415. Romero, A. 2003e. Salmoniformes (Salmons), pp. 405-420, In: Grzimek's Animal Life Encyclopedia, 2nd. Edition, Vol 4, Fishes I., (M. Hutchins, D.A. Thoney, P.V. Loiselle, and N. Schlager, eds.). Farmington Hills, MI: Gale Group.

Salmoniformes
(Salmons)

Class Actinopterygii
Order Salmoniformes
Number of families 1

Photo: Sockeye salmon (*Oncorhynchus nerka*) in spawning area of Alaska, USA. (Photo by Animals Animals ©Victora McCormick. Reproduced by permission.)

Evolution and systematics

Salmoniform fossils are known from the Upper Cretaceous (about 100 million years ago) until the Pleistocene (about 11,000 years ago), mostly from North America and Europe. This order possesses several primitive anatomical features representative of an early stage in the evolution of modern bony fishes. There have been a number of systematic arrangements for this group, ranging from a single order with a single family (Salmonidae), to two orders with several families (see, for example, Johnson and Patterson 1996). For the purpose of this chapter, we will follow Nelson (1994), who considers the Salmonidae the only family for this order, with 3 subfamilies, 11 genera, and 66 species.

Physical characteristics

The largest of the salmoniform fishes are the Chinook salmon (*Oncorhynchus tshawytscha*) and the Danube and Siberian huchens (*Hucho hucho*) both about 59 in (1.5 m) in length, with the former weighing up to 136 lb (62 kg). As expected from such strong swimmers, the salmoniform body and fins are streamlined and symmetrical, being covered with small and smooth cycloid scales. All fins have soft rays. They have a small, fleshy adipose fin (which is a primitive character) located between the dorsal fin and the powerful caudal fin. The dorsal fin is located midway along the body; the paired pectoral fins are ventral and located directly posterior to the head. They also have a pair of pelvic fins directly beneath the dorsal fin, and a single anal fin located beneath the adipose fin. The swim bladder is connected to the gut.

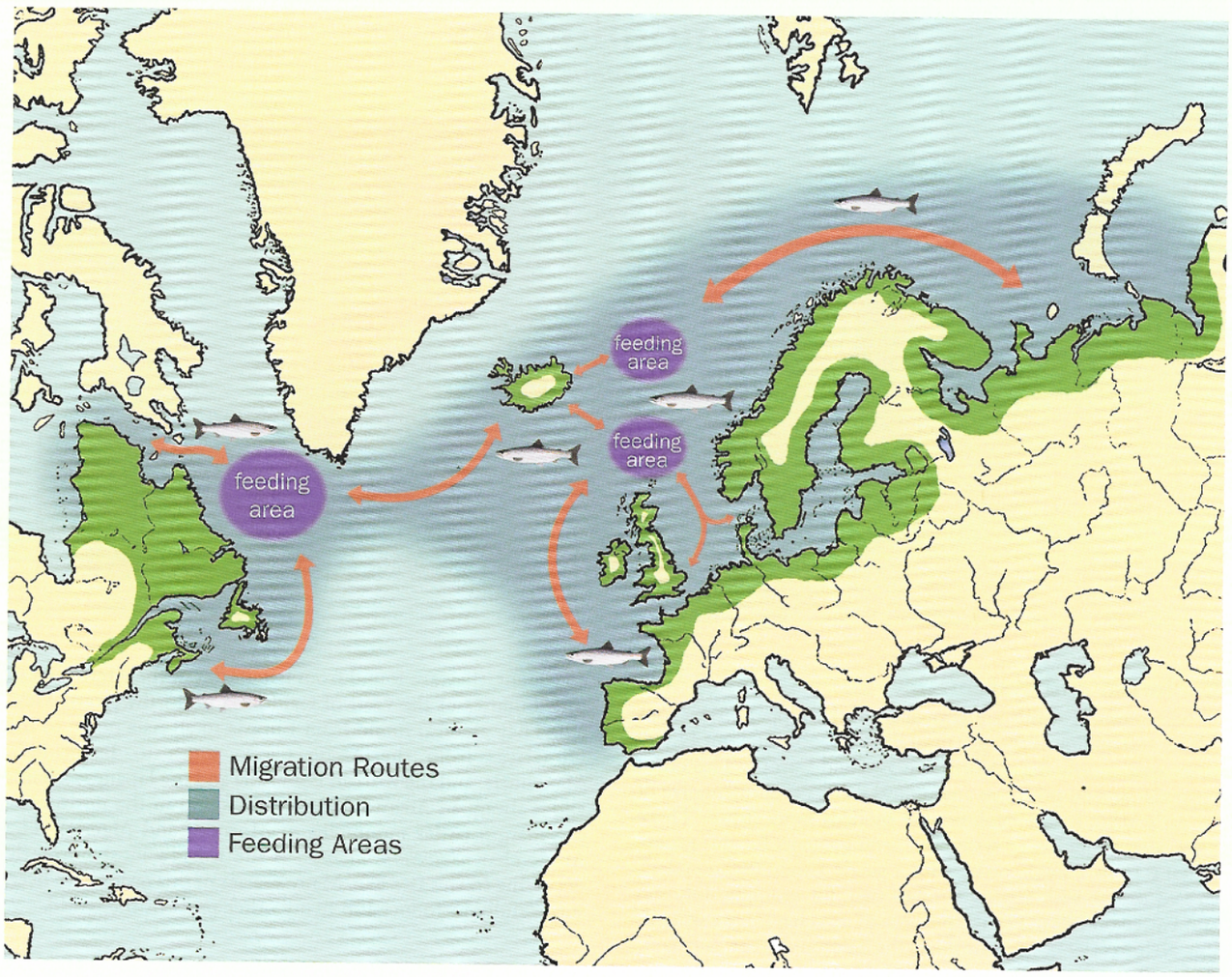
Distribution

Salmoniformes were originally found only in cool and cold waters of the Northern Hemisphere, where they are one of the most dominant freshwater fishes. In the North American continent, they are found from tributaries of the Arctic Ocean to tributaries of the Gulf of California in northwestern Mexico. They are also found from Eurasia to all Asia north to the Himalayas from the Arctic Circle south to Bangladesh, Manchuria, and the Korean Peninsula and the Japanese Islands and Taiwan. In Africa they are only found in the northwestern margin (Atlas mountains of Morocco and Algeria). The Arctic char (*Salvelinus alpinus*) is the world's most northerly occurring freshwater fish. Many species of this order have been successfully introduced in many other parts of the world.

Habitat

Many salmoniform species (such as trouts and salmons) have an anadromous life cycle, in that they spawn in fresh

Brook trout (*Salvelinus fontinalis*) in their vibrant autumn spawning colors. Note the tail of the male, lower left, showing a bite mark received during one of the many battles between males for the right to court a female. (Photograph. AP/Wide World Photos. Reproduced by permission.)



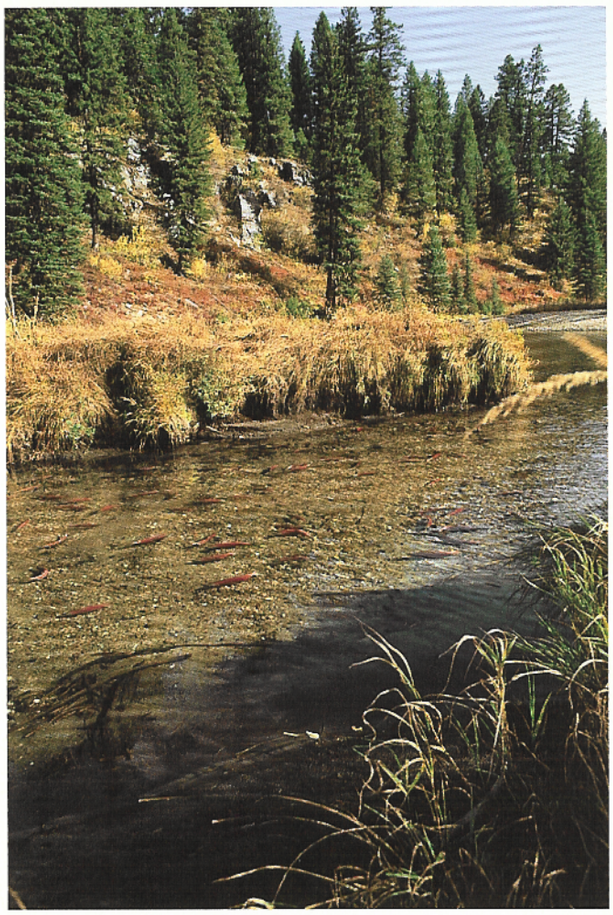
Salmon migration routes. (Illustration by John Megahan)

Grizzly bear fishing for salmon at a waterfall in Katmai National Park in Alaska. (Photo by Galen Rowell/Corbis. Reproduced by permission.)

waters, but migrate to sea for feeding and maturation. The pink salmon (*Oncorhynchus gorbuscha*) is the least anadromous species in the Pacific, since it has reduced the freshwater stage to the spawning migration and incubation of the eggs. Some individuals even spawn in the intertidal zone with no real freshwater phase. However, others are entirely freshwater, with completely landlocked local populations.

Behavior

Some species of Salmoniformes are fiercely territorial; others form schools shortly after hatching before they initiate their seaward migration. the most remarkable behavioral characteristic in these fishes is their strong swimming ability (some can leap over obstacles such as waterfalls as high as 10 ft/3 m) and their migratory capability. Almost all, if not all, Salmoniformes can return to the stream of their birth after migrating thousands of miles (or kilometers) in the ocean for one or more years, a behavior known as homing. They use their sense of smell to orient themselves, but some experi-



Sockeye salmon (*Oncorhynchus nerka*) spawning in North Fork Payette River, Idaho. (Photo by Willam H. Mullins/Photo Researchers, Inc. Reproduced by permission.)

ments suggest that vision and magnetic clues may also play a role in this behavior. This is not surprising, since other migratory species of animals, such as some birds, can use more than one source of information to achieve their migratory paths. Because of their migrations between fresh and salt waters, salmoniforms have developed a number of physiological adaptations to cope with changes in salinity. This is achieved via osmotic regulation by excreting excess salts through cells in the gills and by having well-developed kidneys, which, in fresh waters, excrete the excess water that diffuses into their blood via the gills.

Feeding ecology and diet

There is variation in feeding habits in this order. Some species feed upon plankton and benthic invertebrates, while others are top predators of other fish species.

Reproductive biology

All salmoniforms lay eggs that are externally fertilized. The egg size is related to the amount of nutrients in the water, with the largest eggs (0.16–0.31 in/4–8 mm), found in nutrient-poor waters. This allows individuals born under those conditions to have enough nutrients to survive, and is followed by direct development. This means that the young look very much like small adults. The size of the egg is also conversely proportional to the number of the eggs. In the case of smaller eggs, the young are less developed after hatching.

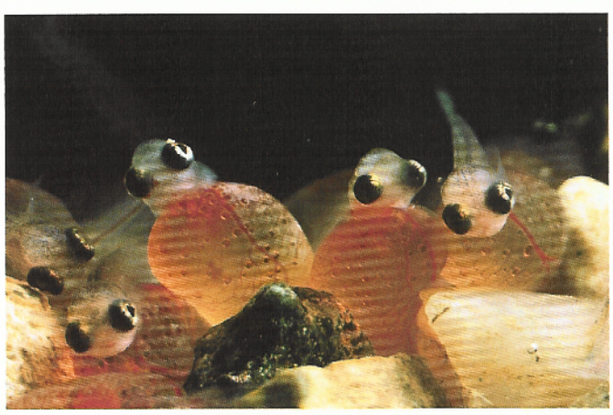
Conservation status

The IUCN Red List includes 36 salmoniform species. Of these, four are categorized as Extinct (*Coregonus alpenae*, *C. johannae*, *C. nigripinnis*, and *Salvelinus agassizi*); four are Critically Endangered; five are Endangered; 10 are Vulnerable; and 13 are Data Deficient.

Because all salmoniforms depend upon migrations into clear, highly oxygenated waters, they are very sensitive to water pollution as well as interruptions in the watercourse by means of dams. This problem is particularly acute for the Pacific salmon, whose numbers and genetic diversity have both declined dramatically.

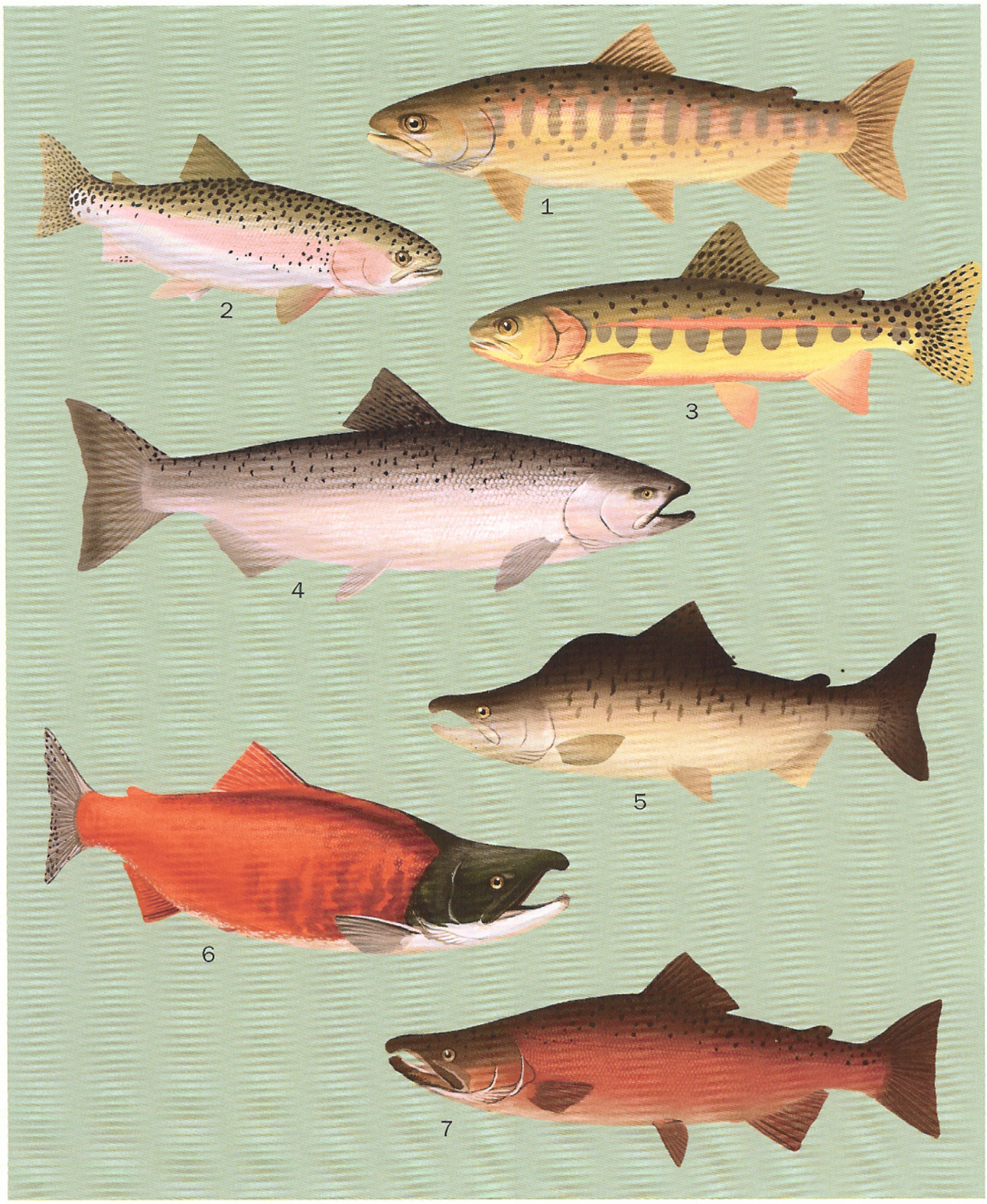
Significance to humans

Many species of trouts, salmons, chars, whitefishes, and graylings are among the best-known and most intensively studied species of fishes. They have tremendous economic importance in many areas because of their value in both sport and commercial fisheries. This is the reason they have been introduced all over the world. Information about the life cycle and reproduction, some of it based on DNA analysis, has been used to settle disputes between nations regarding the origin of fishes caught in the open ocean, as well as for their management.



Close-up photo of newly hatched brown trout (*Salmo trutta*) on a river bed. (Photo by Science Pictures Ltd/Science Photo Library/Photo Researchers, Inc. Reproduced by permission.)

1. Brook trout (*Salvelinus fontinalis*); 2. Brown trout (*Salmo trutta*); 3. Lake trout (*Salvelinus namaycush*); 4. Charr (*Salvelinus alpinus*); 5. Atlantic salmon (*Salmo salar*); 6. Arctic grayling (*Thymallus arcticus arcticus*); 7. Lake whitefish (*Coregonus clupeaformis*). (Illustration by John Megahan)



1. Cherry salmon (*Oncorhynchus masou*); 2. Rainbow trout (*Oncorhynchus mykiss*); 3. Golden trout (*Oncorhynchus aguabonita*); 4. Chinook salmon (*Oncorhynchus tshawytscha*); 5. Pink salmon (*Oncorhynchus gorbuscha*); 6. Sockeye salmon (*Oncorhynchus nerka*); 7. Coho salmon (*Oncorhynchus kisutch*). (Illustration by John Megahan)

Species accounts

Lake whitefish
Coregonus clupeaformis

FAMILY
Salmonidae

TAXONOMY
Salmo clupeaformis Mitchill, 1818, Falls of St. Mary's River, Chippewa County, Michigan, United States. May be conspecific with *Coregonus lavaretus.*

OTHER COMMON NAMES
English: Common whitefish, eastern whitefish, lake whitefish; French: Grand corégone; German: Felchen; Spanish: Corégono; Inuktitut: Kavisilik.

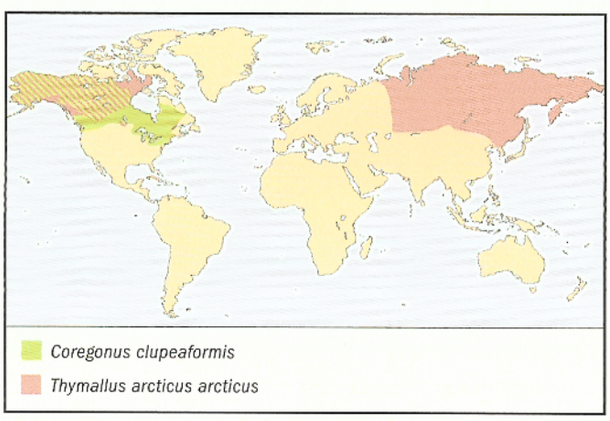
PHYSICAL CHARACTERISTICS
Length 40 in (100 cm). A well-developed adipose fin, usually larger among males, characterizes this species. Coloration is dark brown to midnight blue above fading to silver on sides and white beneath.

DISTRIBUTION
North America throughout Alaska and most of Canada, south into New England, the Great Lakes basin, and central Minnesota. Successfully introduced in Chile and Argentina.

HABITAT
Primarily a lake dweller; can also be found in large rivers and enters brackish water.

BEHAVIOR
When not migrating, tends to be sedentary in small lakes. Migration in large lakes consists of movement from deep to shallow water in the spring, movement back to deep water in the summer as the shoal water warms, migration to shallow-water spawning areas in the fall and early winter, and post-spawning movement back to deeper water.

FEEDING ECOLOGY AND DIET
Adults feed on aquatic insect larvae, amphipods, mollusks, as well as smaller fishes and fish eggs, including their own. They are vulnerable to larger fishes, otters, bears, and fish-eating birds.



REPRODUCTIVE BIOLOGY
Spawns annually at night from October through December. One female and one or more males rise to the surface where the eggs are released and fertilized. Spawning fish are very active, sometimes leaping out of the water. Eggs are demersal.

CONSERVATION STATUS
Not listed by the IUCN.

SIGNIFICANCE TO HUMANS
Extensively hatchery-reared in the Great Lakes and other areas because of their value as meat and roe. ◆

Golden trout
Oncorhynchus aguabonita

FAMILY
Salmonidae

TAXONOMY
Salmo mykiss aguabonita Jordan, 1892, Kern River California.

OTHER COMMON NAMES
French: Troite dorée; Spanish: Aguabonita.

PHYSICAL CHARACTERISTICS
Length 28 in (71 cm); maximum weight 11 lb (5 kg). One of the smallest species of trouts, characterized by a golden color with orange to red stripes along the side. In both the dorsal fin

and the area right before the tail, coloration is speckled with dark spots. This species is also known for its small scales.

DISTRIBUTION
High altitude, freshwater bodies in the western area of the United States, particularly in Wyoming, Idaho, Washington State, and most abundantly in California, where it was first discovered. Introduced in Canada.

HABITAT
Freshwater lakes and rivers at altitudes of 9,000–12,000 ft (2,740–3,700 m), generally in hard-to-access mountain areas. Because the waters they inhabit are very clear, with little vegetation, and of great beauty, the Spanish name is *aguabonita* (pretty water).

BEHAVIOR
Unlike other species of salmoniforms, largely a social species that travels in small schools. Active all summer. Because of their lack of aggressiveness and small size, they cannot compete with larger, more aggressive salmonids. This accounts for their restriction to headwaters of streams, where physical barriers such as waterfalls prevent other fish species from entering.

FEEDING ECOLOGY AND DIET
Diet includes surface water-dwelling insects, such as caddisflies and midges, as well as small crustaceans and terrestrial insects floating on the surface. Feeds mostly between May and September due to the scarcity of insects during winter. Practices a form of filter feeding, in which it opens the gills and inhales the prey whole, after which the food remains in the mouth. Vulnerable to larger fishes, otters, bears, and fish-eating birds.

REPRODUCTIVE BIOLOGY
The development of this small species is rather brief when compared to that in other salmoniform species. The egg is almost completely ripe by the time temperatures arrest development at the beginning of winter. The fishes are then ready to spawn the following spring. The spawning routine begins at the time the snow starts to melt, sometime from March through July. As with other trout species, the female prepares the nest and lays her eggs in specific areas. After some behavioral displays, the males then come to fertilize them. Egg development, hatching, and early growth stages are virtually the same as in other spring spawners.

CONSERVATION STATUS
Translocated rainbow trouts aggressively out compete golden trouts and also hybridize with them. The *whitei* population has been classified as threatened since 1978 by the U.S. federal government. The California Department of Fish and Games Committee on Threatened Trout has been working to conserve and enhance the survival of this species. Although many attempts to stock this species in other appropriate waters in the western United States have taken place, most have not been successful.

SIGNIFICANCE TO HUMANS
Highly prized by sport fishers and much sought after as food. ◆

Pink salmon
Oncorhynchus gorbuscha

FAMILY
Salmonidae

TAXONOMY
Salmo gorbuscha Walbaum, 1792, rivers of Kamchatka, Russia.

OTHER COMMON NAMES
English: Humpback salmon; French: Saumon rose; German: Buckelkopflachs; Spanish: Salmón rosado.

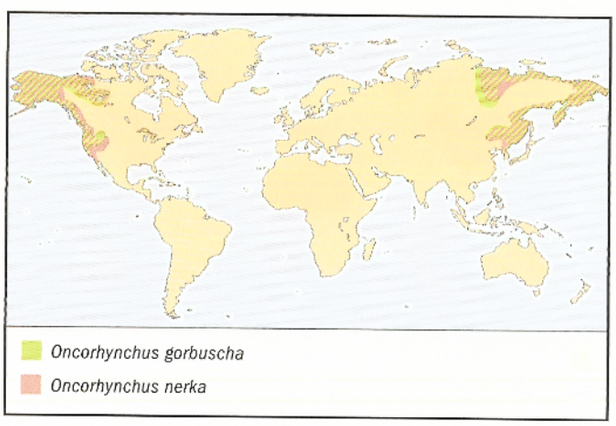
PHYSICAL CHARACTERISTICS
Length 30 in (76 cm); weight 15 lb (6.8 kg). The smallest of the true salmon species. Like most salmoniforms, has a streamlined, fusiform body, somewhat laterally compressed. The mouth is terminal, and among breeding males is greatly deformed by being very oblique, with the lower jaw enlarged and turned up at the tip, preventing the mouth from closing. Another characteristic is the presence of large black spots on the back and on both lobes of the caudal fin. The general coloration varies. Individuals at sea are steel blue to blue-green on the back, silver on the sides, and white on the belly, with large oval spots present on the back, the adipose fin, and on both lobes of the caudal fin. Breeding males are dark on the back, and red with brownish green blotches on the sides. Breeding females are similar to males, although less distinctly colored.

DISTRIBUTION
Arctic and Eastern Pacific, from eastern Korea and Hokkaido, Japan, to the Bering and Okhotsk Seas, to Alaska and the Aleutian Islands, to southern California, United States. Successfully introduced in Canada, Ireland, Norway, Greenland, Poland, Finland, and the United Kingdom.

HABITAT
Spends 18 months at sea before returning either to its native river or some other river to spawn. Unique because the homing behavior is not as strong as that of other salmoniform species. After emerging from the gravel, fry move downstream, remaining inshore for a few months before going out to sea.

BEHAVIOR
Reaches sexual maturity at two years of age. Both male and female die up to a few weeks after spawning.

FEEDING ECOLOGY AND DIET
The diet varies with age. Fry feed on nymphal and larval insects while in fresh water, but once at sea may not feed at all until they become juveniles, when they eat copepods and other zooplankton. As they continue to grow the food items shift toward larger crustaceans and fishes. They are preyed upon by other salmonids as fry, and by larger fishes (including sharks), fish-eating birds, and mammals as they grow.



REPRODUCTIVE BIOLOGY
Upstream migration takes place from June to late September, triggered by high water. The female builds the redd or spawning trench by lying on one side and using her tail to displace silt and light gravel. The accompanying male spends most of the time defending its territory. When the nest is complete, the female drops into it, followed immediately by the male. As for other salmoniforms, both male and female open their mouths, vibrate, and release eggs (1,200–1,800) and sperm. Then the eggs are covered by the female digging a new redd at the upstream edge of the previous one.

CONSERVATION STATUS
Not listed by the IUCN.

SIGNIFICANCE TO HUMANS
The flesh is highly prized; eggs are highly valued as caviar, particularly in Japan. ◆

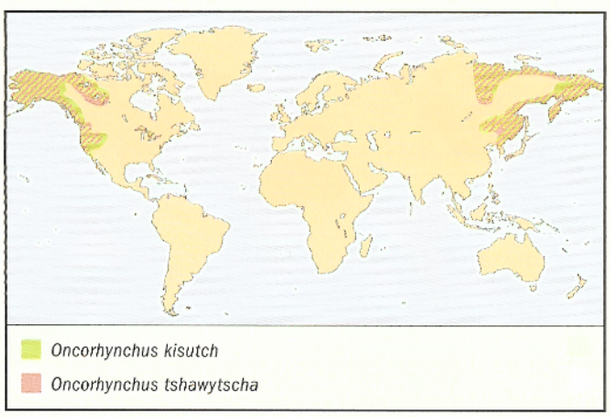
Coho salmon
Oncorhynchus kisutch

FAMILY
Salmonidae

TAXONOMY
Salmo kisatch Walbaum, 1792, rivers and lakes of Kamchatka, Russia.

OTHER COMMON NAMES
English: Blueback, silver salmon; French: Saumon argenté; German: Chumlachs; Spanish: Salmón plateado.

PHYSICAL CHARACTERISTICS
Length 42.5 in (108 cm) in males, 25.8 in (65.5 cm) in females; weight 35.5 lb (15.2 kg). Characterized by the presence of small black spots on the back and on the upper lobe of the caudal fin, as well as by the lack of dark pigment along the gum line of the lower jaw. Coloration varies according to environmental and reproductive conditions, as well as with sex. Females are generally more brightly colored than males. At sea all are dark metallic blue or greenish on the back and upper sides, with a brilliant silver color on middle and lower sides, and white below. In fresh water they display small black spots on the back and upper sides, and on upper lobe of the caudal fin. When ready for breeding they become dark to bright green on head and back and bright red on the sides, and often dark on the belly. The lateral line is nearly straight.



DISTRIBUTION
North Pacific in Asia from the Anadyr River in Russia in the north to Hokkaido, Japan, in the south. In North America from Point Hope in Alaska to Chamalu Bay, Baja California, Mexico. Successfully introduced in Chile, France, and the Laurentian Great Lakes in North America.

HABITAT
Oceans or lakes, returns to streams for spawning.

BEHAVIOR
Reach sexual maturity between two and four years of age.

FEEDING ECOLOGY AND DIET
Food items vary with age. Young in freshwater streams feed mainly on insects. Smolts feed on planktonic crustaceans upon reaching the sea. As they mature, they venture further into the ocean and feed on larger organisms. They are preyed upon by lampreys and various other species of fishes, birds, marine mammals, and bears.

REPRODUCTIVE BIOLOGY
Adults migrate from the sea or large lakes to the mouths of rivers, where they aggregate in large numbers forming schools. As rains increase the rivers' flow, they start swimming upstream. The reproductive behavior is very similar to that of the Chinook salmon. Females are in charge of finding the appropriate spot and digging a pit, they brush off any other female trying to do the same thing at the same spot. Attending males court females even while they are still digging the pit, As soon the pit is complete, the female drops into it, immediately followed by the male. After that, a ritualistic behavior takes place, which includes staying side by side and opening their mouths. This is followed by quivering and the release of eggs and sperm, with other males moving in and releasing sperm into the nest. The female then moves to the upstream edge of the nest and starts digging a new pit, covering the eggs. The entire process is repeated several times for several days, until the female deposits all her eggs and then dies. Meanwhile the male may pursue other females.

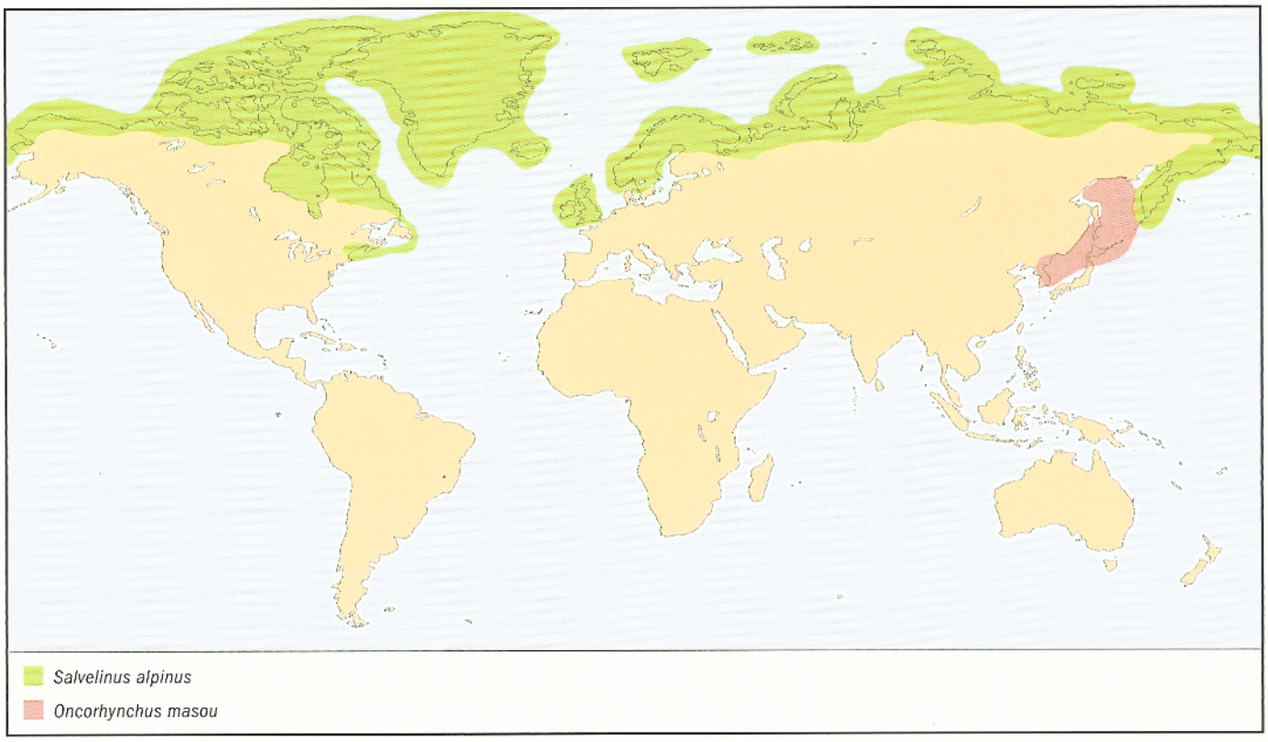
CONSERVATION STATUS
Not listed by the IUCN. The Alaskan fishery has been certified by the Marine Stewardship Council as well managed and sustainable.

SIGNIFICANCE TO HUMANS
Highly esteemed for its meat and supports important recreational fisheries in many parts of the world. ◆

Cherry salmon
Oncorhynchus masou

FAMILY
Salmonidae

TAXONOMY
Salmo masou Brevoort, 1856, Japan. There are two subspecies: one, *Oncorhynchus masou masou*, spawns in the sea; the other, restricted to freshwater, is yamame, or *Oncorhynchus masou ishikawae*.



OTHER COMMON NAMES
English: Salmon trout; French: Saumon masou; German: Masu-Lachs; Japanese: Masu.

PHYSICAL CHARACTERISTICS
Length 28 in (71 cm); weight 22 lb (10 kg). Troutlike shape. Coloration variable depending upon age and habitat or subspecies. Many adults have a general yellowish coloration and two series of gray oval spots: one fully laterally consisting of about 10 spots and one more dorsally consisting of five to six smaller spots. There are additional smaller spots over most of the rest of the body.

DISTRIBUTION
Northwest Pacific in Okhotsk Sea and Sea of Japan; northern Japan and eastern Korea Peninsula. Unlike other Pacific species of salmon, does not enter North American waters, and is said to be the most southerly salmonid. Introduced in Chile.

HABITAT
The river form generally inhabits headwaters.

BEHAVIOR
Like many other salmonids, defends a feeding territory.

FEEDING ECOLOGY AND DIET
Feeds mainly on insects and also on small crustaceans and fishes. The sea-run form goes downstream forming schools. After a short stay in the brackish zone it enters the sea, where it feeds on small fishes and pelagic crustaceans.

REPRODUCTIVE BIOLOGY
Not much is known about the reproduction of this species in nature, except that it is anadromous and spawns between August and October. Japanese hatcheries have promoted a number of programs designed to accelerate growth rate and fecundity by adding hormones to the diet.

CONSERVATION STATUS
Not listed by the IUCN. This species is monitored by The North Pacific Anadromous Fish Commission (NPAFC) established under the Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean, signed in 1992.

SIGNIFICANCE TO HUMANS
The common name derives from the Japanese nickname *sakurasmasu* (cherry salmon), a reference to the fact that it spawns at cherry blossom time. Marketed fresh and frozen; eaten broiled and baked. ◆

Rainbow trout
Oncorhynchus mykiss

FAMILY
Salmonidae

TAXONOMY
Salmo mykiss Walbaum, 1792, mouth of Columbia River at Fort Vancouver, Washington State, United States.

OTHER COMMON NAMES
English: Rainbow trout (North American landlocked populations), steelhead (sea populations); French: Truite arc-en-ciel; German: Regenbogenforelle; Spanish: Trucha arco iris.

PHYSICAL CHARACTERISTICS
Length 47.2 in (120 cm); weight 56 lb (25.4 kg). Body elongate and somewhat compressed, especially in larger individuals. Brightly colored, varies in color (especially males) depending upon habitat, size, and sexual condition. Stream residents and spawners are darker with more intense colors, lake residents tend to be lighter, brighter, and more silvery.

DISTRIBUTION
Eastern Pacific from Alaska to Baja California, Mexico. This is one of the most widely introduced fishes in the world in at least 50 countries, which makes its present distribution virtually global. In tropical countries where it has been introduced it is found only above 4,000 ft (about 1,200 m) of altitude above sea level. Introduction has had a negative ecological impact in many parts of the world.

HABITAT
Fresh waters where the water temperature is not higher than 53.6°F (12°C) in summer. Although they can be found in cold lakes, they require moderate-to-fast flowing, well-oxygenated waters for breeding. Yet, their survivorship is better in lakes than in streams.

BEHAVIOR
Adults aggressively defend feeding territories. All stocks of rainbow trout are opportunistic regarding migration, since they are able to migrate to, or at least to adapt to sea water, according to environmental factors. This may be another case of extreme behavioral plasticity.

FEEDING ECOLOGY AND DIET
Benthic feeders. Adults consume mostly aquatic and terrestrial insects, mollusks, crustaceans, fish eggs, minnows, and other small fishes (including other trouts). Young feed mostly on zooplankton. Ocean-going populations are vulnerable to larger fishes, pinnipeds, and toothed whales. Freshwater populations are preyed upon by larger fishes, otters, bears, and fish-eating birds.

REPRODUCTIVE BIOLOGY
As for other salmonids, growth rate varies according to environmental conditions. Usually reach sexual maturity between two and three years of age, with some extreme cases becoming sexually mature at five years. In this species, the female finds a spot and digs a pit. However, while she digs she is accompanied by an attendant male, which courts her and also drives away other males. Once the pit is completed, the female drops into it, immediately followed by the male. When the pair is side by side, they open their mouths, quiver, and release egg and sperm. A total of 700–4,000 eggs are produced per spawning event, which are then fertilized by the subordinate male. The female then quickly moves to the upstream edge of the nest and starts digging a new pit, covering the eggs. This process goes on for several days until the female has deposited all her eggs. The young move downstream at night, shortly after they emerge.

CONSERVATION STATUS
Not listed by the IUCN. However, in May 2002 the National Marine Fisheries Service (under the Endangered Species Act) issued a ruling redefining the geographic range of the listed anadromous population of this species to include all steelheads and their progeny occurring in coastal river basins from the Santa Maria River (inclusive) to the United States/Mexico Border. Within the redefined geographic range, only anadromous, naturally spawned populations and their progeny, which reside below naturally occurring and man-made impassable barriers, such as impassable waterfalls and dams, are listed as endangered.

SIGNIFICANCE TO HUMANS
Perhaps the most often bred fish species in the world because of its adaptability and value as the subject of commercial and sports fisheries. Anglers find it very interesting because of its spectacular leaps and hard fighting when hooked. ◆

Sockeye salmon
Oncorhynchus nerka

FAMILY
Salmonidae

TAXONOMY
Salmo nerka Walbaum, 1792, rivers and seas of Kamchatka, Russia.

OTHER COMMON NAMES
English: Blueback salmon, land-locked sockeye, red salmon; French: Saumon rouge; German: Blaurücken; Spanish: Salmon rojo.

PHYSICAL CHARACTERISTICS
Length 33 in (84 cm) in males, 28 in (71 cm) in females; weight 17 lb (7.7 kg). Like most salmoniforms, has a streamlined, fusiform body that is laterally compressed, but unlike other species, the body depth is moderate, slightly deeper among breeding males. Head is conical, very pointed, with small eyes. Lateral line is straight. Has long, fine, serrated, and closely spaced gill rakers on the first arch. Coloration varies with sex and reproductive stage. Pre-spawning individuals are dark steel blue to greenish blue on the head and back, silvery on the sides, and white to silvery on the belly. Spawning individuals (particularly males) have a bright to olive green head with black on the snout and upper jaw; the adipose and anal fins turn red and the paired fins and tail generally become grayish to green or dark. Females are less brightly colored than males.

DISTRIBUTION
North Pacific, from northern Japan to Bering Sea and to Los Angeles, California, United States, with landlocked populations in Alaska, Yukon Territory, and British Columbia in Canada, and Washington and Oregon, United States. Successfully introduced in New Zealand.

HABITAT
There are two forms of this species: the sockeye, an anadromous form (a marine form that migrates to fresh water for spawning), and the kokanee, a landlocked form (with a much smaller maximum size).

BEHAVIOR
Age structure and morphology differ among populations. Sexual selection and reproductive capacity (fecundity and egg size) generally favor large (old), deep-bodied fish, thus the sizes and shapes of salmon vary among spawning habitats. Stream width is positively correlated with age at maturity and negatively correlated with the level of predation by bears. Therefore, sexual maturity can be reached as early as at one year of age or as late as five. Adults show a great inclination for homing, which takes place during summer and fall, as late as December.

FEEDING ECOLOGY AND DIET
Young in lakes feed largely on crustaceans and insect larvae; adults in lakes become pelagic and feed on plankton in the upper 60 ft (20 m) or so of the water column. As they grow, their diet starts to include other fishes. The landlocked form feeds

mainly on plankton, insects, and benthic organisms. Ocean-going populations are preyed upon by larger fishes, including sharks, as well as by pinnipeds and killer whales. Freshwater populations are vulnerable to larger fishes, otters, bears, and fish-eating birds.

REPRODUCTIVE BIOLOGY
Like other salmoniforms, the female selects a site to dig a nest, where she is attended by a dominant male along with a few subordinate males. Both females and males protect their site by aggressively shoving off individuals of the same sex. After courtship by the dominant male, the female enters the nest, followed immediately by the dominant male, which comes close beside her. After the ritual of mouth gaping, the pair vibrates to release eggs and sperm, and one or more subordinate males comes to the other side of the female and joins in the spawning. The female then moves to the upstream edge of the nest and digs again, covering the old nest, while at the same time creating a new one just upstream. After three to five days of depositing eggs, the female is exhausted and, along with the male, dies. The fry emerging from the gravel is very photophobic, and becomes mostly nocturnal.

CONSERVATION STATUS
Not listed by the IUCN.

SIGNIFICANCE TO HUMANS
One of the most commercially important Pacific salmons. The kokanee form is much sought after as a sport fish and is valued as food. ◆

Chinook salmon
Oncorhynchus tshawytscha

FAMILY
Salmonidae

TAXONOMY
Salmo tshawytscha Walbaum, 1792, rivers of Kamchatka, Russia.

OTHER COMMON NAMES
English: King salmon, Pacific salmon; French: Saumon chinook; German: Königslachs; Spanish: Salmón chinook.

PHYSICAL CHARACTERISTICS
Length 59 in (150 cm); weight 136.36 lb (61.4 kg). The fusiform body is streamlined and laterally compressed among large adults. Important distinguishing characteristics are small black spots on the back and the upper and lower lobes of the caudal fin, as well as on the black gums of the lower jaw. The gill rakers are widely spaced and rough. Coloration varies with environmental conditions. At sea, adults are dark greenish to blue black on top of head and back and silvery to white on the lower sides and belly; they also present numerous small and dark spots along back and upper sides and on both lobes of the caudal fin. In fresh water, they acquire an olive brown to red or purplish coloration, which is particularly noticeable among males.

DISTRIBUTION
Arctic and Pacific regions, in the drainages from Point Hope, Alaska to California, United States, as well as Japan, the Bering Sea, and the Okhotsk Sea. Successfully introduced in Australia, New Zealand, and Chile.

HABITAT
Similar to that of other salmoniforms; however, in lakes they may inhabit depths down to 1,230 ft (375 m).

BEHAVIOR
Like other salmoniforms, adults show a strong homing behavior. Their migratory behavior varies greatly. Usually, after three months in fresh water, most fry migrate to the sea, although some may stay in fresh waters for as long as three years. Some individuals remain close inshore throughout their lives, others make extensive migrations.

FEEDING ECOLOGY AND DIET
Food in streams consists mainly of terrestrial insects and small crustaceans; at sea major food items include fishes, crustaceans, and other invertebrates. The young are preyed upon by fishes and birds, such as mergansers and kingfishers; adults are preyed upon by sharks, large mammals (including killer whales), and birds.

REPRODUCTIVE BIOLOGY
Anadromous adults can migrate nearly 3,100 mi (5,000 km) from the ocean upstream to spawn. In December adults start to migrate from the sea, so that by early spring the first individuals arrive near the river mouths. The female is in charge of selecting the spawning spot where she will dig her nest, and aggressively drives away other females competing for the same spot. Once she has established her territory, a dominant male and several smaller males join her, at the same time driving away other males that compete for her. Male courtship behavior includes resting beside the female, quivering, swimming around over her, touching her dorsal fin with his body and fins, and occasionally nudging her side gently with the snout. Once the nest is complete, the female drops into it, and is immediately joined by the dominant male. Both open their mouths, vibrate, and eggs and sperm are released. At this point smaller males may swim into the nest and release their own sperm. (It is unclear to what extent these smaller males play a role in fertilizing the eggs.) The female then quickly covers the eggs by moving to the upstream edge of the nest and digging small pebbles for a new nest. This process, which may last several days, is repeated several times, until the female releases all her eggs. The female guards the nest for as long as she can. The male leaves the female and may mate with another female. Spent adults usually die a few days after spawning.

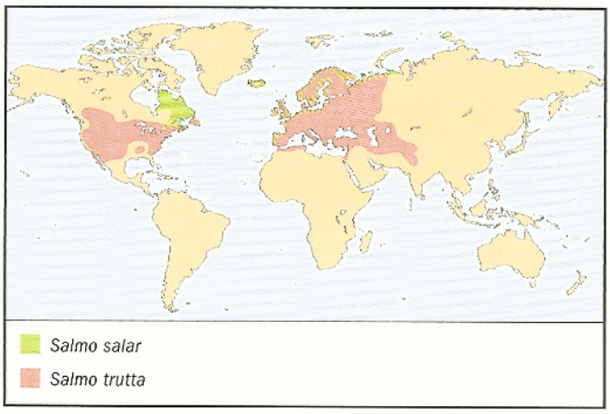
CONSERVATION STATUS
Not listed by the IUCN. The Alaskan fishery of this species has been certified by the Marine Stewardship Council as well managed and sustainable.

SIGNIFICANCE TO HUMANS
Highly regarded commercial and game fishes, whose red meat commands a high price. The viscera are rich in vitamin A and are used as food for hatchery fish. ◆

Atlantic salmon
Salmo salar

FAMILY
Salmonidae

TAXONOMY
Salmo salar Linnaeus, 1758, "Seas of Europe."



OTHER COMMON NAMES
English: Black salmon, sea salmon; French: Saumon Atlantique; German: Atlantischer Salmon; Spanish: Salmón.

PHYSICAL CHARACTERISTICS
Length in males 59.1 in (150 cm), in females 47.2 in (120 cm); weight 103 lb (46.8 kg). Individuals display different morphology and coloration depending upon the phase of the breeding season or the habitat they are in. Body usually has black spots, caudal fin usually is unspotted, and adipose fin is not black bordered. Other times they are blue-green overlaid with a silvery guanine coating in salt water, losing silvery coat to become greenish or reddish brown mottled with red or orange in freshwater.

DISTRIBUTION
Western Atlantic in the coastal drainages from northern Quebec, Canada, to Connecticut, United States; Eastern Atlantic in drainages from Arctic Circle to Portugal. Some landlocked stocks can be found in North America, Norway, Finland, Sweden, and Russia. Successfully introduced in Chile, Argentina, Finland, Australia, and New Zealand.

HABITAT
Juveniles inhabit freshwater; adults inhabit marine waters except to spawn. Usually found in rocky runs and pools of rivers, large and small, as well as lakes.

BEHAVIOR
Young remain in freshwater for one to six years, after which they migrate to the ocean. They remain there for one to four years, before returning to fresh water to spawn, then they return to the sea. Active mostly during the day.

FEEDING ECOLOGY AND DIET
Juveniles feed on mollusks, crustaceans, insects, and fishes; adults at sea feed on squids, shrimps, and fishes. Ocean-going populations are vulnerable to larger fishes, pinnipeds, and toothed whales. Freshwater populations are preyed upon by larger fishes, otters, bears, and fish-eating birds.

REPRODUCTIVE BIOLOGY
Growth rate depends on food availability and quality, as well as on water temperature and photoperiods. They reach sexual maturity between three and seven years of age. Adults reaching sexual maturity return to their home rivers, usually to the same areas where they were hatched and spent their initial freshwater life. Once there, the female selects a spawning site with appreciable current based on depth (usually 1.6–9.6 ft (0.5–3 m) and gravel size. Then she excavates a hole by turning on her side and flexing her body up and down creating a current and never touching the stones. After the female releases 8,000–26,000 eggs, the males visit the area, fertilize them, and cover the eggs. Spawning takes between two and three days. Early maturing or sneaker males return to their home stream every year, older males do so after several years in the ocean. The older males are not only larger, but also more colorful. Aggregations around a female are composed of both sneaker (smaller, younger) and older males. Once the female releases her eggs, all males release their sperm, with the greater number of eggs being fertilized by the first male that enters the nest. Young salmons fathered by precocious males grow faster than those fathered by anadromous males. Juvenile salmons (known as parr) spend most of their freshwater life in shallow riffles, mostly at the southern end of their range, until they reach 4–5 in (12–15 cm) in length, when they transform themselves into smolt and are ready for migration in spring the first year after hatching.

CONSERVATION STATUS
Not listed by the IUCN. Listed in Appendix III of The (Bern) Convention on the Conservation of European Wildlife and Natural Habitats as long as the species is in fresh waters.

SIGNIFICANCE TO HUMANS
Commercially valued for meat and consumed in many forms. ◆

Brown trout
Salmo trutta

FAMILY
Salmonidae

TAXONOMY
Salmo trutta Linnaeus, 1758, "Europe."

OTHER COMMON NAMES
English: German brown trout, herling, sea trout; French: Truite brune de mer; German: Lassföhren; Spanish: Trucha común.

PHYSICAL CHARACTERISTICS
Length 55.1 in (140 cm); weight 110.4 lb (50 kg). Coloration varies only according to the breeding season. They are dorsally black, usually orange on sides, surrounded by pale halos. The adipose fin has always a red margin. Troutlike body. The upper jaw reaches below the center of the eye in juveniles and well beyond the eye in larger individuals.

DISTRIBUTION
Originally from Eurasia. Now introduced all over the world, including Europe, Latin America, Australia, and New Zealand. Widely transplanted because it thrives in warmer waters than most other species of trouts. As with other species of salmonids, the introductions have had a negative impact on the local fauna.

HABITAT
Prefers cold, well-oxygenated upland waters. Favorite habitat is large streams in mountain areas with submerged rocks, undercut banks, and overhanging vegetation. Preferences in terms of high temperature tend to be looser than that of the rainbow trout.

BEHAVIOR
Mainly diurnal. Very territorial, aggressively defends feeding areas from conspecifics (members of the same species) and other trout species.

FEEDING ECOLOGY AND DIET
Diverse diet including small aquatic and terrestrial insects, mollusks, crustaceans, and small fishes. When eating very small prey, utilizes gill rakers on the surface of the gill arches. The plasticity in feeding preferences is accompanied by morphological plasticity in the feeding apparatus. For example, the mouth is fairly large and has nonspecialized teeth on the jaws and on several bones within the mouth, which serve for eating any almost creature. Very voracious, adults prey on items up to one-fourth their own length. The well-defined muscular stomach opens by a valve into the intestine. The intestine has a series of fingerlike appendages (pyloric ceca) that open off the intestine, immediately posterior to the stomach. These appendages secrete enzymes to facilitate food digestion. This character is typical of many very predacious species, and the more predacious they are, the higher the number of pyloric ceca. Ocean-going populations are vulnerable to larger fishes, pinnipeds, and toothed whales. Freshwater populations are preyed upon by larger fishes, otters, bears, and fish-eating birds.

REPRODUCTIVE BIOLOGY
Life history is similar to that of the Atlantic salmon, reproducing in rivers, producing about 10,000 eggs, and taking between three and four years for maturation.

CONSERVATION STATUS
Not listed by the IUCN.

SIGNIFICANCE TO HUMANS
Much sought after as a food item, particularly in Europe. Ocean-going individuals are called sea trout, and are larger than freshwater forms. They provide good sport, as do those that enter large lakes. ◆

Charr
Salvelinus alpinus

FAMILY
Salmonidae

TAXONOMY
Salmo alpinus Linnaeus, 1758, "Europe."

OTHER COMMON NAMES
English: Alpine char, Arctic charr; French: Omble arctique; German: Schwarzreuter; Spanish: Trucha alpina; Inuktitut: Akalukpik; Italian: Salmerino alpino; Portuguese: Truta-das-fontes.

PHYSICAL CHARACTERISTICS
Length 42 in (107 cm); weight 33 lb (15 kg). Distinguished from other species by light rather than black spots and by a boat-shaped bone (vomer) that is toothed only in front, on the roof of the mouth. Another distinguishing characteristic is the presence of 23–32 gill rakers and pink to red spots on the sides and back, the largest of which are usually larger than the pupil of the eye. Unlike other salmoniforms, the lateral line is not straight, but curves slightly downward from the head. Coloration varies with location, time of year, and degree of sexual development. Generally the back is dark, mostly brown, but also somewhat green, with lighter sides and a rather pale belly. Spawning adults, especially males, acquire very bright orange to red coloration on the ventral side and on the pectoral, pelvic, and anal fins.

DISTRIBUTION
North America and Europe in the Arctic and adjacent oceans, also rivers and lakes they enter to breed. This distribution includes the North Atlantic south to southern Norway, including Iceland and southern Greenland. There are isolated populations in northern United Kingdom, Scandinavia, Finland, and the Alps. Other populations are restricted to freshwater lakes (colonized in glacial times) in Quebec, Canada, and in Maine and New Hampshire, United States. Successfully introduced in Yugoslavia and France.

HABITAT
Like other salmoniforms this is an anadromous species found in fresh, brackish; and marine waters ranging in depth from 100 to 230 ft (30–70 m).

BEHAVIOR
Little is known besides feeding and reproductive behavior.

FEEDING ECOLOGY AND DIET
Freshwater populations feed on planktonic crustaceans, amphipods, mollusks, insects, and fishes (particularly finfish). Large individuals are piscivorous; dwarf and small fishes feed on a wide range of invertebrates. The proportion of plankton in the diet of dwarf and small individuals correlates positively with the number and length of gill rakers. Ocean-going populations are preyed upon by larger fishes and pinnipeds. Freshwater populations are vulnerable to larger fishes, otters, bears, and fish-eating birds.

REPRODUCTIVE BIOLOGY
Males reach sexual maturity between 4 and 5 years of age, females do so between 5 and 10 years old. The males establish a territory in order to attract females. When the female enters the territory, she looks for a suitable spot for a redd (nest) and starts digging. As she does, the male begins its courting behavior by circling around her and then gliding along her side and quivering. Once the redd is complete, the pair release egg and sperm. The female then covers the eggs by digging at the edge of the pit, thus starting the next redd. In the subarctic Lake Fjellfrosvatn, northern Norway, there are two morphs of Arctic charr that are reproductively isolated because they spawn five months apart. The smaller morph (less than or equal to 5.5 in [14 cm]) is confined to the deeper zones of the lake, the larger morph is mainly littoral.

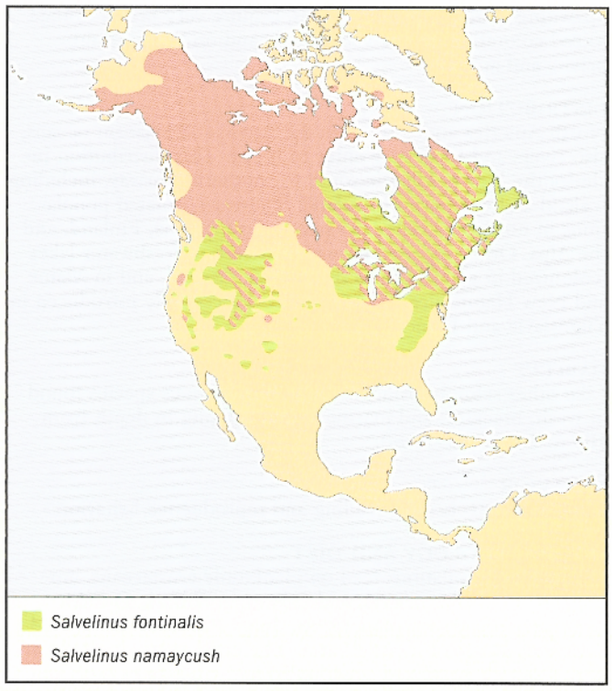
CONSERVATION STATUS
Not listed by the IUCN.

SIGNIFICANCE TO HUMANS
Highly prized as both a food and sport fish. ◆

Brook trout
Salvelinus fontinalis

FAMILY
Salmonidae

TAXONOMY
Salmo fontinalis Mitchill, 1814, vicinity of New York City, New York, United States.



OTHER COMMON NAMES
English: Brook charr, speckled trout, squaretail; French: Omble de fontaine; German: Bachsaibling; Spanish: Salvelino; Inuktitut: Iqaluk tasirsiutik.

PHYSICAL CHARACTERISTICS
Length 33.9 in (86.0 cm); maximum weight 20.7 lb (9.39 kg). Characterized by combination of dark green marbling on the back and dorsal fin, and by red spots with blue halos on the sides. Coloration can vary among populations and in reproductive states, with lower sides and fins red in spawning fishes. While migrating, dark green above with silvery sides, and white bellies and pink spots.

DISTRIBUTION
North America in most of eastern Canada from Newfoundland to western side of Hudson Bay; south in Atlantic, Great Lakes, and Mississippi River basins to Minnesota and northern Georgia, United States. In general, south of the Hudson River, distribution is correlated to altitude. For example, populations in North Carolina and Georgia are restricted to headwaters of streams in the Piedmont region of the Appalachians. Introduced in temperate regions all over the world.

HABITAT
Clear, cool, well-oxygenated creeks, small to medium rivers, and lakes.

BEHAVIOR
Migrates upstream in early spring, summer and late fall, migrates downstream in late spring and fall. As stream temperatures rise in the spring, may run to the sea (never more than a few miles [kilometers] from river mouths) and stay there for up to three months.

FEEDING ECOLOGY AND DIET
Opportunistic feeders, eating worms, leeches, crustaceans, insects, mollusks, fishes, amphibians, and even small mammals and plant matter. Littoral individuals exhibit lower physiological performance than do pelagic individuals, when restricted to feeding in the pelagic zones. Ocean-going populations are preyed upon by larger fishes and pinnipeds. Freshwater populations are vulnerable to larger fishes, otters, bears, and fish-eating birds.

REPRODUCTIVE BIOLOGY
Reaches sexual maturity between one and three years, with variable growth rates depending upon temperature conditions. Spawning takes place from October through December. Hatching takes about 100 days or longer if waters are below 41°F (5°C). The male courts females by attempting to drive them toward a suitable spawning gravel site that he will defend aggressively. If a female is receptive, she will choose a spot and dig a redd. Even while the female is digging, the male continues its courtship by darting alongside the female, swimming over and under her, and rubbing her with his fins. When the redd is complete, the pair enter the nest and deposit eggs and milt (sperm). The female then covers the eggs with small pebbles. Once the eggs are completely covered, she moves to the upstream end of the redd and begins digging a new redd. Early maturing, dwarf "jack" or sneaker males return to their home stream every year; "hooknose" males do so after several years in the ocean. The latter are not only larger, but also more colorful. Aggregations surrounding a female are composed of both "jacks" and "hooknose" males. Once the female releases her eggs, all males release their sperm, with the greater number of eggs being fertilized by the first male that enters the nest. Individuals of this species can reach 15 years of age in captivity.

CONSERVATION STATUS
Not listed by the IUCN.

SIGNIFICANCE TO HUMANS
Commercially farmed because of their value as food, also used extensively as an experimental animal. Anglers regard them highly because of their fighting qualities when hooked. ◆

Lake trout
Salvelinus namaycush

FAMILY
Salmonidae

TAXONOMY
Salmo namaycush Walbaum, 1792, Hudson Bay.

OTHER COMMON NAMES
English: Great Lake trout, lake charr, Mackinaw trout, salmon trout; French: Omble d'Amérique; German: Amerikanische Seeforelle; Spanish: Trucha lacustre; Inuktitut: Isuuq.

PHYSICAL CHARACTERISTICS
Average length 59 in (150 cm); average weight 72 lb (32.7 kg). Body typically troutlike, elongate, somewhat rounded, with a stout head that is dorsally broad. The deeply forked tail distinguishes them from other species. The lateral line is slightly curved at the front. Coloration characterized by white or yellowish spots on a dark green to grayish background, but also have pale spots on dorsal, adipose, and caudal fins, and usually on base of anal fin; sometimes orange-red on paired fins. During spawning males develop a dark lateral stripe and become paler on the back.

DISTRIBUTION
North America, from northern Canada and Alaska, south to New England in United States, and Great Lakes basin in Canada and the United States. Successfully introduced in many other areas, including South America, Europe, and New Zealand.

HABITAT
Shallow and deep waters of northern lakes and streams, rarely brackish waters.

BEHAVIOR
Sexually mature fishes return to the rocky creek where they were spawned in the same manner that river-living salmonids return home to their natal stream.

FEEDING ECOLOGY AND DIET
Extremely voracious. Most populations feed on freshwater sponges, crustaceans, insects, fishes, and small mammals; others feed on plankton throughout their lives. Planktivorous trouts show characteristics typical of plastic (variable) populations. For example, they grow more slowly, mature earlier and at smaller size, die sooner, and attain smaller maximum size than do their fish-eating counterparts. Vulnerable to larger fishes, otters, bears, and fish-eating birds.

REPRODUCTIVE BIOLOGY
More or less dispersed away from the spawning beds during the day, returning in late afternoon and spawning mostly at night, particularly between dusk and 9 or 10 P.M. Males establish their territory by rocks on the substrate, females arrive a few days later when males court them. From one to seven males will approach one to three females in the same area and press themselves against the sides of one or more females. Then the eggs fall into the crevices and the spawners disperse. This behavior is repeated until the female releases all her eggs. The eggs are heavy and sink to the bottom.

CONSERVATION STATUS
Not listed by the IUCN, yet they are highly susceptible to insecticides. In the 1930s sea lampreys invading the Great Lakes reduced this species almost to extinction. Great Lakes populations are largely sustained by extensive stocking of hatchery-reared fry.

SIGNIFICANCE TO HUMANS
Fished by both commercial and sport fishers. ◆

Arctic grayling
Thymallus arcticus arcticus

FAMILY
Salmonidae

TAXONOMY
Salmo arcticus Pallas, 1776, Ob River, Siberia, Russia.

OTHER COMMON NAMES
English: American grayling, Black's grayling; French: Ombre arctique; Russian: Kharius sibirskiy; Inuktitut: Sulukpauga.

PHYSICAL CHARACTERISTICS
Length 30 in (76.0 cm); weight 8.45 lb (3,830 g). They have a dark, enlarged dorsal fin (especially among males) and a small mouth with fine teeth on both jaws. The pelvic fins are rather long, reaching the anal fin in adult males, but not in females. The lower lobe of caudal fin is usually longer than the upper. Bodies are brightly colored, dark purple or blue-black to blue-gray in dorsal areas; sides are gray to dark blue with pinkish iridescence, gray to white in ventral region. Scattered dark spots on sides, particularly the young, with a dark longitudinal stripe along lower sides between pectoral and pelvic fins.

DISTRIBUTION
North America in the Arctic drainages from Hudson Bay, Canada to Alaska, and in Arctic and Pacific drainages to central Alberta and British Columbia in Canada. Relict populations are also found in the upper Missouri River drainage in Montana, United States. Past distribution included the Great Lakes basin in Michigan, United States, and in Siberia, Russia.

HABITAT
Clear, open waters of cold, medium-to-large rivers and lakes. Spawns in rocky creeks.

BEHAVIOR
Forms schools of moderate numbers.

FEEDING ECOLOGY AND DIET
Young feed on zooplankton but later prefer immature insects. Adults feed mainly on surface insects as well as other fishes, fish eggs, lemmings, and planktonic crustaceans. Vulnerable to larger fishes, otters, bears, and fish-eating birds.

REPRODUCTIVE BIOLOGY
Sexual maturity comes between two and six years of age. Spawning takes place between April and June. Once spawning adults move into tributaries, males establish territories. When a female enters a territory, males court her with displays of the dorsal fin. Then he positions himself beside the female and curves his extended dorsal fin over her. The pair releases eggs and milt while vibrating, with that vibration stirring up the substrate to produce a slight depression. After spawning, adults establish summer territories in pools farther upstream from the spawning site, returning downstream in mid-September.

CONSERVATION STATUS
Not listed by the IUCN.

SIGNIFICANCE TO HUMANS
Utilized as food and as an object of recreational fishery.

Resources

Books

Berra, T. M. *Freshwater Fish Distribution.* San Diego: Academic Press, 2001.

Elliott, J. M. *Quantitative Ecology and the Brown Trout.* Oxford: Oxford University Press, 1994.

Johnson, G. D., and C. Patterson. "Relationships of Lower Teleostean Fishes." In *Interrelationships of Fishes,* edited by M. L. J. Stiassny, L. R. Parenti, and G. D. Johnson. San Diego: Academic Press, 1996.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. *Atlas of North American Freshwater Fishes.* Raleigh, NC: North Carolina State Museum of Natural History, 1980.

Lichatowich, J. *Salmon Without Rivers: A History of the Pacific Salmon Crisis.* Washington, DC: Island Press, 1999.

Page, L. M., and B. M. Burr. *A Field Guide to Freshwater Fishes of North America North of Mexico.* Boston: Houghton Mifflin Company, 1991.

Taylor, J. E. *Making Salmon: An Environmental History of the Northwest Fisheries Crisis.* Seattle: University of Washington Press, 1999.

Periodicals

Alekseyev, S. S., V. P. Samusenok, A. N. Matveev, and M. Y. Pichugin. "Diversification, Sympatric Speciation, and Trophic Polymorphism of Arctic Charr, *Salvelinus alpinus* Complex, in Transbaikalia." *Environmental Biology of Fishes* 64 (2002):97–114.

Garant, D., P. M. Fontaine, S. P. Good, J. J. Dodson, and L. Bernatchez. "The Influence of Male Parental Identity on Growth and Survival of Offspring in Atlantic Salmon (*Salmo salar*)." *Evolutionary Ecology Research* 4 (2002): 537–549.

Klemetsen A., J. M. Elliott, R. Knudsen, and P. Sorensen. "Evidence for Genetic Differences in the Offspring of Two Sympatric Morphs of Arctic Charr." *Journal of Fish Biology* 60 (2002): 933–950.

Levin, P. S., and M. H. Schiewe. "Preserving Salmon Biodiversity." *American Scientist* 89 (2002): 220–227.

Proulx, R., and P. Magnan. "Physiological Performance of Two Forms of Lacustrine Brook Charr, *Salvelinus fontinalis,* in the Open-Water Habitat." *Environmental Biology of Fishes* 64 (2002): 127–136.

Quinn, T. P., L. Wetzel, S. Bishop, K. Overberg, and D. E. Rogers. "Influence of Breeding Habitat on Bear Predation and Age at Maturity and Sexual Dimorphism of Sockeye Salmon Populations." *Canadian Journal of Zoology* 79 (2001): 1,782–1,793.

Winfield, I. J., C. W. Bean, and D. P. Hewitt. "The Relationship Between Spatial Distribution and Diet of Arctic Charr, *Salvelinus alpinus,* in Loch Ness, UK." *Environmental Biology of Fishes* 64 (2002): 63–73.

Organizations

Salmon and Trout Association (UK). Fishmongers' Hall, London Bridge, London, EC4R 9EL UK. Phone: (020) 7283 5838. Fax: (020) 7626 5137. E-mail: salmon.trout@virgin.net Web site: http://www.salmon-trout.org

United States Trout Farmers Association. 111 West Washington St., Suite One, Charles Town, WV 25414-1529 USA. Phone: (304) 728 2189. Fax: (304) 728 2196. E-mail: ustfa@intrepid.net Web site: http://www.ustfa.org

Other

The Northwest Salmon Crisis: A Documentary History [cited January 29, 2003]. <http://www.netLibrary.com/urlapi.asp?action=summary>

"Pictures available for *Oncorhynchus masou*" [cited February 7, 2003]. <http://www.fishbase.org/Photos/ThumbnailsSummary.cfm?ID=242>

"*Oncorhynchus masou masou*" [cited February 7, 2003]. <http://www.city.chitose.hokkaido.jp/tourist/salmon/event/miniatrure/masou.html>

Aldemaro Romero, PhD