Salmon

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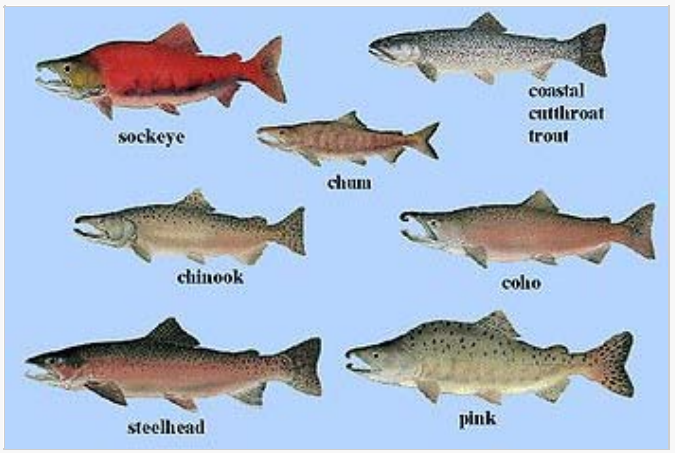
For other uses, see Salmon (disambiguation).

Salmon is the common name for several species of the family Salmonidae. Several other fish in the family are called trout; the difference is often said to be that salmon migrate and trout are resident, a distinction that holds true for the *Salmo* genus. Salmon live along the coasts of both the North Atlantic (one migratory species *Salmo salar*) and Pacific Oceans (approximately a dozen species of the genus *Oncorhynchus*), as well as having been introduced into the Great Lakes of North America.



Principal Pacific salmon species: sockeye, chum, coastal cutthroat trout, chinook, coho, steelhead and pink

Typically, salmon are anadromous: they are born in fresh water, migrate to the ocean, then return to fresh water to reproduce. However, there are populations of several species that are restricted to fresh water through their life. Folklore has it that the fish return to the exact spot where they were born to spawn; tracking studies have shown this to be true, and this homing behavior has been shown to depend on olfactory memory.[1] [2] Salmon are intensively produced in aquaculture in many parts of the world.

Contents [hide]

Life cycle [edit]

Eggs in different stages of development. In some only a few cells grow on top of the yolk, in the lower right the blood vessels surround the yolk and in the upper left the black eyes are visible, even the little lens

Salmon eggs are laid in freshwater streams typically at high latitudes. The eggs hatch into *alevin* or *sac fry*. The fry quickly develop into *parr* with camouflaging vertical stripes. The parr stay for 6 months to three years in their natal stream before becoming *smolts*, which are distinguished by their bright silvery colour with scales that are easily rubbed off. It is estimated that only 10% of all salmon eggs survive to this stage.[3] The smolt body chemistry changes, allowing them to live in salt water. Smolts spend a portion of their out-migration time in brackish water, where their body chemistry becomes accustomed to osmoregulation in the ocean.

Salmon fry hatching — the baby has grown around the remains of the yolk — visible are the arteries spinning around the yolk and little oildrops, also the gut, the spine, the main caudal blood vessel, the bladder and the arcs of the gills

The salmon spend about one to five years (depending on the species) in the open ocean where they gradually become sexually mature. The adult salmon then return primarily to their natal stream to spawn. In Alaska, the crossing-over to other streams allows salmon to populate new streams, such as those that emerge as a glacier retreats. The precise method salmon use to navigate has not been established, though their keen sense of smell is involved. Atlantic salmon spend between one and four years at sea. (When a fish returns after just one year's sea feeding it is called a *grilse* in Canada, the UK and Ireland.) Prior to spawning, depending on the species, salmon undergo changes. They may grow a hump, develop canine teeth, develop a *kype* (a pronounced curvature of the jaws in male salmon). All will change from the silvery blue of a fresh run fish from the sea to a darker color. Salmon can make amazing journeys, sometimes moving hundreds of miles upstream against strong currents and rapids to reproduce. Chinook and sockeye salmon from central Idaho, for example, travel over 900 miles (1,400 km) and climb nearly 7,000 feet (2,100 m) from the Pacific ocean as they return to spawn. Condition tends to deteriorate the longer the fish remain in fresh water, and they then deteriorate further after they spawn, when they are known as *kelts*. In all species of Pacific salmon, the mature individuals die within a few days or weeks of spawning, a trait known as semelparity. Between 2% and 4% of Atlantic salmon kelts survive to spawn again, all females. However, even in those species of salmon that may survive to spawn more than once (iteroparity), post-spawning mortality is quite high (perhaps as high as 40 to 50%.)

To lay her roe, the female salmon uses her tail (caudal fin), to create a low-pressure zone, lifting gravel to be swept downstream, excavating a shallow depression, called a *redd*. The redd may sometimes contain 5,000 eggs covering 30 square feet (2.8 m^2).[4] The eggs usually range from orange to red. One or more males will approach the female in her redd, depositing his sperm, or milt, over the roe.[5] The female then covers the eggs by disturbing the gravel at the upstream edge of the depression before moving on to make another redd. The female will make as many as 7 redds before her supply of eggs is exhausted.[5]

male ocean phase Chinook

Each year, the fish experiences a period of rapid growth, often in summer, and one of slower growth, normally in winter. This results in rings (annuli) analogous to the growth rings visible in a tree trunk. Freshwater growth shows as densely crowded rings, sea growth as widely spaced rings; spawning is marked by significant erosion as body mass is converted into eggs and milt.


male freshwater phase Chinook

Freshwater streams and estuaries provide important habitat for many salmon species. They feed on terrestrial and aquatic insects, amphipods, and other crustaceans while young, and primarily on other fish when older. Eggs are laid in deeper water with larger gravel, and need cool water and good water flow (to supply oxygen) to the developing embryos. Mortality of salmon in the early life stages is usually high due to natural predation and human-induced changes in habitat, such as siltation, high water temperatures, low oxygen concentration, loss of stream cover, and reductions in river flow. Estuaries and their associations wetlands provide vital nursery areas for the salmon prior to their departure to the open ocean. Wetlands not only help buffer the estuary from silt and pollutants, but also provide important feeding and hiding areas.

Species [edit]

The various species of salmon have many names, and varying behaviors.

Atlantic Ocean species [edit]

The Atlantic ocean has only one species of salmon, in the genus *Salmo*:


Atlantic salmon

- Atlantic salmon, or salmon, (*Salmo salar*) reproduce in northern rivers on both coasts of the ocean.
  - Land-locked salmon (*Salmo salar* m. *sebago*) live in a number of lakes in eastern North America and in Northern Europe, for instance in lakes Onega, Ladoga, Saimaa and Vänern. They are not a different species from the Atlantic salmon, but have independently evolved a non-migratory life cycle, which they maintain even when they can access the ocean.

Pacific Ocean species [edit]

Pacific species belong to the genus *Oncorhynchus*, some examples include;

- Cherry salmon or seema (*Oncorhynchus masou*) is found only in the western Pacific Ocean in Japan, Korea and Russia. There is also a landlocked subspecies known as the *Taiwanese salmon* or *Formosan salmon* (*Oncorhynchus masou formosanum*) in central Taiwan's Chi Chia Wan Stream.[6]
- Chinook salmon (*Oncorhynchus tshawytscha*) is also known in the USA as King or Blackmouth Salmon, and as Spring Salmon in British Columbia. Chinook are the largest of all Pacific salmon, frequently exceeding 30 lb (14 kg).[7] The name Tyee is used in British Columbia to refer to Chinook over 30 pounds. Chinook salmon are known to range as far north as the Mackenzie River and Kugluktuk in the central Canadian arctic.[8]
- Chum salmon (*Oncorhynchus keta*) is known as Dog, Keta, or Calico salmon in some parts of the USA. This species has the widest geographic range of the Pacific species:[9] south to the Sacramento River in California in the eastern Pacific and the island of Kyūshū in the Sea of Japan in the western Pacific; north to the Mackenzie River in Canada in the east and to the Lena River in Siberia in the west.
- Coho salmon (*Oncorhynchus kisutch*) is also known in the USA as Silver salmon. This species is found throughout the coastal waters of Alaska and British Columbia and up most clear-running streams and rivers. It is also now known to occur, albeit infrequently, in the Mackenzie River.[8]


Male ocean phase Coho salmon

- Pink salmon (*Oncorhynchus gorbuscha*), known as humpies in south east and south west Alaska, are found from northern California and Korea, throughout the northern Pacific, and from the Mackenzie River[8] in Canada to the Lena River in Siberia, usually in shorter coastal streams. It is the smallest of the Pacific species, with an average weight of 3.5 lb (1.6 kg) to 4 lb (1.8 kg).[10]
- Sockeye salmon (*Oncorhynchus nerka*) is also known in the USA as Red salmon.[11] This lake-rearing

species is found south as far as the Klamath River in California in the eastern Pacific and northern Hokkaidō Island in Japan in the western Pacific and as far north as Bathurst Inlet in the Canadian Arctic in the east and the Anadyr River in Siberia in the west. Although most adult Pacific salmon feed on small fish, shrimp and squid; sockeye feed on plankton that they filter through gill rakers.[5] Kokanee salmon is a land-locked form of sockeye salmon.

Other species [edit]

- The huchen or **Danube salmon** (*Hucho hucho*), the largest permanent fresh water salmonid species.

Salmon fisheries [edit]

Spawning sockeye salmon in Becharof Creek, Becharof Wilderness, Alaska

The salmon has long been at the heart of the culture and livelihood of coastal dwellers. Many people of the Northern Pacific shore had a ceremony to honor the first return of the year. For many centuries, people caught salmon as they swam upriver to spawn. A famous spearfishing site on the Columbia River at Celilo Falls was inundated after great dams were built on the river. The Ainu, of northern Japan, trained dogs to catch salmon as they returned to their breeding grounds *en masse*. Now, salmon are caught in bays and near shore.

Salmon population levels are of concern in the Atlantic and in some parts of the Pacific but in Alaska stocks are still abundant. Fish farming of Pacific salmon is outlawed in the United States Exclusive Economic Zone,[12] however, there is a substantial network of publicly funded hatcheries,[13] and the State of Alaska's fisheries management system is viewed as a leader in the management of wild fish stocks. Some of the most important Alaskan salmon sustainable wild fisheries are located near the Kenai River, Copper River, and in Bristol Bay. In Canada, returning Skeena River wild salmon support commercial, subsistence and recreational fisheries, as well as the area's diverse wildlife on the coast and around communities hundreds of miles inland in the watershed. The status of wild salmon in Washington is mixed. Out of 435 wild stocks of salmon and steelhead, only 187 of them were classified as healthy; 113 had an unknown status, 1 was extinct, 12 were in critical condition and 122 were experiencing depressed populations.[14] The Columbia River salmon population is now less than 3% of what it was when Lewis and Clark arrived at the river.[15] The commercial salmon fisheries in California have been either severely curtailed or closed completely in recent years, due to critically low returns on the Klamath and or Sacramento Rivers, causing millions of dollars in losses to commercial fishermen.[16] Both Atlantic and Pacific salmon are popular sportfish. Salmon populations now exist in all the Great Lakes. Coho stocks were planted in the late 1960s in response to the growing population of non-native alwifes by the state of Michigan. Now Chinook (King), Atlantic, and Coho (silver) salmon are annually stocked in all Great Lakes by mosts bordering states and provinces. These populations are not self sustaining and do not provide much in the way of a commercial fishery, but have led to the development of a thriving sportfishery.

Aquaculture [edit]

Main article: Salmon in aquaculture

Salmon farm in the archipelago of Finland.

Salmon aquaculture is the major economic contributor to the world production of farmed fin-fish, representing over U$1 billion annually. Other commonly cultured fish species include: tilapia, catfish, sea bass, carp, bream, and trout. Salmon farming is very big in Chile, Norway, Scotland, Canada and the Faroe Islands, and is the source for most salmon consumed in America and Europe. Atlantic salmon are also, in very small volumes, farmed in Russia and the island of Tasmania, Australia.

Salmon are carnivorous and are currently fed a meal produced

from catching other wild fish and other marine organisms. Salmon farming leads to a high demand for wild forage fish. Salmon require large nutritional intakes of protein, and consequently, farmed salmon consume more fish than they generate as a final product. To produce one pound of farmed salmon, products from several pounds of wild fish are fed to them. As the salmon farming industry expands, it requires more wild forage fish for feed, at a time when seventy five percent of the worlds monitored fisheries are already near to or have exceeded their maximum sustainable yield.[17] The industrial scale extraction of wild forage fish for salmon farming then impacts the survivability of the wild predator fish who rely on them for food.

Work continues on substituting vegetable proteins for animal proteins in the salmon diet. Unfortunately though, this substitution results in lower levels of the highly valued Omega-3 content in the farmed product.

Intensive salmon farming now uses open-net cages which have low production costs but have the drawback of allowing disease and sea lice to spread to local wild salmon stocks.[18]

On a dry-dry basis, it takes 2–4 kg of wild caught fish to produce one kg of salmon.[19]

Artificially-incubated chum salmon

Another form of salmon production, which is safer but less controllable, is to raise salmon in hatcheries until they are old enough to become independent. They are then released into rivers, often in an attempt to increase the salmon population. This system is referred to as ranching and was very common in countries like Sweden before the Norwegians developed salmon farming, but is seldom done by private companies, as anyone may catch the salmon when they return to spawn, limiting a company's chances of benefiting financially from their investment. Because of this, the method has mainly been used by various public authorities and non profit groups like the Cook Inlet Aquaculture Association as a way of artificially increasing salmon populations in situations where they have declined due to overharvest, construction of dams, and habitat destruction or fragmentation. Unfortunately, there can be negative consequences to this sort of population manipulation, including genetic "dilution" of the wild stocks, and many jurisdictions are now beginning to discourage supplemental fish planting in favour of harvest controls and habitat improvement and protection. A variant method of fish stocking, called ocean ranching, is under development in Alaska. There, the young salmon are released into the ocean far from any wild salmon streams. When it is time for them to spawn, they return to where they were released where fishermen can then catch them.

An alternative method to hatcheries is to use spawning channels. These are artificial streams, usually parallel to an existing stream with concrete or rip-rap sides and gravel bottoms. Water from the adjacent stream is piped into the top of the channel, sometimes via a header pond to settle out sediment. Spawning success is often much better in channels than in adjacent streams due to the control of floods which in some years can wash out the natural redds. Because of the lack of floods, spawning channels must sometimes be cleaned out to remove accumulated sediment. The same floods which destroy natural redds also clean them out. Spawning channels preserve the natural selection of natural streams as there is no temptation, as in hatcheries, to use prophylactic chemicals to control diseases.

Farm raised salmon are fed the carotenoids astaxanthin and canthaxanthin, so that their flesh color matches wild salmon.[20]

Diseases and parasites [edit]

See also: Fish diseases and parasites

According to Canadian biologist Dorothy Kieser, myxozoan parasite *Henneguya salminicola* is commonly found in the flesh of salmonids. It has been recorded in the field samples of salmon returning to the Queen Charlotte Islands. The fish responds by walling off the parasitic infection into a number of cysts that contain milky fluid. This fluid is an accumulation of a large number of

Henneguya salminicola, a myxozoan parasite commonly found in the flesh of salmonids on the West Coast of Canada. Coho salmon

parasites.

Henneguya and other parasites in the myxosporean group have a complex lifecycle where the salmon is one of two hosts. The fish releases the spores after spawning. In the *Henneguya* case, the spores enter a second host, most likely an invertebrate, in the spawning stream. When juvenile salmon out-migrate to the Pacific Ocean, the second host releases a stage infective to salmon. The parasite is then carried in the salmon until the next spawning cycle. The myxosporean parasite that causes whirling disease in trout, has a similar lifecycle.[21] However, as opposed to whirling disease, the *Henneguya* infestation does not appear to cause disease in the host salmon — even heavily infected fish tend to return to spawn successfully.

According to Dr. Kieser, a lot of work on *Henneguya salminicola* was done by scientists at the Pacific Biological Station in Nanaimo in the mid-1980s, in particular, an overview report[22] which states that "the fish that have the longest fresh water residence time as juveniles have the most noticeable infections. Hence in order of prevalence coho are most infected followed by sockeye, chinook, chum and pink." As well, the report says that, at the time the studies were conducted, stocks from the middle and upper reaches of large river systems in British Columbia such as Fraser, Skeena, Nass and from mainland coastal streams in the southern half of B.C. "are more likely to have a low prevalence of infection." The report also states "It should be stressed that *Henneguya*, economically deleterious though it is, is harmless from the view of public health. It is strictly a fish parasite that cannot live in or affect warm blooded animals, including man".

According to Klaus Schallie, Molluscan Shellfish Program Specialist with the Canadian Food Inspection Agency, "*Henneguya salminicola* is found in southern B.C. also and in all species of salmon. I have previously examined smoked chum salmon sides that were riddled with cysts and some sockeye runs in Barkley Sound (southern B.C., west coast of Vancouver Island) are noted for their high incidence of infestation."

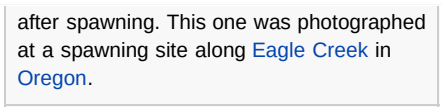
Sea lice, particularly *Lepeophtheirus salmonis* and various *Caligus* species, including *Caligus clemensi* and *Caligus rogercresseyi*, can cause deadly infestations of both farm-grown and wild salmon.[23][24] Sea lice are ectoparasites which feed on mucus, blood, and skin, and migrate and latch onto the skin of wild salmon during free-swimming, planktonic *nauplii* and *copepodid* larval stages, which can persist for several days.[25][26][27] Large numbers of highly populated, open-net salmon farms can create exceptionally large concentrations of sea lice; when exposed in river estuaries containing large numbers of open-net farms, many young wild salmon are infected, and do not survive as a result.[28][29] Adult salmon may survive otherwise critical numbers of sea lice, but small, thin-skinned juvenile salmon migrating to sea are highly vulnerable. On the Pacific coast of Canada, the louse-induced mortality of pink salmon in some regions is commonly over 80%.[30]

Environmental pressures [edit]

All species of Pacific Salmon die shortly

The population of wild salmon declined markedly in recent decades, especially north Atlantic populations which spawn in the waters of western Europe and eastern Canada, and wild salmon in the Snake and Columbia River system in northwestern United States. The decline is attributed to the following factors:

- Disease transfer from open net cage salmon farming, especially sea lice. The European Commission (2002) concluded “The reduction of wild salmonid abundance is also linked to other factors but there is more and more scientific evidence



after spawning. This one was photographed at a spawning site along Eagle Creek in Oregon.

establishing a direct link between the number of lice-infested wild fish and the presence of cages in the same estuary."[31] It is reported that wild salmon on the west coast of Canada are being driven to extinction by sea lice from nearby salmon farms.[32]

- For Atlantic salmon smolts, it takes as few as eight sea lice to kill the fish. On the Pacific Coast where the smolt are much smaller, only one or two can be critical, often resulting in death. In the Atlantic, sea lice have been a proven factor in both Norwegian and Scottish salmon declines. In the Western Atlantic there has been little research at sea, but sea lice numbers in the period post-2000 do not appear to be a significant factor in the critical decline of endangered inner Bay of Fundy salmon. The situation may have been different in the 1980s and 1990s, but we are unlikely ever to know the factual history in that regard.
- Overfishing in general but especially commercial netting in the Faroes and Greenland. Several seafood sustainability guides have recommendations on which salmon fisheries are sustainable and which have negative impacts on Salmon populations.
- Ocean and river warming which can delay spawning and accelerate transition to smolting.
- Ulcerative dermal necrosis (UDN) infections of the 1970s and 1980s which severely affected adult salmon in freshwater rivers.
- Loss of suitable freshwater habitat, especially degradation of stream pools and reduction of suitable material for the excavation of redds. Historically stream pools were, to a large extent, created by beavers (see section below). With the extirpation of the beaver, the nurturing function of these ponds was lost.
- Reduction of the retention of the nutrients brought by the returning adult salmon in stream pools. Without stream pools, dead adult salmon tend to be washed straight back down the streams and rivers.
- The construction of dams, weirs, barriers and other "flood prevention" measures, which bring severe adverse impacts to river habitat and on the accessibility of those habitats to salmon. This is particularly true in the northwest USA, where large numbers of dams have been built in many river systems, including over 400 in the Columbia River Basin.[33]
- Other environmental factors such as light intensity, water flow, or change in temperature dramatically affects salmon during their migration season.[34]
- Loss of invertebrate diversity and population density in rivers because of modern farming methods and various sources of pollution, thus reducing food availability.
- Reduction in freshwater base flow in rivers and disruption of seasonal flows, because of diversions and extractions, hydroelectric power generation, irrigation schemes, barge transportation, and slackwater reservoirs, which inhibit normal migratory processes and increase predation for salmon.[35]
- Loss of suitable low gradient stream habitats due to agricultural practices such as the removal of riparian plants, destabilization of stream banks by livestock and irrigation processes.[36][37]

There are efforts to relieve this situation. As such, several governments and NGOs are sharing in research and habitat restoration efforts.

- In the western Atlantic, the Atlantic Salmon Federation has developed a major sonic tracking technology program to understand the high at-sea mortality since the early 1990s. Ocean arrays are deployed across the Baie des Chaleurs and between Newfoundland and Labrador at the Strait of Belle Isle. Salmon have now been tracked half way from rivers such as the Restigouche to Greenland feeding grounds. Now the first line of the Ocean Tracking Network initiative is installed by DFO and Dalhousie University of Halifax from Halifax to the edge of the continental shelf. First results include Atlantic salmon travelling from the Penobscot River in Maine, the "anchor river" for US Atlantic salmon populations.
- In the northern Atlantic, the North Atlantic Salmon Fund, lead by Icelandic Entrepreneur Orri Vigfússon, has since 1989 worked closely with governments and fishermen for conservation. The conservation efforts are not limited to oceans, and a sustainable angling scheme has been developed in rivers, notably in Vopnafjörður, Iceland.

Results overall are showing that estuary problems exist for some rivers, but issues involving feeding grounds at sea are impacting populations as well. In 2008 returns were markedly improved for Atlantic salmon on both sides of the Atlantic Ocean, but no one knows if this is a temporary improvement or sign of a trend.

- NOAA's Office of Protected Resources maintains a list of Endangered Species, the Endangered

Species Act.
- Sweden has generated a protection program as part of its Biodiversity Action Plan.
- State of Salmon maintains an IUCN redlist of endangered salmon.
- The Kamchatka Peninsula, in the Russian Far East, contains the world's greatest salmon sanctuary.
- Bear Lake, Alaska, is the site of salmon enhancement activities since 1962.[38]

Salmon and beavers [edit]

Beavers are archetypal ecosystem engineers; in the process of clear cutting and damming, beavers alter their ecosystem extensively. Beaver ponds can provide critical habitat for juvenile salmon. An example of this was seen in the years following 1818 in the Columbia River Basin. In 1818, the British government made an agreement with the U.S. government to allow U.S. citizens access to the Columbia catchment (see Treaty of 1818). At the time, the Hudson's Bay Company sent word to trappers to extirpate all furbearers from the area in an effort to make the area less attractive to U.S. fur traders. In response to the elimination of beavers from large parts of the river system, salmon runs plummeted, even in the absence of many of the factors usually associated with the demise of salmon runs. Salmon recruitment can be affected by beavers' dams because dams can:[39][40][41]

- Slow the rate at which nutrients are flushed from the system; nutrients provided by adult salmon dying throughout the fall and winter remain available in the spring to newly-hatched juveniles
- Provide deeper water pools where young salmon can avoid avian predators
- Increase productivity through photosynthesis and by enhancing the conversion efficiency of the cellulose-powered detritus cycle
- Create low-energy environments where juvenile salmon put the food they ingest into growth rather than into fighting currents
- Increase structural complexity with many physical niches where salmon can avoid predators

Beavers' dams are able to nurture salmon juveniles in Estuarine tidal marshes where the salinity is less than 10ppm. Beavers build small dams of generally less than 2 feet (0.61 m) high in channels in the Myrtle zone. These dams can be overtopped at high tide and hold water at low tide. This provides refuges for juvenile salmon so they don't have to swim into large channels where they are subject to predation.[42]

Salmon as food [edit]


Édouard Manet: *Still Life with Salmon*

Salmon is a popular food. Classified as an "oily fish",[43] salmon is considered to be healthy due to the fish's high protein, high Omega-3 fatty acids, and high vitamin D[44] content. Salmon is also a source of cholesterol, with a range of 23–214 mg/100g depending on the species.[45] According to reports in the journal *Science*, however, farmed salmon may contain high levels of dioxins. PCB (polychlorinated biphenyl) levels may be up to eight times higher in farmed salmon than in wild salmon.[46] Omega-3 content may also be lower than in wild caught specimens, and in a different proportion to what is found naturally. Omega-3 comes in three types, ALA, DHA and EPA; wild salmon has traditionally been an important source of DHA and EPA, which are important for brain function and structure, among other things. This means if the farmed salmon is fed on a meal which is partially grain, then the amount of omega-3 it contains will be present as ALA (alpha-linolenic acid).[*citation needed*] The body can itself convert ALA omega-3 into DHA and EPA, but at a very inefficient rate (2–15%). Nonetheless, according to a 2006 study published in the Journal of the American Medical Association, the benefits of eating even farmed salmon still outweigh any risks imposed by contaminants.[47] The type of omega-3 present may not be a factor for other important health functions.

A simple rule of thumb is that the vast majority of Atlantic salmon available on the world market are farmed (greater than 99%), whereas the majority of Pacific salmon are wild-caught (greater than 80%). Farmed Atlantic salmon outnumber wild Atlantic salmon 85-to-1.[48]

Raw salmon sashimi

Salmon flesh is generally orange to red, although there are some examples of white fleshed wild salmon. The natural colour of salmon results from carotenoid pigments, largely astaxanthin but also canthaxanthin, in the flesh.[49] Wild salmon get these carotenoids from eating krill and other tiny shellfish. Because consumers have shown a reluctance to purchase white-fleshed salmon, astaxanthin (E161j), and very minutely canthaxanthin (E161g), are added as artificial colorants to the feed of farmed salmon, because prepared diets do not naturally contain these pigments. In most cases, the astaxanthin is made chemically; alternatively it is extracted from shrimp flour. Another possibility is the use of dried red yeast, which provides the same pigment. However, synthetic mixtures are the least expensive option. Astaxanthin is a potent antioxidant that stimulates the development of healthy fish nervous systems and enhances the fish's fertility and growth rate. Research has revealed canthaxanthin may have negative effects on the human eye, accumulating in the retina at high levels of consumption.[49] Today, the concentration of carotenoids (mainly canthaxanthin and astaxanthin) exceeds 8 mg/kg of flesh, and all fish producers try to reach a level that represents a value of 16 on the "Roche Color Card", a colour card used to show how pink the fish will appear at specific doses. This scale is specific for measuring the pink colour due to astaxanthin and is not for the orange hue obtained with canthaxanthin. The development of processing and storage operations, which can be detrimental on canthaxanthin flesh concentration, has led to an increased quantity of pigments added to the diet to compensate for the degrading effects of the processing. In wild fish, carotenoid levels of up to 25 mg are present, but levels of canthaxanthin are, in contrast, minor.[49]

Canned salmon in the U.S. is usually wild Pacific catch, though some farmed salmon is available in canned form. Smoked salmon is another popular preparation method, and can either be hot or cold smoked. Lox can refer either to cold smoked salmon or to salmon cured in a brine solution (also called gravlax). Traditional canned salmon includes some skin (which is harmless) and bone (which adds calcium). Skinless and boneless canned salmon is also available.

Raw salmon flesh may contain *Anisakis* nematodes, marine parasites that cause Anisakiasis. Before the availability of refrigeration, the Japanese did not consume raw salmon. Salmon and salmon roe have only recently come into use in making sashimi (raw fish) and sushi.

Filet of an Atlantic Salmon

Poached salmon

Smoked salmon

Salad with ham and smoked salmon

Salmon in marinade

Grilled salmon

Salmon for sale

Salmon roe (still in the

skin) at the Shiogama seafood market in Japan

Salmon in mythology [edit]

The salmon is an important creature in several strands of Celtic mythology and poetry, which often associated them with wisdom and venerability. In Irish mythology, a creature called the Salmon of Wisdom (or the Salmon of Knowledge)[50] plays key role in the tale known as *The Boyhood Deeds of Fionn*. The Salmon will grant powers of knowledge to whoever eats it, and has been sought by the poet Finn Eces for seven years. Finally Finn Eces catches the fish and gives it to his young pupil, Fionn mac Cumhaill, to prepare it for him. However, Fionn burns his thumb on the salmon's juices, and he instinctively puts it in his mouth. As such, he inadvertently gains the Salmon's wisdom. Elsewhere in Irish mythology, the salmon is also one of the incarnations of both Tuan mac Cairill[51] and Fintan mac Bóchra.[52]

Salmon also figure into Welsh mythology. In the prose tale *Culhwch and Olwen*, the Salmon of Llyn Llyw is the oldest animal in Britain, and the only creature who knows the location of Mabon ap Modron. After speaking to a string of other ancient animals who do not know his whereabouts, King Arthur's men Cai and Bedwyr are led to the Salmon of Llyn Llyw, who lets them ride its back to the walls of Mabon's prison in Gloucester.[*citation needed*]

In Norse mythology, after Loki tricked the blind god Höðr into killing his brother Baldr, Loki jumped into a river and transformed himself into a salmon in order to escape punishment from the other gods. When they held out a net to trap him he attempted to leap over it but was caught by Thor who grabbed him by the tail with his hand, and this is why the salmon's tail is tapered.[*citation needed*]

Salmon are central to Native American mythology on the Pacific coast, from the Haida to the Nootka.[*citation needed*]

See also [edit]

- Alaska salmon fishery
- Aquaculture of salmon
- Atlantic salmon
- Fish diseases and parasites
- Pacific salmon
- Salmon run
- Salmon louse
- Sea louse

References [edit]

Notes [edit]

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Further reading [edit]

- *Atlas of Pacific Salmon*, Xanthippe Augerot and the State of the Salmon Consortium, University of California Press, 2005, hardcover, 152 pages, ISBN 0-520-24504-0
- *Making Salmon: An Environmental History of the Northwest Fisheries Crisis*, Joseph E. Taylor III, University of Washington Press, 1999, 488 pages, ISBN 0-295-98114-8
- *Trout and Salmon of North America*, Robert J. Behnke, Illustrated by Joseph R. Tomelleri, The Free Press, 2002, hardcover, 359 pages, ISBN 0-7432-2220-2
- *Come back, salmon*, By Molly Cone, Sierra Club Books, 48 pages, ISBN 0-87156-572-2 - A book for juveniles describes the restoration of 'Pigeon Creek'.
- *The salmon: their fight for survival*, By Anthony Netboy, 1973, Houghton Mifflin Co., 613 pages, ISBN 0-395-14013-7
- *A River Lost*, by Blaine Harden, 1996, WW Norton Co., 255 pages, ISBN 0-393-31690-4. (Historical view of the Columbia River system).
- *River of Life, Channel of Death*, by Keith C. Peterson, 1995, Confluence Press, 306 pages, ISBN 978-0-87071-496-2. (Fish and dams on the Lower Snake river.)
- *Salmon*, by Dr Peter Coates, 2006, ISBN 1-86189-295-0
- NEWS January 31, 2007: U.S. Orders Modification of Klamath River - Dams Removal May Prove More Cost-Effective for allowing the passage of Salmon
- Salmon age and sex composition and mean lengths for the Yukon River area, 2004 / by Shawna Karpovich and Larry DuBois. Hosted by Alaska State Publications Program.
- Trading Tails: Linkages Between Russian Salmon Fisheries and East Asian Markets. Shelley Clarke. (November 2007). 120pp. ISBN 978-1-85850-230-4.
- *The Salmons Tale* one of the twelve Ionan Tales by Jim MacCool
- "Last Stand of the American Salmon," G. Bruce Knecht for Men's Journal
- Sea Lice and Salmon: Elevating the dialogue on the farmed-wild salmon story *Watershed Watch Salmon Society*, 2004.

External links [edit]

- *Plea for the Wanderer*, an NFB documentary on West Coast salmon
- *Fish farms drive wild salmon populations toward extinction* Biology News Net. December 13, 2007.

- *Salmonid parasites* University of St Andrews Marine Ecology Research Group.
- Watershed Watch Salmon Society A British Columbia advocacy group for wild salmon
- Wild Salmon in Trouble: *The Link Between Farmed Salmon, Sea Lice and Wild Salmon* - Watershed Watch Salmon Society. Animated short video based on peer-reviewed scientific research, with subject background article *Watching out for Wild Salmon*.
- Aquacultural Revolution: *The scientific case for changing salmon farming* - Watershed Watch Salmon Society. Short video documentary. Prominent scientists and First Nation representatives speak their minds about the salmon farming industry and the effects of sea lice infestations on wild salmon populations.
- Genetic Status of Atlantic Salmon in Maine: Interim Report (2002) Online book
- University of Washington Libraries Digital Collections – Salmon Collection A collection of documents describing salmon of the Pacific Northwest.
- *Salmon-omics: Effect of Pacific Decadal Oscillation on Alaskan Chinook Harvests and Market Price* Kevin Ho, Columbia University, 2005.
- Salmon Nation A movement to create a bioregional community, based on the historic spawning area of Pacific salmon (CA to AK).
- The Distribution of Pacific Salmon (*Oncorhynchus* spp.) in the Canadian Western Arctic, by S. A. Stephenson
- *Sea Lice* - Coastal Alliance for Aquaculture Reform. An overview of farmed- to wild-salmon interactive effects.
- *Salmon Farming Problems* - Coastal Alliance for Aquaculture Reform. An overview of environmental impacts of salmon farming.

recipe/module on ***Salmon***

v • d • e	Principal commercial fishery species groups		
Wild	Large pelagic fish	Mackerel · **Salmon** · Shark · Swordfish · Tuna (yellowfin, bigeye, bluefin, albacore and skipjack)	
	Forage fish	Anchovy · Capelin · Herring · Hilsa · Menhaden · Sardines · Shad	
	Demersal fish	Catfish · Cod (Atlantic, Pacific) · Flatfish (flounder, halibut, plaice, sole and turbot) · Haddock · Mullet · Orange roughy · Pollock · Smelt-whitings · Toothfish	
	Freshwater fish	Carp · Sturgeon · Tilapia · Trout	
	Other wild fish	Eel · Whitebait · more...	
	Crustaceans	Crab · Krill · Lobster · Shrimp · more...	
	Molluscs	Abalone · Mussels · Octopus · Oysters · Scallops · Squid · more...	
	Echinoderms	Sea cucumbers · Sea urchin · more...	
Farmed	Carp (bighead, common, crucian, grass, silver) · Catfish · Freshwater prawns · Mussels · Oysters · Salmon (Atlantic, salmon trout, coho, chinook) · Shrimp · Tilapia		
Commercial fishing · World fish production · Fishing topics · Fisheries glossary			

Categories: Salmon | Salmonidae | Alaskan cuisine | Commercial fish | Oily fish