland excludes returns to commercial ranching stations. (2) The catches for Norway, Sweden, and Faroe Islands include harvests at West Greenland and in the Northern Norwegian Sea fishery. (3) The catch for Finland includes harvests in the Northern Norwegian Sea fishery. (4) The catch for Denmark includes catches in the Faroese zone, in the Northern Norwegian Sea fishery, and at West Greenland. (5) The catch for Germany is from the Northern Norwegian Sea fishery.

mortality is estimated to be low (0–10%) but highly variable.

By-catch of nontarget species in salmon fishing gear is thought to be generally low. Drift nets may have a by-catch associated with their use, but this has not been fully quantified. However, as this gear is often tended by the fishermen, there may be an opportunity to release sea birds and marine mammals from the nets. 'Ghost fishing' by lost or abandoned nets is not thought to be a problem associated with salmon fishing gear. By-catch of salmon in gear set for species such as bass, lumpsucker, mackerel, herring, and cod is known to occur but it is not generally a problem. In some countries regulations have been introduced to protect salmon from capture in coastal fisheries for other species. There is, however, concern about the possible by-catch of salmon post-smolts in pelagic fisheries for herring and mackerel in the Norwegian Sea, which overlap spatially and temporally with European-origin post-smolt migration routes.

In addition to exploitation of Atlantic salmon in the North Atlantic region, there are fisheries in the Baltic Sea. Catches since 1972 have ranged from approximately 2000 to 5600 tonnes. These fisheries, which are based to a large extent on hatchery smolts released to compensate for loss of habitat following hydroelectric development, are described in detail by Christensen *et al.* (see Further Reading).

Economic Value

A wide variety of techniques have been used to assess the economic value of Atlantic salmon and, in the absence of a standardized approach, assessment of the economic value of salmon fisheries on a North Atlantic basis is not possible. Many assessments concern the expenditure associated with salmon fishing. Economic value, however, reflects willingness to pay for use of the resource, and as willingness to pay must at least be equal to actual expenditure, many assessments underestimate the full economic value. However, it is clear that throughout its range the Atlantic salmon generates considerable economic benefits that may have impacts on a regional basis or, where visiting anglers from other countries are involved or where the harvest is exported, impacts on national economies. The following examples serve to highlight the considerable economic value of salmon fisheries.

The total net economic value of salmon fisheries, both recreational and commercial, in Great Britain was estimated in 1988 to be £340 million, of which

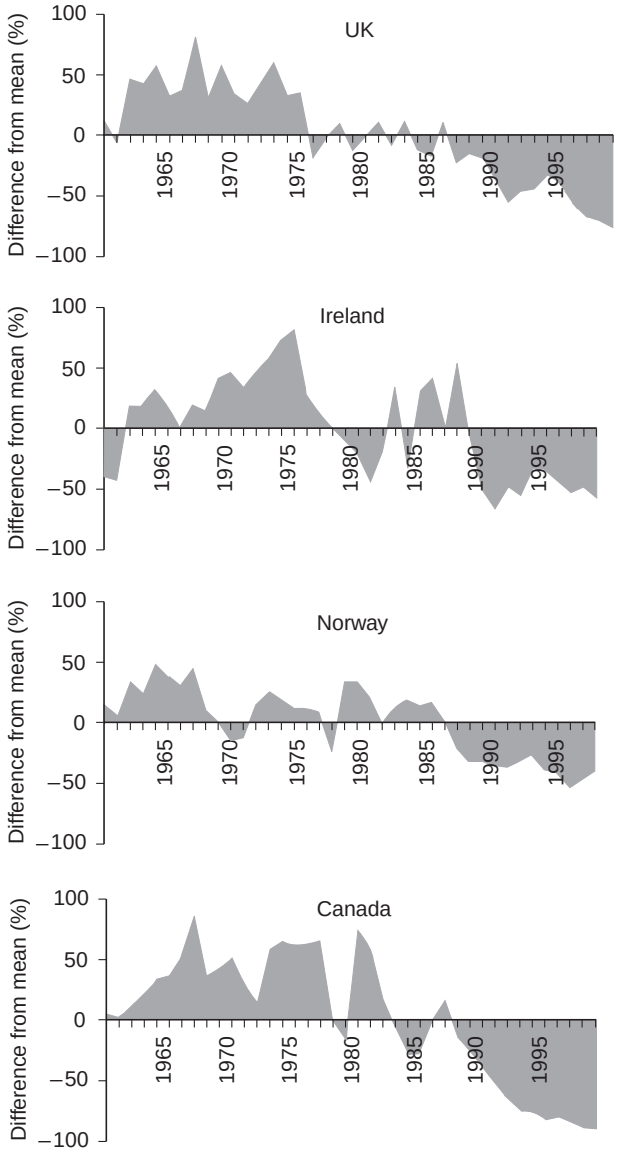

Figure 2 Catches of Atlantic salmon (tonnes), expressed as the percentage difference from the 40-year mean, for four major states of origin.

the recreational fisheries accounted for approximately £327 million.

In Canada, recreational anglers spent Can$39 million on salmon fishing in 1985 with a further Can$45 million invested on major durables and property.

In Greenland, the salmon fishery in 1980 was a substantial source of income (30–35% of total annual income to the fishermen), and 50% of fishermen could not have met their current vocational and domestic expenses at that time without the salmon fishery. Many people other than the fishermen depended on the salmon fishery for gear and equipment sales and repair and shore processing.

The expenditure by recreational salmon fishermen visiting one major Scottish salmon river, the Tweed, was estimated to be £9 million in 1996, with a total economic impact of more than £12 million. Approximately 500 full-time job equivalents depended on this activity. This is for one river and there are more than 2000 salmon rivers in the North Atlantic region, with fisheries that bring economic benefits, often to remote areas where job creation is otherwise very difficult.

In addition to the economic value associated with the fisheries, individuals are willing to contribute to salmon conservation even though they have no interest in fishing. Sixty percent of the New England population was found to 'care' about the Atlantic salmon restoration program and in 1987 their willingness to pay was estimated to exceed the cost of the restoration program. Economic assessments that fail to take these non-user aspects into account will considerably underestimate the economic value of the resource. The salmon has a special place in human perception and there are many nongovernment organizations dedicated to its conservation.

Management of the Fisheries

Legislation regulating the operation of salmon fisheries is known to have been introduced in Europe as early as the twelfth century. In Scotland, for example, legislation was introduced to establish a weekly close time and to prevent total obstruction of rivers by fishing weirs. Similarly, in the middle of the thirteenth century, legislation establishing close seasons was introduced in Spain. Since these early conservation measures were enacted, a wide variety of laws and regulations concerning the salmon fisheries have been developed by each North Atlantic country. These laws and regulations include those that permit or prohibit certain methods of fishing; specify permitted times and places of fishing; restrict catch by quota; prohibit the taking of young salmon and kelts; restrict or place conditions on the trade in salmon; and ensure the free passage of salmon.

The last quarter of the twentieth century witnessed dramatic changes in the exploitation of Atlantic salmon. Commercial fisheries have been greatly reduced, partly as a result of management measures taken in response to concern about abundance and partly as a result of the growth of salmon farming. Production of farmed Atlantic salmon has increased from less than 5000 tonnes in 1980 to more than 620 000 tonnes in 1999 (**Figure 3**). This rapidly growing industry has had a marked impact on the profitability of commercial fisheries for salmon. While it has been argued that the growth of

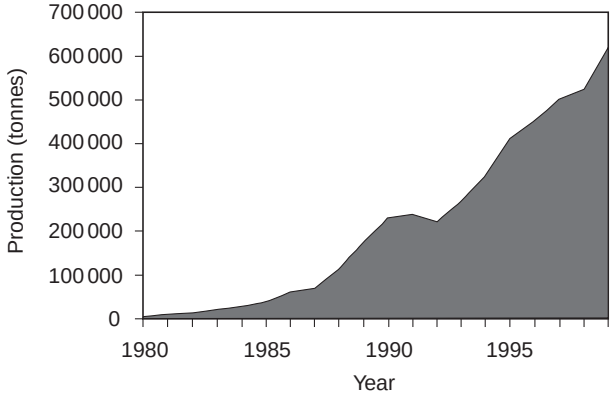

Figure 3 Production of farmed Atlantic salmon (tonnes) in the North Atlantic area.

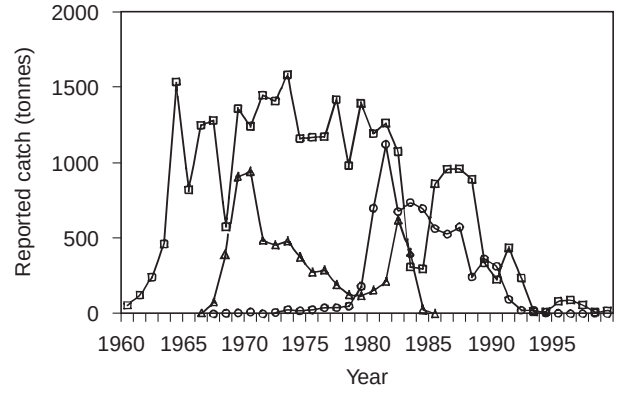

Figure 4 Reported catches (tonnes) of Atlantic salmon in the fisheries at West Greenland (□), in the Northern Norwegian Sea (△) and in the Faroese zone (○).

salmon farming, which in 1999 produced about 300 times the harvest of the fisheries, has reduced exploitation pressure on the wild stocks, there are concerns about the genetic, disease, parasite, and other impacts the industry may be having on the wild Atlantic salmon. In some countries, escaped farm salmon frequently occur in fisheries for wild salmon and in spawning stocks.

Distant Water Fisheries

Prior to the 1960s, management of salmon fisheries in the North Atlantic region was at a local, regional, or national level. During the 1960s and early 1970s, however, distant water fisheries developed at West Greenland (harvesting both European and North American origin salmon) and in the Northern Norwegian Sea and, later, in the Faroese zone (harvesting predominantly European-origin salmon). The rational management of these fisheries required international cooperation, the forum for which was created in 1984 with the establishment of the intergovernment North Atlantic Salmon Conservation Organization (NASCO). The development and subsequent regulation of these fisheries in terms of reported catch are illustrated in **Figure 4**. The Newfoundland and Labrador commercial fishery in Canada, which before its closure harvested US-origin salmon in addition to salmon returning to Canadian rivers, was also subject to a regulatory measure agreed in NASCO.

West Greenland Salmon Fishery The presence of salmon off West Greenland was first reported in the late eighteenth century and a fishery for local consumption purposes has probably been conducted since the beginning of the twentieth century. From 1960 to 1964 the landings by Greenlandic vessels using fixed gill nets increased from 60 tonnes to more than 1500 tonnes and increased further from 1965 when vessels from Denmark, Sweden, the Faroe Islands, and Norway joined the fishery and monofilament gill nets were introduced. From 1975 the fishery was restricted to Greenlandic vessels. The salmon harvested at West Greenland are almost exclusively one-sea-winter salmon that would return to rivers in North America (principally Canada, but harvests of US salmon were significant in comparison to the number of fish returning to spawn) and Europe (particularly the United Kingdom and Ireland) as multi-sea-winter salmon. During the 1990s, the proportion of salmon of North American origin in the catch has increased, comprising 90% of samples in 1999.

International agreement on regulation of the harvests at West Greenland first occurred in 1972 when the International Commission for the Northwest Atlantic Fisheries (ICNAF) endorsed a US–Danish bilateral agreement to limit the catch to 1100 tonnes (adjusted to 1191 tonnes in 1974). This quota, with small adjustments to take account of delays in the start of the seasons in 1981 and 1982, applied until 1984, since when regulatory measures have been developed within NASCO. Details of these measures are given in **Table 3**.

Northern Norwegian Sea Fishery Seven years after the start of the West Greenland fishery, a salmon fishery involving, at different times, vessels from Denmark, Norway, Sweden, Finland, Germany, and the Faroe Islands commenced in the Northern Norwegian Sea. Initially drift nets were used, but the vessels soon changed to longlines. Prior to 1975, the fishery was conducted over a large geographical area between 68°N and 75°N and between the Greenwich meridian and 20°E. However, following

Table 3 Regulatory measures agreed by NASCO for the West Greenland salmon fishery

Year	*Allowable catch* (tonnes)	*Comments/other measures*
1984	870	
1985	–	Greenlandic authorities unilaterally established quota of 852 t.
1986	850	Catch limit adjusted for season commencing after 1 August.
1987	850	Catch limit adjusted for season commencing after 1 August.
1988–1990	2520	Annual catch in any year not to exceed annual average (840 t) by more than 10%. Catch limit adjusted for season commencing after 1 August.
1991	–	Greenlandic authorities unilaterally established quota of 840 t.
1992	–	No TAC imposed by Greenlandic authorities but if the catch in first 14 days of the season had been higher compared to the previous year, a TAC would have been imposed.
1993	213	
1994	159	
1995	77	
1996	–	Greenlandic authorities unilaterally established a quota of 174 t.
1997	57	
1998	Internal consumption fishery only	Amount for internal consumption in Greenland has been estimated to be 20 t.
1999	Internal consumption fishery only	Amount for internal consumption in Greenland has been estimated to be 20 t.
2000	Internal consumption fishery only	Amount for internal consumption in Greenland has been estimated to be 20 t.

TAC, total allowable catch.

the extension of fishery limits to 200 nautical miles, the fishery shifted westward to the area between the Norwegian fishery limit and Jan Mayen Island. The catch peaked at almost 950 tonnes in 1970. In response to the rapid escalation of this fishery, the North-East Atlantic Fisheries Commission (NEAFC) adopted a variety of measures intended to stabilize harvests, although a proposal to prohibit high-seas salmon fishing failed to obtain unanimous approval. However, this fishery ceased to exist in 1984 as a result of the prohibition on fishing for salmon beyond areas of fisheries jurisdiction in the Convention for the Conservation of Salmon in the North Atlantic Ocean (the NASCO Convention).

In the period 1989–94 vessels were identified fishing for salmon in international waters. These vessels were based mainly in Denmark and Poland and some had re-registered to Panama in order to avoid the provisions of the NASCO Convention. On the basis of information on the number of vessels, the number of trips per year, and known catches, ICES has provided estimates of the harvest (tonnes) as follows:

1990	1991	1992	1993	1994
180–350	25–100	25–100	25–100	25–100

Following diplomatic initiatives by NASCO and its Contracting Parties there have been no sightings of vessels fishing for salmon in international waters in the North-East Atlantic since 1994. NASCO is cooperating with coastguard authorities in order to coordinate and improve surveillance activities.

Faroes Salmon Fishery During the period 1967–78 exploratory fishing for salmon was conducted off the Faroe Islands using floating longlines. During this period no more than nine Faroese vessels were involved in the fishery and the catches, which were mainly of one-sea-winter salmon, did not exceed 40 tonnes. During the period 1978–85 Danish vessels also participated in the fishery and in 1980 and 1981 there was a marked increase in fishing effort and catches. As the fishery developed, it moved farther north and catches were dominated by two-sea-winter salmon. The salmon caught in the fishery are mainly of Norwegian and Russian origin. Initially negotiations on regulatory measures for the Faroese fishery were conducted on a bilateral basis between the Faroese authorities and the European Commission. Since 1984, the fishery has been regulated through NASCO. Details of these measures are given in **Table 4**.

Compensation Arrangements In the period 1991–98 the North Atlantic Salmon Fund (NASF) entered into compensation arrangements with the Faroese salmon fishermen. Similar arrangements were in place at West Greenland in 1993 and 1994. Under these arrangements the fishermen in these

Table 4 Regulatory measures agreed by NASCO for the Faroese salmon fishery

Year	*Allowable catch* (tonnes)	*Comments/other measures*
1984/85	625	
1986	–	
1987–1989	1790	Catch in any year not to exceed annual average (597 t) by more than 5%.
1990–1991	1100	Catch in any year not to exceed annual average (550 t) by more than 15%.
1992	550	
1993	550	
1994	550	
1995	550	
1996	470	No more than 390 t of the quota to be allocated if fishing licenses issued.
1997	425	No more than 360 t of the quota to be allocated if fishing licenses issued.
1998	380	No more than 330 t of the quota to be allocated if fishing licenses issued.
1999	330	No more than 290 t of the quota to be allocated if fishing licenses issued.
2000	300	No more than 260 t of the quota to be allocated if fishing licenses issued.

Note: The quotas for the Faroe Islands detailed above were agreed as part of effort limitation programs (limiting the number of licenses, season length, and maximum number of boat fishing days) together with measures to minimize the capture of fish less than 60 cm in length. The measure for 1984/85 did not set limits on the number of licenses or the number of boat fishing days.

countries were paid not to fish the quotas agreed within NASCO. As a result of the permanent closure of the Northern Norwegian sea fishery, regulatory measures agreed by NASCO, and compensation arrangements, the proportion of the total North Atlantic catch taken in the distant water fisheries declined from an average of 21% in the 1970s to an average of only 4% in the 1990s.

Home Water Fisheries

Management measures introduced in home water fisheries partly for domestic reasons and partly under the process of 'putting your own house in order before expecting others to make or continue to make sacrifices' have also resulted in major changes in the level and pattern of exploitation of Atlantic salmon.

In Canada, approximately Can$80 million was invested in the period 1972–99 to reduce the number of commercial salmon fishing licenses. No commercial salmon fishing licenses were issued in the year 2000. Drift netting for salmon was prohibited in Scotland in 1962 and in Norway in 1989. Between 1970 and 1999, the number of fixed commercial gears in Norway has been reduced by 68%. Similarly, in the United Kingdom and Ireland there have been reductions in netting effort. In Scotland the reduction in effort between 1970 and 1999 was 83%. In England and Wales there has been a 53% reduction in the number of salmon netting licenses issued over the last 25 years. It is the UK government's policy to phase out fisheries in coastal waters that exploit stocks from more than one river. In Ireland, there has been a reduction in netting effort of at least 20% since 1997.

Recreational fisheries have also been subject to restrictive management measures. In the United States, the recreational fishery was restricted to catch-and-release fishing and in the year 2000 closed completely with the exception of a fishery in the Merrimack River based on releases of surplus hatchery broodstock. In Canada, daily and seasonal catch limits have been reduced, mandatory catch-and-release has been introduced, and where conditions require, individual rivers have been closed to fishing. In England and Wales, measures were introduced in 1999 to protect early running salmon by delaying the start of the netting season to 1 June and by requiring anglers to return salmon to the water before 16 June. Catch-and-release fishing is becoming increasingly commonplace. In 1999, 100%, 77%, 49%, 44% and 29% of the total rod catch in the United States, Russia, Canada, England and Wales, and Scotland respectively, was released.

While these examples highlight the severe nature of the restrictions on fisheries, all countries around the North Atlantic have introduced measures

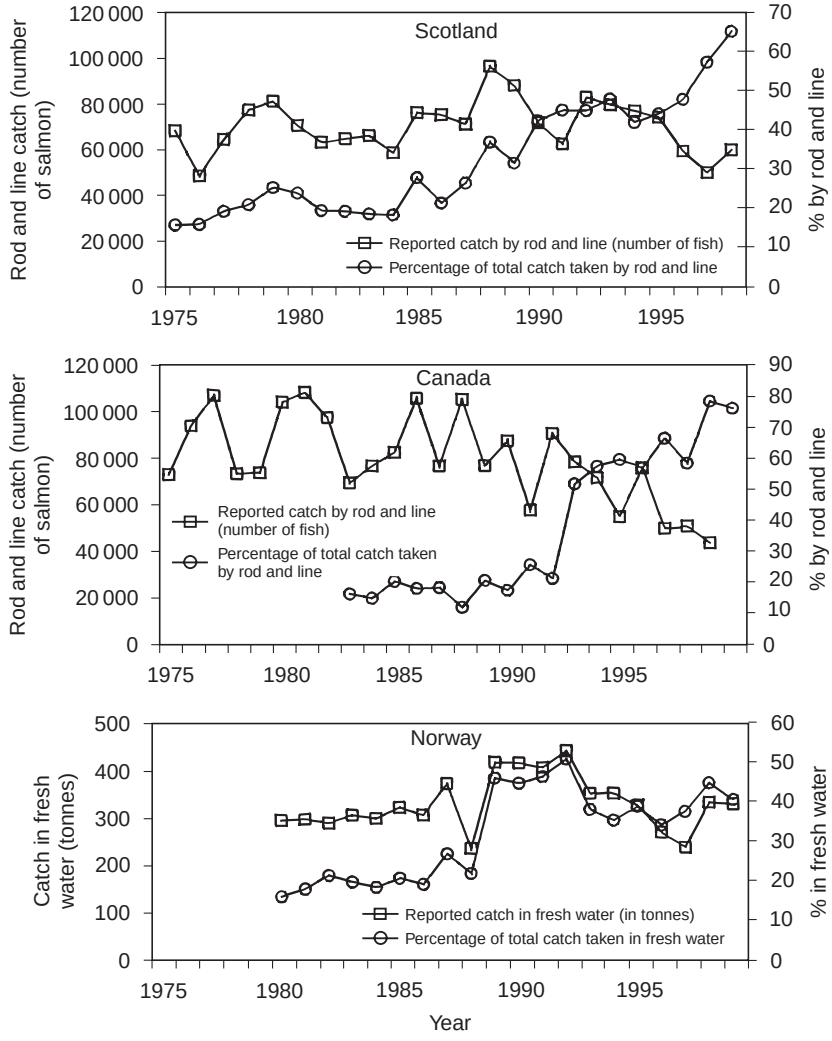

Figure 5 Reported catches (tonnes) of Atlantic salmon by rod and line (Scotland and Canada) or in fresh water (Norway) expressed as number or weight of fish and as a percentage of the total catch. Source of data: Scottish Rural Affairs Department, Edinburgh; Canadian Department of Fisheries and Oceans, Ottawa; Norwegian Directorate for Nature Management, Trondheim.

designed to conserve the resource. One result of these measures has been to change the pattern of exploitation, with rod fisheries taking an increasing proportion of the total catch. This trend is illustrated for Canada, Norway and Scotland in **Figure 5**. Exploitation is, therefore, increasingly occurring in fresh water rather than at sea, and is focused more on individual river stocks.

Management of Salmon Fisheries Under a Precautionary Approach

Concern about the status of salmon stocks in the North Atlantic has given rise to the adoption of a precautionary approach to salmon management by NASCO and its Contracting Parties. This approach, which will guide management of North Atlantic salmon fisheries in the twenty-first century, means that there is a need for caution when information is uncertain, unreliable, or inadequate and that the absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures. The precautionary approach requires, *inter alia*, consideration of the needs of future generations and avoidance of changes that are not potentially reversible; prior identification of undesirable outcomes and of measures that will avoid them or correct them; and that priority be given to conserving the productive capacity of the resource where the likely impact of resource use is uncertain. A decision structure for the management of North

1. **Is the stock threatened by external factors (e.g., acidification, disease)***?*
   If yes, take special management action as appropriate (e.g., establish gene bank).
   If no, go to (2).
2. **Assess status of the stock (abundance and diversity)**
   (a) Have age-specific conservation limits been set?
      (i) If yes, is the conservation limit being exceeded according to agreed compliance criteria (e.g., 3 out of 4 years)?
      (ii) If no, assess other measures of abundance.
   (b) Is the stock meeting other diversity criteria?
3. **If either abundance or diversity are unsatisfactory, then seek to identify the reasons**
   (a) Immediately implement pre-agreed procedures to introduce appropriate measures to address reasons for failure (including stock rebuilding programs).
   (b) Monitor the effect of the measures and take the results into account in future management and assessment; include identification of information gaps, process, and timeframe for resolution.
4. **If both abundance and diversity are satisfactory**
   (a) Implement pre-agreed management actions to permit harvest of the surplus taking into account uncertainty (where appropriate use management targets to establish the exploitable surplus).
   (b) Monitor the effect of the measures and take the results into account in future management and assessment; include identification of information gaps, process and timeframe for resolution.

Figure 6 Decision structure for implementing the precautionary approach to management of single stock salmon fisheries.

1. **Identify river stocks that are available to the fishery**
2. **Identify stock components that are exploited by the fishery**
3. **Assess abundance and diversity of individual stocks contributing to the fishery**
4. **Are abundance and diversity satisfactory (consider the percentage of stocks that are unsatisfactory and the extent of failure for each stock)***?*
   (a) If yes, go to (5).
   (b) If no, consider closing the fishery (taking into account socioeconomic factors). If the decision is made not to close the fishery, then continue to (5).
5. **Are the combined conservation limit(s) for all stocks subject to the fishery being exceeded***?*
   (a) If yes, implement pre-agreed procedures for the management of the fishery based on effort or quota control:
      - *Quota control*
        – define management target based on an assessment of risk of failing conservation limits
        – predict prefishery abundance
        – determine exploitable surplus
        – apply pre-agreed rules on setting quotas
      - *Effort control* (and quota control in the absence of management targets and/or prediction of prefishery abundance)
        – evaluate effectiveness of previous effort control measures and apply appropriate changes.
   (b) If no, consider closing the fishery, taking into account socioeconomic factors. If the decision is made not to close the fishery, apply pre-agreed reserve measures to minimize exploitation.
6. **Monitor the effect of the measures and take the results into account in future management and assessment; include identification of information gaps, process, and timeframe for resolution**

Figure 7 Decision structure for implementing the precautionary approach to mixed stock salmon fisheries.

Atlantic salmon fisheries has been adopted by NASCO on a preliminary basis. This decision structure is shown in **Figures 6** and **7** for single stock (i.e., exploiting salmon from one river) and mixed stock (i.e., exploiting salmon from more than one river) fisheries, respectively.

In short, salmon fisheries changed greatly in the last four decades of the twentieth century and the development of salmon farming had a marked effect on these fisheries. There is great concern about the future of the wild stocks and the fisheries continue to undergo critical re-examination.

See also

Fishery Management. Fishing Methods and Fishing Fleets. Salmonid Farming. Salmonids.

Further Reading

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Introduction

Pacific salmon comprise six species of anadromous salmonids that spawn in fresh water from central California in North America across the North Pacific Ocean to Korea in Asia: chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), and masu or cherry salmon (*O. masou*). Pacific salmon spawn in rivers, streams, and lakes where they die soon after spawning. Most juveniles migrate to the ocean as smolts, where they spend a significant portion of their life cycle. The length of freshwater and marine residence varies by species and the life span ranges from 2 years for pink salmon to as much as 7 or 8 years for some chinook salmon populations. Spawning runs of adult salmon have contributed an important source of protein for human cultures as well as a large influx of marine nutrients into terrestrial ecosystems. Large runs of mature fish returning from the sea every year have been highly visible to people living near rivers and salmon have historically assumed a role in the lives of people that extends beyond subsistence and commerce. Salmon became part of the social fabric of the cultures with which they interacted, and this significance continues today.

History

Salmon played an important role in the lives of people long before the arrival of Europeans on the