Home construction and urbanization have contributed to sedimentation and chemical pollution, and have increased the amount of impervious surface, increasing the variability in stream flow.

Collectively these impacts have eliminated many populations of Pacific salmon and have compromised the productivity of many remaining ones. Reduced productivity of natural stocks has increased their susceptibility to overharvest, and the construction of hatcheries to mitigate the impacts of water development projects and enhance fisheries has often exacerbated the problem by increasing competition between natural and hatchery fish and increasing the harvest pressure on all fish in the attempt to harvest hatchery fish. As a result, many natural populations are at critically low abundance where they are at higher risk of extirpation from random environmental and demographic variability or from catastrophic events. As a result, a number of distinct population segments of Pacific salmon and steelhead trout in the contiguous United States have been listed as threatened or endangered under the US Endangered Species Act. At the time of writing (2000) the listings include 17 distinct population segments of chinook, coho, chum, and sockeye salmon, and another 10 distinct population segments of steelhead trout. The additional regulatory complexities of dealing with listed species has greatly complicated the management of Pacific salmon fisheries in the USA.

In response to these listings, and critically low abundance of some Canadian stocks, harvest impacts on depressed stocks have been substantially reduced in the contiguous United States and British Columbia. Efforts are being made to reduce the combined negative impacts of habitat loss and degradation, overharvest, and the negative impacts of hatchery production. Fishery scientists and managers are exploring changes in harvest practices to allow more selective harvest of hatchery stocks and healthy natural stocks while reducing impacts on listed stocks.

See also

El Niño Southern Oscillation (ENSO). Fishing Methods and Fishing Fleets. International Organizations. Law of the Sea. Ocean Ranching. Salmonid Farming. Salmonids.

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SALMONIDS

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Introduction

The Atlantic and Pacific salmon and related members of the Salmonidae are anadromous fish, breeding in fresh water and migrating to sea as juveniles at various ages where they feed voraciously and grow fast. Survival at sea is dependent on exploitation, sea surface temperature, ocean climate and predation. Their return migration to breed reveals a remarkable homing instinct based on various guidance mechanisms. Some members of the family, however, are either not anadromous or have both anadromous and nonanadromous forms.

Taxonomy

The Atlantic salmon (*Salmo salar*) and the seven species of Pacific salmon (*Oncorhynchus*) are members of one of the most primitive superorders of the teleosts, namely the Protacanthopterygii. The family Salmonidae includes the Atlantic and Pacific salmon, the trout (*Salmo* spp.), the charr (*Salvelinus* spp.) and huchen (*Hucho* spp.). The anatomical features that separate the genera *Salmo* and *Oncorhynchus* from the genus *Salvelinus* are the positioning of the teeth. In the former two genera the teeth form a double or zigzag series over the whole of the vomer bone, which is flat and not boat-shaped, whereas in the latter the teeth are restricted to the front of a boat-shaped vomer. In the genus *Salmo* there is only a small gap between the vomerine and palatine teeth but this gap is wide in adult *Oncorhynchus* and not in *Salmo*. A specialization occurring in *Oncorhynchus* and not in *Salmo* is the simultaneous ripening of all the germ cells so that these fish can only spawn once (semelparity). There are a number of anatomical features that help in the identification of the various species of *Salmo* and *Oncorhynchus*; these include scale and fin ray counts, the number and shape of the gill rakers on the first arch and the length of the maxilla in relation to the eye.

Origin

There has been much debate as to whether the Salmonidae had their origins in the sea or fresh water. Some scientists considered that the Salmonidae had a marine origin with an ancestor similar to the Argentinidae (argentines) which are entirely marine and, like the salmonids and smelts (Osmeridae), bear an adipose fin. Other scientists considered the salmonids to have had a freshwater origin, supporting their case by suggesting that since the group has both freshwater-resident and migratory forms within certain species there has been recent divergence. Furthermore, there are no entirely marine forms among modern salmonids so they can not have had a marine origin. The Salmonidae have been revised as relatively primitive teleosts of probable marine pelagic origin whose specializations are associated with reproduction and early development in fresh water. The hypothesis of the evolution of salmonid life histories through penetration of fresh water by a pelagic marine fish, and progressive restrictions of life history to the freshwater habitat, involves adaptations permitting survival, growth and reproduction there. The salmonid genera show several ranges of evolutionary progression in this direction, with generally greater flexibility among *Salmo* and *Salvelinus* than among *Oncorhynchus* species (**Table 1**). Evidence for this evolutionary progression is perhaps

Table 1 Examples of flexibility of life history patterns in salmonid genera: anadromy implies emigration from fresh water to the marine environment as juveniles and return to fresh water as adults; nonanadromy implies a completion of the life cycle without leaving fresh water, although this may involve migration between a river and a lake habitat

Genus	*Species*		
	Anadromous form only	*Both anadromous and nonanadromous forms*	*Nonanadromous form only*
Oncorhynchus	*gorbuscha* (pink salmon) *keta* (chum salmon) *tschawytscha* (chinook salmon)	*nerka* (sockeye salmon) *kisutch* (coho salmon) *masou* (cherry salmon) *rhodurus* (amago salmon) *mykiss* (steelhead/rainbow trout) *clarki* (cut throat trout)	*aguabonito* (golden trout)
Salmo	none	*salar* (Atlantic salmon) *trutta* (sea/brown trout)	
Salvelinus	none	*alpinus* (arctic charr) *fontinalis* (brook trout) *malma* (Dolly Varden) *leucomanis*	*namaycush* (lake trout)
Hucho	none	*perryi*	*hucho* (Danube salmon)

Adapted from Thorpe (1988).

even greater if one starts with the Argentinidae and Osmeridae which are basically marine coastal fishes. Some enter the rivers to breed, some live in fresh water permanently, and others such as the capelin (*Mallotus villosus*) spawn in the gravel of the seashore.

Life Histories

Members of the Salmonidae have a similar life history pattern but with varying degrees of complexity. A typical life history involves the female excavating a hollow in the river gravel into which the large yolky eggs are deposited and fertilized by the male. Because of egg size and the protection afforded them in the gravel the fecundity of the Salmonidae is low when compared with species such as the herring and the cod which are very fecund but whose eggs have no protection. On hatching the salmonid young (alevins) live on their yolk sac within the gravel for some weeks depending on water temperature. On emerging the fry may remain in the freshwater environment for a varying length of time (**Table 2**) changing as they grow into the later stages of parr and then smolt, at which stage they go to sea (**Figure 1**). Not all the Salmonidae have a prolonged freshwater life before entering the sea, and the juveniles of some species such as the pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) migrate to sea on emerging from the gravel. Others such as the sockeye salmon (*O. nerka*) have specialized freshwater requirements, namely the need for a lacustrine environment to which the young migrate on emergence (**Table 2**).

Distribution

Atlantic Salmon

The Atlantic salmon occurs throughout the northern Atlantic Ocean and is found in most countries whose rivers discharge into the North Atlantic Ocean and Baltic Sea from rivers as far south as Spain and Portugal to northern Norway and Russia and one river in Greenland. It has been introduced to some countries in the Southern Hemisphere, including New Zealand where they only survive as a land-locked form.

Sea Trout

The marine distribution of the anadromous form of *S. trutta* is confined to coastal and near-offshore waters and is not found in the open ocean. It has a more limited distribution than the salmon being confined mainly to the eastern seaboard of the North Atlantic, although it has been introduced includes Iceland, and the Faroe Islands, Scandinavia, the Cheshkaya Gulf in the north, throughout the Baltic and down the coast of Europe to northern Portugal. It occurs as a subspecies in the Black Sea (*S. trutta labrax*) and Caspian Sea (*S. trutta caspius*). It has been introduced to countries in the Southern Hemisphere including Chile and the Falkland Islands.

Sockeye Salmon

The natural range of the sockeye, as other species of Pacific salmon, is the temperate and subarctic waters of the North Pacific Ocean and the northern

Table 2 Life histories

Species	*Length of freshwater life* (years)	*Particular features*
Oncorhynchus nerka	1–3	Lake environment required for juveniles
O. gorbuscha	Migrate to estuarine waters on emergence	Tend to spawn closer to sea than other oncorhynchids, and may frequent smaller river systems
O. keta	Migrate to estuarine waters on emergence	Spawning takes place in lower reaches of rivers
O. tschawytscha	Some migrate to estuary on emergence, others remain in fresh water for one or more years	Two races: *anadromous*, long freshwater residence *semelparous*, short freshwater residence
O. kisutch	1–2	Tend to utilize small coastal streams
O. masou	1–2	Large parr become smolts and go to sea Small to medium-sized parr remain in fresh water
Salmo salar	1–7	A small percentage spawn more than once. 'Land-locked' forms live in lakes and spawn in afferent or efferent rivers
S. trutta	1–4 (anadromous form)	May spawn frequently, the anadromous form after repeat spawning migrations
S. alpinus	2–6	Anadromous form only occurs in rivers lying north of 60°N

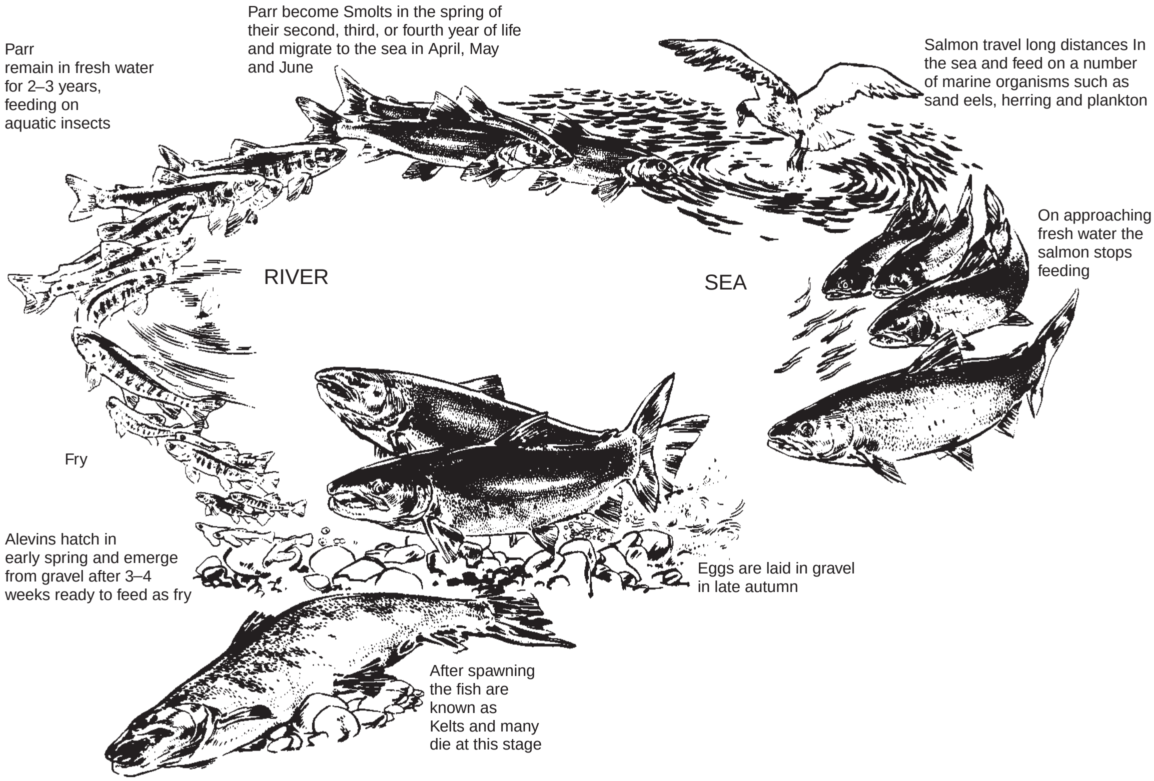

Figure 1 Life cycle of the Atlantic salmon. (Reproduced from Mills, 1989.)

adjoining Bering Sea and Sea of Okhotsk. However, because sockeye usually spawn in areas associated with lakes, where their juveniles spend their freshwater existence before going to sea, their spawning distribution is related to north temperate rivers with lakes in their systems. The Bristol Bay watershed in southwestern Alaska and the Fraser River system are therefore the major spawning areas for North American sockeye.

Pink Salmon

The natural freshwater range of pink salmon embraces the Pacific coast of Asia and North America north of 40°N and during the ocean feeding and maturation phase they are found throughout the North Pacific north of 40°N. The pink is the most abundant of the Pacific salmon species followed by the chum and sockeye in that order. Pink salmon have been transplanted outside their natural range to the State of Maine, Newfoundland, Hudson Bay, the North Kola Peninsula and southern Chile.

Chum Salmon

The chum occurs throughout the North Pacific Ocean in both Asian and North American waters north of 40°N to the Arctic Ocean and along the western and eastern arctic seaboard to the Lena River in Russia and the Mackenzie River in Canada.

Chinook Salmon

The chinook has a more southerly distribution than the other Pacific salmon species, extending as far south as the Sacramento–San Joaquin River system in California as well as into the northerly waters of the Arctic Ocean and Beaufort Sea. It has been transplanted to the east coast of North America, the Great Lakes, south Chile and New Zealand.

Coho Salmon

The coho is the least abundant of the Pacific salmon species but has a similar distribution as the other species. It has been introduced to the Great Lakes, some eastern states of North America and Korea and Chile.

Masu Salmon

This species only occurs in Far East Asia, in the Sea of Japan and Sea of Okhotsk. Some have been transported to Chile. The closely related amago salmon mainly remain in fresh water but some do migrate to coastal waters but few to the open sea.

Arctic Charr

The anadromous form of this species has a wide distribution throughout the subarctic and arctic regions of the North Atlantic north of 40°N. It enters rivers in the late summer and may remain in fresh water for some months.

Migrations

Once Atlantic salmon smolts enter the sea and become postsmolts they move relatively quickly into the ocean close to the water surface. Patterns of movement are strongly influenced by surface water currents, wind direction and tidal cycle. In some years postsmolts have been caught in the near-shore zone of the northern Gulf of St Lawrence throughout their first summer at sea, and in Iceland some postsmolts, mainly maturing males, forage along the shore following release from salmon-ranching stations. These results indicate that the migratory behavior of postsmolts can vary among populations. Pelagic trawl surveys conducted in the Iceland/Scotland/Shetland area during May and June and in the Norwegian Sea from 62°N to 73°N in July and August, have shown that postsmolts are widely distributed throughout the sampled area, although they do not reach the Norwegian Sea until July and August. Over much of the study area, catches of postsmolts are closely linked to the main surface currents, although north of about 64°N, where the current systems are less pronounced, postsmolts appear to be more diffusely distributed.

Young salmon from British Columbia rivers descend in discontinuous waves, and it has been suggested that this temporal pattern has evolved in response to short-term fluctuations in the availability of zooplankton prey. Although zooplankton production along the British Columbia coast is adequate to meet this seasonal demand, there is debate about the adequacy of the Alaska coastal current to support the vast populations of growing salmon in the summer. Density-dependent growth has been shown for the sockeye salmon populations at this time, suggesting that food can be limiting.

The movements of salmon in offshore waters are complex and affected by physical factors such as season, temperature and salinity and biological factors such as maturity, age, size and food availability and distribution of food organisms and stock-of-origin (i.e. genetic disposition to specific migratory patterns). Through sampling of stocks of the various Pacific salmon at various times of the year over many years scientists have been able to construct oceanic migration patterns of some of the major stocks of North American sockeye, chum and pink salmon (**Figure 2**) as well as for stocks of chinook and masu salmon. Similarly, as a result of ocean surveys and tagging experiments it has been possible to determine the migration routes of North American Atlantic salmon very fully (**Figures 3** and **4**). A picture of the approximate migration routes of Atlantic salmon in the North Atlantic area as a whole has been achieved from tag recaptures (**Figure 5**).

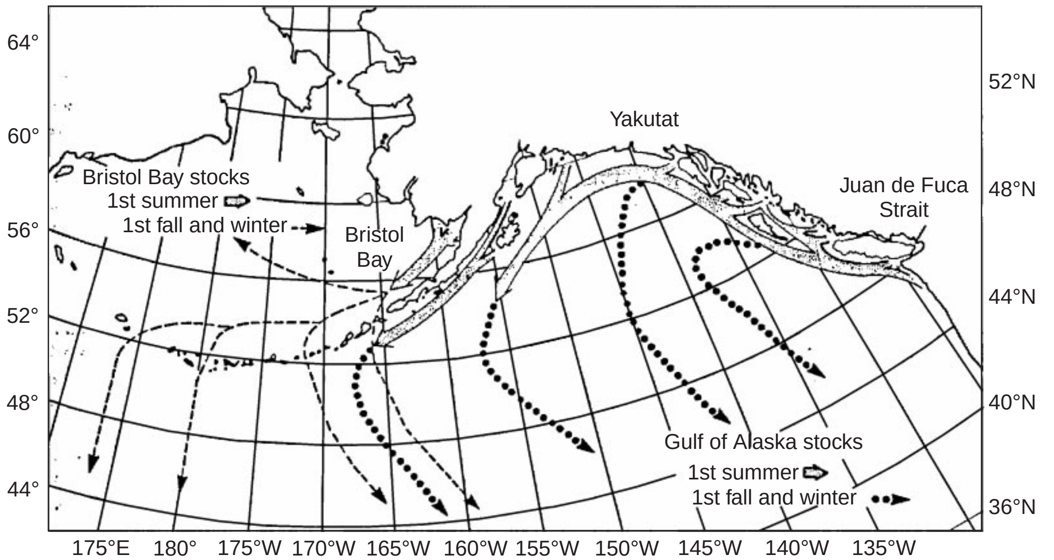

Figure 2 Diagram of oceanic migration patterns of some major stocks of North American sockeye, chum and pink salmon during their first summer at sea, plus probable migrations during their first fall and winter. (Reproduced from Burgner, 1991.)

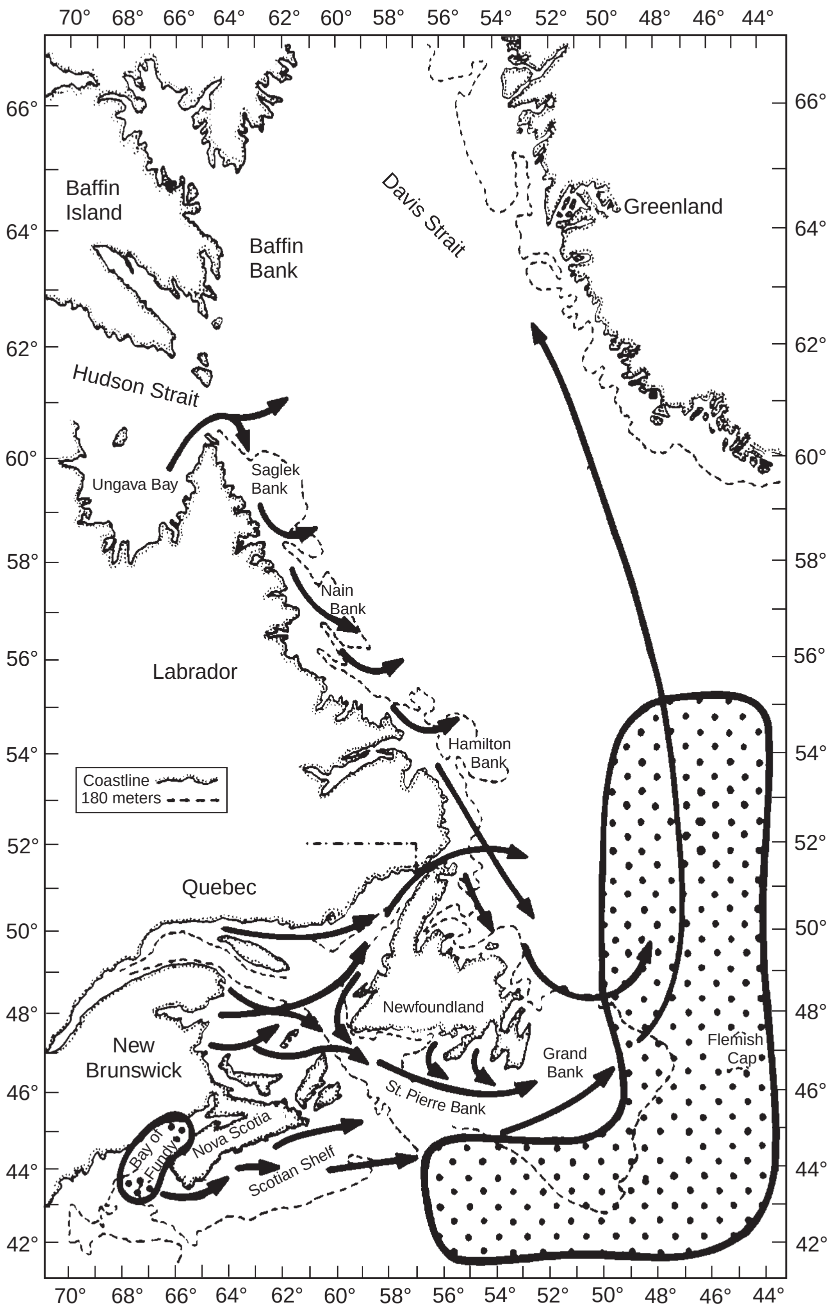

Figure 3 The migration routes for Atlantic salmon smolts away from coastal areas showing possible overwintering areas and movement of multi-sea winter salmon into the West Greenland area. Arrows indicate the path of movement of the salmon, and dotted area indicates the overwintering area. (Reproduced from Reddin, 1988.)

Movements

Vertical and horizontal movements of Atlantic salmon have been investigated using depth-sensitive tags and data storage tags. Depth records show that salmon migrate mostly in the uppermost few meters and often show a diel rhythm in vertical movements. The salmon are closest to the surface at mid-day and go deeper at night. They have been recorded diving to a depth of 110 m.

Available information from research vessels and operation of commercial Pacific salmon fisheries suggest that Pacific salmon generally occur in near-surface waters.

Details of rates of travel are given in **Table 3.**

Food

The marine diet of both Pacific and Atlantic salmon comprises fish and zooplankton. The proportion of fish and zooplankton in their diet varies with season, availability and area. Among the fish species sockeye eat capelin (*Mallotus villosus*), sand eels (*Ammodytes hexapterus*), herring (*Clupea harengus pallasi*) and pollock (*Theragra chalcogramma*). Zooplankton organisms include euphausiids, squid, copepods and pteropods.

The diet of pink salmon includes fish eggs and larvae, squid, amphipods, euphausiids and copepods, whereas chum salmon were found to take pteropods, salps, euphausiids and amphipods. Chinook salmon eat herring, sand eels, pilchards and anchovies and in some areas zooplankton never exceeds 6% of the diet. However, the diet varies

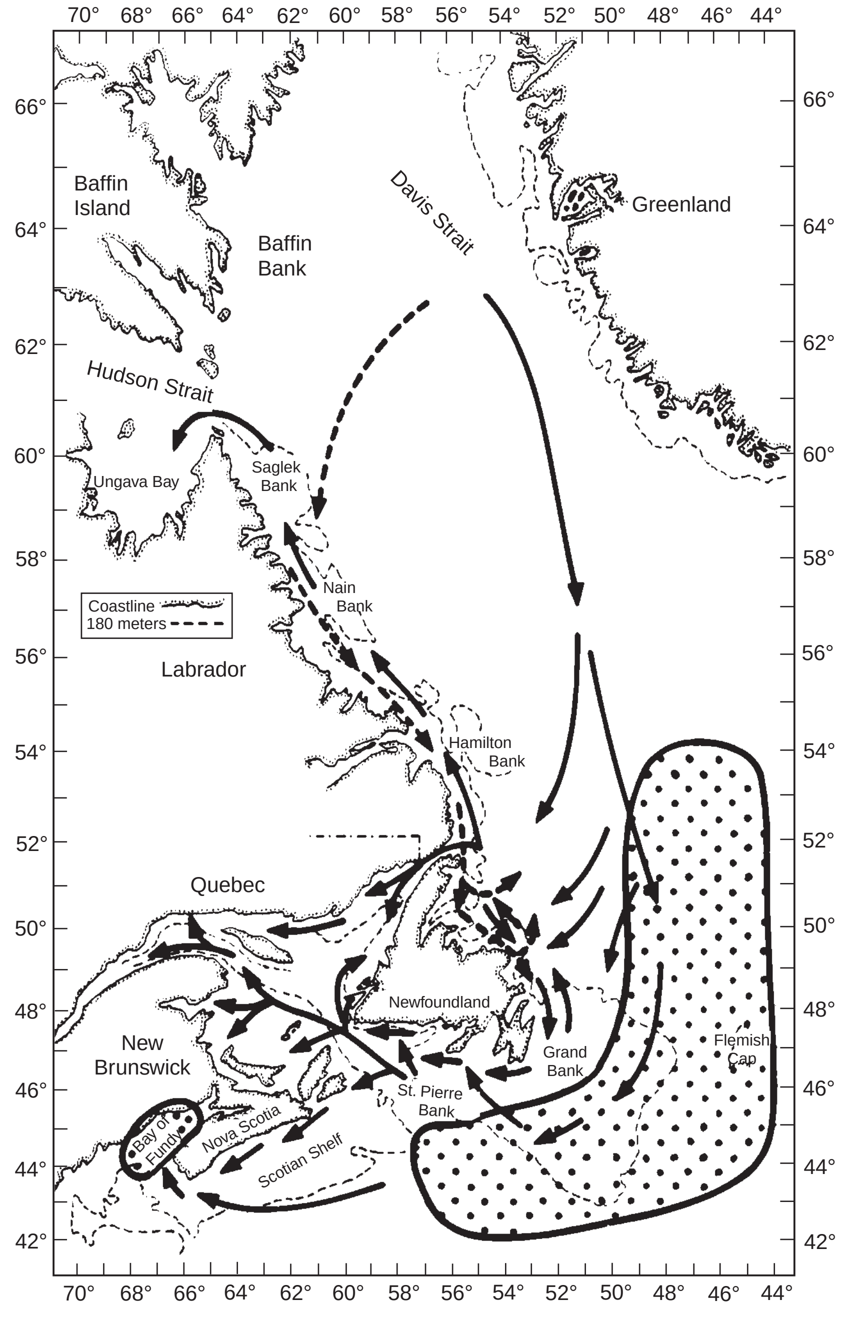

Figure 4 The migration routes of salmon from West Greenland and overwintering areas on return routes to rivers in North America. Solid arrows indicate migration in mid-summer and earlier; broken arrows indicate movement in late summer and fall; dotted areas are the wintering areas. (Reproduced from Reddin, 1988.)

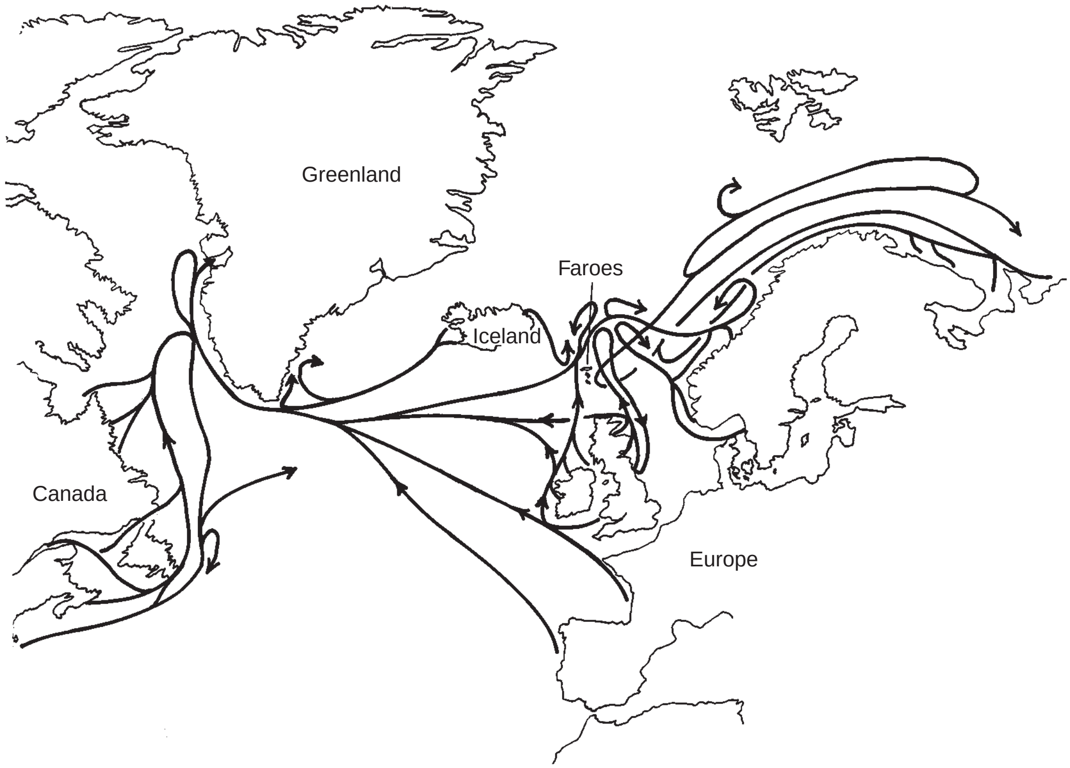

Figure 5 Approximate migration routes of Atlantic salmon in the North Atlantic area. (Reproduced from Mills, 1989.)

Table 3 Rates of travel in the sea of Atlantic and Pacific salmon

Species	*Rate of travel* (km day^{-1})	*Conditions*
Atlantic salmon	19.5–24	Icelandic postsmolts from ranching stations
	15.2–20.7	Postsmolts based on smolt tag recaptures
	22–52	Grilse and large salmon
	32	Average for maturing salmon of all sea ages
	26	For previous spawners migrating to Newfoundland and Greenland
	28.8–43.2	Icelandic coastal waters
	10–50	Baltic Sea
Sockeye salmon	46–56	During their final 30–60 days at sea
Pink salmon	17.2–19.8	Juveniles during first 2–3 months at sea
	45–54.3	Fish recovered at sea and in coastal waters
	43.3–60.2	For eastern Kamchatka stocks tagged in Aleutian Island passes or the Bering Sea
Coho salmon	30	
	55	Could be maintained over long distances

considerably from area to area and up to 21 different taxonomic groups have been recorded in this species' diet. Similarly, the diet of coho salmon is a varied one, with capelin, sardines, lantern fish (myctophids), other coho salmon, being eaten along with euphausiids, squid, goose barnacles and jellyfish.

Masu salmon eat mainly small-sized fish and squid and large zooplankton such as amphipods and euphausiids. Fish species taken include capelin, herring, Dolly Varden charr, Japanese pearlside (*Maurolicus japonicus*), saury (*Cololabis saira*), sand eels, anchovies, greenlings (*Hexagrammos otakii*) and sculpins (*Hemilepidotus* spp.).

There is no evidence of selective feeding among sockeye, pink and chum salmon.

The food of Atlantic salmon postsmolts is mainly invertebrate consisting of chironomids and gammarids in the early summer in inshore waters and in the late summer and autumn the diet changes to one of small fish such as sand eels and herring larvae. A major dietary study of 4000 maturing Atlantic salmon was undertaken off the Faroes and it confirmed the view that salmon forage opportunistically, but that they demonstrate a preference for fish rather than crustaceans when both are available. They are also selective when feeding on crustaceans, preferring hyperiid amphipods to euphausiids. Feeding intensity and feeding rate of Atlantic salmon north of the Faroes have been shown to be lower in the autumn than in the spring, which might suggest that limited food is available at this time of year. Similar results have been found for Atlantic salmon in the Labrador Sea and in the Baltic. Salmon in the north Atlantic also rely on amphipods in the diet in the autumn, whereas at other times fish are the major item. Fish taken include capelin, herring, sprat (*Clupea sprattus*), lantern fishes, barracudinas and pearlside (*Maurolicus muelleri*).

Predation

Marine mammals recorded predating on Pacific salmon include harbour seal (*Phoca vitulina*), fur seal (*Callorhinus uresinus*), Californian sea lion (*Zalophus grypus*), humpbacked whale (*Megaptera novaeangliae*) and Pacific white-sided dolphin (*Lagenorhynchus obliquideus*). Pinniped scar wounds on sockeye salmon, caused by the Californian sea lion and harbor seal, increased from 2.8% in 1991 to 25.9% in 1996 and on spring-run chinook salmon they increased from 10.5% in 1991 to 31.8% in 1994.

Predators of Atlantic salmon postsmolts include gadoids, bass (*Dicentrarchus labrax*), gannets (*Sula bassana*), cormorants (*Phalacrocorax carbo*) and Caspian terns (*Hydroprogne tschegrava*). Adult fish are taken by a number of predators including the grey seal (*Halichoerus grypus*), the common seal (*Phoca vitulina*), the bottle-nosed dolphin (*Tursiops truncatus*), porbeagle shark (*Lamna cornubica*), Greenland shark (*Somniosus microcephalus*) and ling (*Molva molva*).

Environmental Factors

Surface Salinity

Salinity may have an effect on fish stocks and it has been shown that the great salinity anomaly of the 1970s in the North Atlantic adversely affected the spawning success of eleven of fifteen stocks of fish whose breeding grounds were traversed by the anomaly. In the North Pacific there was found to be little relation between the high seas distribution of sockeye salmon and surface salinity. Sockeye are distributed across a wide variety of salinities, with low salinities characterizing 'salmon waters' of the Subarctic Pacific Region.

Sea Surface Temperature

Sockeye salmon are found over a wide variety of conditions. Sea surface temperature (SST) has not been found to be a strong and consistent determinant of sockeye distribution, but it definitely influences distribution and timing of migrations. Sockeye tend to prefer cooler water than the other Pacific salmon species.

Temperature ranges of waters yielding catches of various salmon species in the northwest Pacific in winter are: sockeye, 1.5–6.0°C; pink, 3.5–8.5°C; chum, 1.5–10.0°C; coho, 5.5–9.0°C.

A significant relationship was found for SST and Atlantic salmon catch rates in the Labrador Sea, Irminger sea and Grand Banks (**Figure 6**), with the greatest abundance of salmon being found in SSTs between 4 and 10°C. This significant relationship suggests that salmon may modify their movements at sea depending on SST. It has also been suggested that the number of returning salmon is linked to environmental change and that the abundance of salmon off Newfoundland and Labrador was linked to the amount of water of < 0°C on the shelf in summer. In years when the amount of cold water was large and the marine climate tended to be cold, there were fewer salmon returning to coastal waters. A statistically significant relationship has been found between the area of ice off Labrador and northern Newfoundland and the number of returning salmon

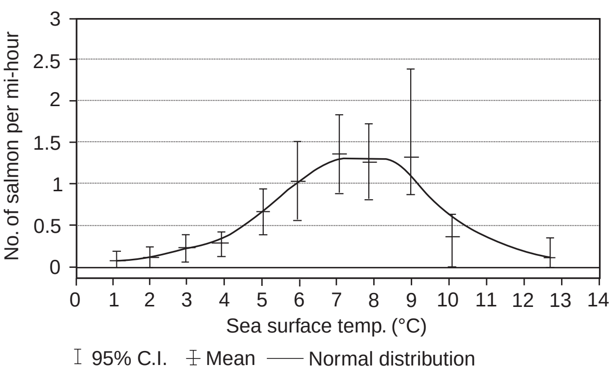

Figure 6 The relationship between sea surface temperatures and salmon catch rates from Labrador Sea, Irminger Sea and Grand Banks, 1965–91. (Reproduced from Reddin and Friedland, 1993.)

in one of the major rivers on the Atlantic coast of Nova Scotia. The timing and geographical distribution of Atlantic salmon along the Newfoundland and Labrador coasts have been shown to be dependent on the arrival of the 4°C water, salmon arriving earlier during warmer years.

In two Atlantic salmon stocks that inhabit rivers confluent with the North Sea a positive correlation was found between the area of 8–10°C water in May and the survival of salmon. An analysis of SST distribution for periods of good versus poor salmon survival showed that when cool surface waters dominated the Norwegian coast and the North Sea during May salmon survival has been poor. Conversely, when the 8°C isotherm has extended northward along the Norwegian coast during May, survival has been good.

Temperature may also be linked to sea age at maturity. An increase in temperature in the northeast Atlantic subarctic was found to be associated with large numbers of older (multi-sea winter) salmon and fewer grilse (one-sea winter salmon) returning to the Aberdeenshire Dee in Scotland.

Ocean Climate

Ocean climate appears to have a major influence on mortality and maturation mechanisms in salmon. Maturation, as evidenced by returns and survival of salmon of varying age, has been correlated with a number of environmental factors. The climate over the North Pacific is dominated by the Aleutian Low Pressure System. The long-term pattern of the Aleutian Low Pressure System corresponds with trends in salmon catch, with copepod production and with other climatic indices, indicating that climate and the marine environment may play an important role in salmon production. Survival of Pacific salmon species varies with fluctuations in large-scale circulation patterns such as El Niño Southern Oscillation (ENSO) events and more localized upwelling circulation that would be expected to affect local productivity and juvenile salmon growth. Runs of Pacific salmon in rivers along the western margin of North America stretching from Alaska to California vary on a decadal scale. When catches of a species are high in one region (e.g. Oregon) they may be low in another (e.g. Alaska). These changes are in part caused by marked interdecadal changes in the size and distribution of salmon stocks in the northeast Pacific, which are in turn associated with important ecosystem shifts forced by hydroclimatic changes linked to El Niño and possibly climate change.

Similarly, in the North Atlantic there have been annual and decadal changes in the North Atlantic Oscillation (NAO) index. Associated with these changes is a wide range of physical and biological responses, including effects on wind speed, ocean circulation, sea surface temperature, prevalence and intensity of Atlantic storms and changes in zooplankton production. For example, during years of positive NAO index, the eastern and western North Atlantic display increases in temperature while temperatures in central North Atlantic and in the Labradon Basin decline. The extremely low temperatures in the Labrador Sea during the 1980s coincided with a decline in salmon abundance. Similarly, in Europe, years of low NAO index were associated with high catches, whereas stocks have declined dramatically during high index years.

In the northeast Atlantic significant correlations were obtained between the variations in climate and hydrography with declines in primary production, standing crop of zooplankton and with reduced abundance and altered distribution of pelagic forage fishes and salmon catches.

By analogy with the North Pacific it is likely that changes in salmon abundance in the northeast Atlantic are linked to alterations in plankton productivity and/or structural changes in trophic transfer, each forced by hydrometeorological variability and possibly climate change as a result of the North Atlantic Oscillation and the Gulf Stream indexes.

Homing

It is suggested that homeward movement involves directed navigation. Fish can obtain directional information from the sun, polarized light, the earth's magnetic field and olfactory clues. Chinook and sockeye salmon have been shown capable of detecting changes in magnetic field. It has been suggested that migration from the feeding areas at sea to the natal stream must be accomplished without strictly retracing the outward migration using a variety of geopositioning mechanisms including magnetic and celestial navigation coordinated by an endogenous clock. Olfactory and salinity clues take over from geopositioning (bi-coordinate navigation) once in proximity of the natal stream because even small changes in declination during the time at sea correspond to a large search area for the home stream.

See also

El Niño Southern Oscillation (ENSO). Fish Feeding and Foraging. Fish Larvae. Fish Migration, Horizontal. Geophysical Heat Flow. North Atlantic Oscillation (NAO). Plankton.

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SALMONID FARMING

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Introduction

All salmonids spawn in fresh water. Some of them complete their lives in streams, rivers, or lakes but the majority of species are anadromous, migrating to sea as juveniles and returning to spawn as large adults after one or more years feeding. The farmed process follows the life cycle of the wild fish; juveniles are produced in freshwater hatcheries and smolt units and transferred to sea for ongrowing in floating sea cages. An alternative form of salmonid mariculture, ocean ranching, takes advantage of their accuracy of homing. Juveniles are released into rivers or estuaries, complete their growth in sea water and return to the release point where they are harvested.

The salmonids cultured in seawater cages belong to the genera *Salmo*, *Oncorhynchus*, and *Salvelinus*. The last of these, the charrs are currently farmed on a very small scale in Scandinavia; this article concentrates on the former two genera. The Atlantic salmon, *Salmo salar* is the subject of almost all production of fish of the genus *Salmo* (1997 worldwide production 640 000 tonnes) although a small but increasing quantity of sea trout (*Salmo trutta*) is produced (1997 production 7000 tonnes). Three species of *Oncorhynchus*, the Pacific salmon are farmed in significant quantities in cages, the chinook salmon (also known as the king, spring or quinnat salmon), *O. tshawytscha* (1997, 10 000 tonnes), the coho (silver) salmon, *O. kisutch* (1997, 90 000 tonnes) and the rainbow trout, *O. mykiss*. The rainbow trout (steelhead) was formerly given the scientific name *Salmo gairdneri* but following studies on its genetics and native distribution was reclassified as a Pacific salmon species. Much of the world rainbow trout production (1997, 430 000 tonnes) takes place entirely in fresh water although in some countries such as Chile part-grown fish are transferred to sea water in the same way as the salmon species.

Here, the history of salmonid culture leading to the commercial mariculture operations of today is reviewed. This is followed by an overview of the requirements for successful operation of marine salmon farms, constraints limiting developments and prospects for the future.