Ichthyology & Fisheries Management

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Demonstrate an appreciation for fishes and an interest in ichthyology.
- Discuss the diversity of fishes in Idaho and demonstrate familiarity with the different groups of fishes.
- Identify the relationship among various groups of fishes.
- Recall the general characteristics of the major groups of fishes.
- Discuss basic principles of fish behavior, physiology, and ecology and relate these principles to environmental adaptations.
- Discuss the habitat needs of various groups of fishes.
- Explain key threats to fisheries in Idaho.
- Tell the distribution of native fishes and their value as indicators of environmental and watershed health.
- Summarize the role that fish play in Idaho ecosystems.
- Recognize threatened, endangered, and at risk fish species.

Why Study Fishes?

There are many reasons for studying fishes ranging from the quest for knowledge to the practical. Throughout history, humans have had an insatiable appetite for knowledge about life on Earth. Much of our education is based on understanding the foundations that underlie the functioning of life on our very diverse planet. We humans are fascinated by our natural world. As a group of organisms, fishes represent a large, diverse, and incredibly interesting variety of species. Humans are interested in fishes for a host of reasons. They provide sport, provide food for millions across the globe, and have other commercial uses as animal food and raw materials. Many species are kept as pets in aquaria by hobbyists, while students concentrate on the structure of fishes, their systematic arrangement, and great evolutionary significance. In considering the relationship between humans and fishes, one automatically considers the use of fishes as food, for this is the greatest and most obvious relationship. Organisms that we classify as fishes are more numerous in number of species (over 25,000). They have a greater variety of body shapes and sizes, occupy a greater number of habitats, feed on a greater range of prey with a wider variety of feeding mechanisms, and reproduce in a larger number of modes than the other groups of vertebrates (amphibians, reptiles, birds, and mammals). Bony fishes represent about 40% of the living vertebrate species. In summary, fishes represent an incredible evolutionary history, diversity, and adaptability.

The first known fish-like vertebrates appeared in the fossil record of the early Cambrian Period, over 500 million years ago. Fishes gave rise to other vertebrate groups, including humans. Thus, the study of fishes can reveal much about other groups of vertebrates. As a group, fishes have evolved and survived through the eons while the Earth was undergoing enormous cataclysmic changes. They have largely maintained their existence during the comparatively short, but significant, realm of humankind. People often mention how many generations their family has lived in an area or owned a business. Compared to the evolutionary and generational histories of fish, we are but a mere blip on the screen. Fish are the ultimate survivors.

Historically, why were fishes studied and why does it remain important?

From the mid eighteenth to the early twentieth century, natural history was a major scientific field that was investigated to further our knowledge beyond the eastern United States. However, some of the major expeditions were led by military or other representatives of the Federal Government and had geopolitical, economic, and expansionist goals. Examples of the government-sponsored expeditions include the Lewis and Clark Expedition to the West Coast (1803-1806), the Long Expedition to the Rocky Mountains (1819-1820, 1823), and the Powell Geographic Expedition (1869). By the late 19th and early 20th century, the government was conducting fisheries surveys both in fresh and marine waters. These surveys were conducted to collect baseline information on fisheries resources. At about the same time, government fishery labs and hatcheries were raising fish to stock streams and lakes across the United States. State fish and wildlife agencies assumed the primary responsibility for conserving and managing fishery resources. This is still one of the primary duties of fish and wildlife agencies to raise fish for stocking, survey fish populations, and protect fish habitat.

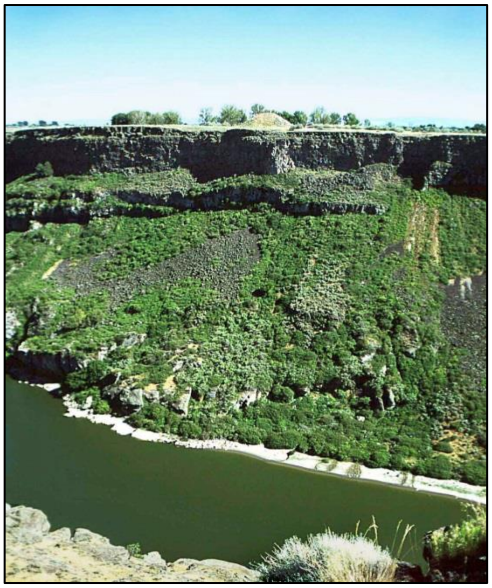
While the importance of fishes to humans is primarily as a food source, their value for recreation is enormously popular, particularly in the United States. In Idaho, trout are the most popular of our game fishes. Many millions of dollars are directed at recreational fisheries statewide. These monies filter through local economies providing revenues and jobs. According to the 2001 Hunting, Fishing and Wildlife-Associated Recreation Report, 416,000 Idahoans and visitors fished in Idaho that year. Cumulatively, they spent over 310 million dollars while fishing in Idaho, buying gas, paying for lodging, eating and buying equipment (USFWS, 2001).

Diversity of Fishes

Fishes as a group and their habitats appear to be of endless variety. They seem to occupy every available niche in the many aquatic environments of the world, ranging from small thermal pools to the deepest abysses of the oceans, in both fresh and salt-water. Fishes occupy freshwater in environments that range from:

- running headwater streams at high elevations characterized by swift current, rocky substrate, high dissolved oxygen, and cold water temperatures, to
- large rivers at lower elevations characterized by sluggish currents, silt-sand substrates, greater water depth, and warmer water temperatures.

Diversity represented by the number of different fish species in these flowing freshwater environments generally ranges from low diversity in small headwater streams to moderate to high diversity in larger river systems.



Petit Lake Creek (far above) is fast moving, shallow, and cold. The Snake River (above) is slower, warmer, and deeper.
Photos courtesy, Idaho Travel Council.

In still water environments, such as ponds and lakes, the diversity of fishes varies greatly depending on the age and productivity of the body of water.

Youthful lakes, in temperate regions, are characterized by low nutrient and organic loads. They have abundant oxygen supplies, colder water temperatures, and thermal stratification. Whitefishes, chars, and trout are the usual inhabitants in such lakes in the northern hemisphere. These lower productivity lakes support a relatively low biomass per unit area of water.

As lakes age and become more productive, the capacity to support a fish fauna changes and they can sustain a large biomass per unit area. However, this increased productivity comes with a tradeoff because the decomposition of the increased organic material requires much oxygen and the deeper waters of an enriched lake can be low or lacking in dissolved oxygen. In northern areas pike, perch, and pike-perches can coexist with or succeed the salmonids, such as trout. In warmer North American waters, fishes can include black basses, crappie, sunfishes, and rock basses.

Groups of Fishes

Fishes are comprised of four natural groups: the hagfishes, lampreys, cartilaginous fishes, and ray-finned fishes.

- **Hagfishes** are blind, eel-shaped, marine predators and scavengers. There are about 43 species worldwide. They are the most primitive vertebrates characterized by lacking mandibular jaws, paired fins, clearly defined vertebrae, and functional eyes. Hagfishes are marine animals and live largely buried in sediments where they feed on soft-bodied vertebrates and carrion. Obviously, since they are marine animals, we have no species of hagfishes in Idaho.

- **Lampreys** also lack mandibular jaws and paired fins but they have true vertebrae and eyes. There are 41 species of lamprey and one species, the Pacific lamprey, occurs in Idaho. Lampreys are eel-like and secretive. They are mainly seen when they are on their spawning migrations. Larger species are parasitic, feeding upon fishes and marine mammals. Smaller species are usually non-parasitic and feed only in the larval stage. Although all lampreys spawn in freshwater, some of the parasitic forms grow to maturity in marine waters, including the Pacific lamprey.

The Pacific Lamprey is a little known and underappreciated native fish of Idaho. Photo courtesy, IDFG

- **Cartilaginous** fishes have mandibular jaws, true vertebrae. They are distinguished from the ray-finned fishes (see next category) in possessing cartilaginous skeletons, teeth-like scales with an enamel-like covering, and horny, un-segmented fin rays that are unpaired. This group includes chimaeroids, sharks, rays, and skates. They are largely marine creatures. There are about 1,000 living representatives of the cartilaginous fishes worldwide. No species of cartilaginous fishes are found in Idaho.

- **The ray-finned or bony fishes** represent about 40% of the living vertebrate species. They possess mandibular jaws, bony skeletons, thin scales lacking an enamel-like covering, segmented paired fin rays. Ray-finned fishes occur in all habitats where fish exist. All of Idaho's native and introduced fish (except the Pacific Lamprey), are ray-finned fish.

A Rainbow trout.
Photo courtesy, Sara Focht, IDFG

Fishes of Idaho

Historically, before the arrival of European man, Idaho was home to 39 native fish species. Currently, there are 82 species of fish in Idaho. Native fishes include Salmonidae (trout, salmon, char), Cyprinidae (minnows), Catostomidae (suckers), Cottidae (sculpin), Petromyzontidae (lamprey), Acipenseridae (sturgeon), Percopsidae (trout-perch), Clupeidae (shad), and Gadidae (cod). Introduced fishes include Esocidae (pike), Ictaluridae (catfishes), Poeciliidae (livebearers), Centrarchidae (sunfishes), Percidae (perches), Cichlidae (cichlids), Cobitidae (loaches), and several game fishes of the family Salmonidae (e.g. brown trout, brook trout).

The Lewis and Clark Expedition of 1803-1806 recorded the first written accounts of Idaho fishes. Their accounts were not detailed enough for positive identification. According to Simpson and Wallace (1978) in their book *Fishes of Idaho*, naturalists, accompanying various early surveys of what is now Idaho, collected fishes for identification and description. The Pacific Railroad surveys of 1853 to 1855 collected specimens, mainly from the northern one-third of the state. In 1870-1871, fishes were collected from southeastern Idaho by the U.S. Geological Survey. A number of investigations under the direction of the U.S. Fish Commission were conducted throughout the Pacific Northwest in the late 1800s, which added to the general knowledge of Idaho fishes.

Idaho Water

While all of Idaho lies west of the Continental Divide, not all of its waters drain westward to the Pacific Ocean. Part of southeast Idaho drains into Bear Lake, which straddles the Idaho-Utah border, one of the largest interior drainage systems in the United States. In eastern Idaho, many isolated drainages do not flow into the Snake or Bear Rivers. These include the Lost Rivers and Birch, Medicine Lodge, Beaver, and Camas Creeks, collectively known as the Sinks drainages.

The remainder of Idaho's surface drainage flows into the Columbia River. Major river drainages in Idaho include the Kootenai, Pend Oreille, Spokane, and the Palouse in the north, and the Snake River drainage, which comprises the bulk of central and southern Idaho. The Snake River and its tributaries drain areas upstream and downstream of Shoshone Falls, a 212-foot high natural barrier in south-central Idaho. Major tributaries of the Snake River drainage above Shoshone Falls include the Henrys Fork and South Fork while major tributaries below Shoshone Falls include Salmon Falls Creek, and the Wood, Bruneau, Owyhee, Boise, Payette, Weiser, Salmon, and Clearwater rivers.

The major natural lakes of Idaho include Priest and Pend Oreille (Pend Oreille drainage), Coeur d'Alene (Spokane drainage), Payette (Payette drainage), Grays (Snake River above Shoshone Falls), Mud (isolated drainage), and Bear (Bear drainage). A great many reservoirs have been created on Idaho's rivers. Some of the major reservoirs include Dworshak (North Fork Clearwater River); Lower Granite, Hells Canyon, Oxbow, and Brownlee (Snake River), Cascade (North Fork Payette River), Arrowrock, Lucky Peak, Anderson Ranch (Boise River drainage), C.J. Strike (Snake River), Blackfoot (Blackfoot River), Palisades (South Fork Snake River), and Island Park (Henrys Fork Snake River).

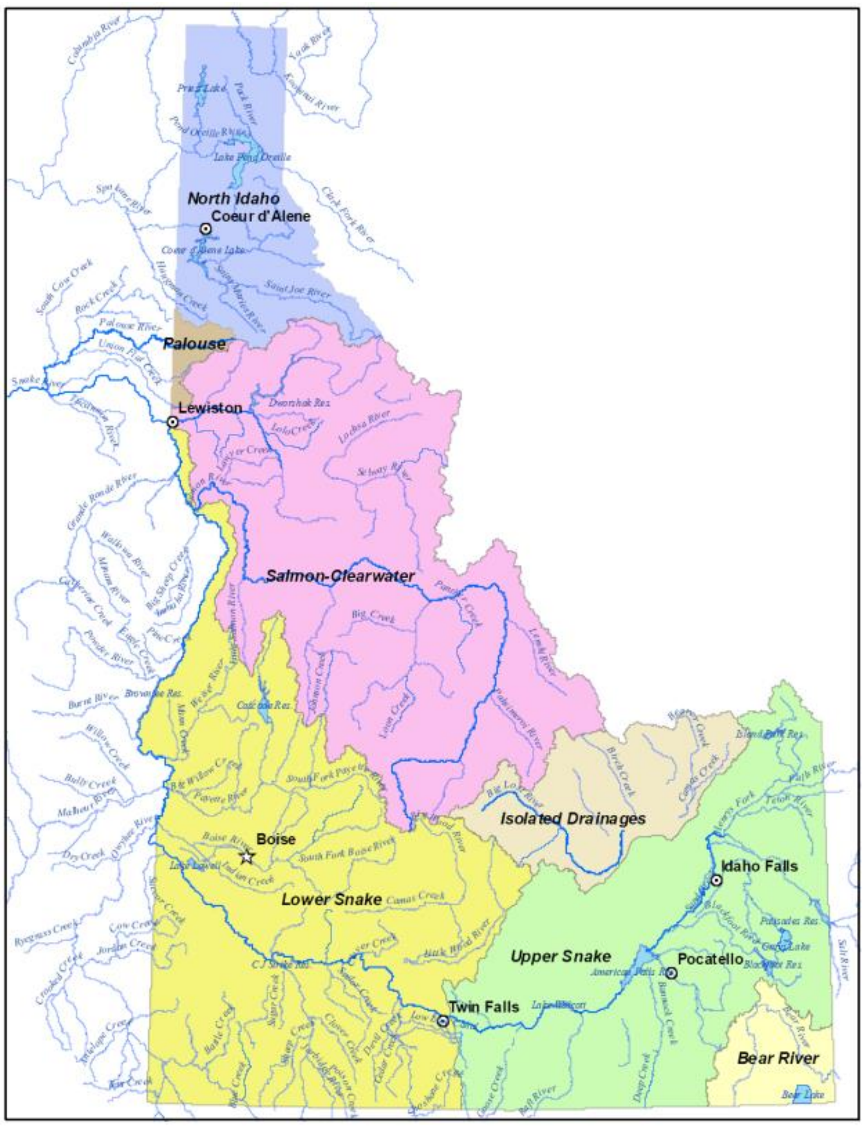
The river systems of Idaho have been profoundly impacted by lava flows and glaciation. Lava flows have changed the course of many streams including the mainstream Snake River. The effects of glaciation formed both temporary and more permanent lakes. Glacial melting caused tremendous floods by breaching temporary dams and resulted in alteration of river courses. These and other impacts have had a significant effect on the current distribution of native Idaho fishes.

In southern Idaho, the development of Shoshone Falls was a major influence on the historical distribution of native fishes and remains a complete barrier to their present dispersal. It is estimated that this falls was created 2-3 million years ago. The result of this barrier to fish distribution was to prevent any species of fish from extending its range upstream above the falls after its formation. Fish species that arrived in Idaho after this time, such as Pacific salmon and trout, were unable to penetrate the Snake River above Shoshone Falls. Any fishes found in the Snake River above the falls likely existed before the falls was created or extended their range to the Snake River drainage from the Great Basin or from east of the Continental Divide.

In southeastern Idaho, during the Pleistocene Era, the immense Lake Bonneville rose and overflowed into the upper Snake River. This great flood scoured out channels and water falls. Lake Bonneville rose and fell several more times and probably spilled out into the upper Snake River, but not with the great force of the first flood. A number of fishes from the Lake Bonneville fauna probably entered the upper Snake River in this way. The Great Salt Lake is a remnant of Lake Bonneville.

In northern Idaho, during the Pleistocene Era, an ice lobe blocked the ancestral Clark Fork River and formed glacial Lake Missoula, a huge lake that occupied much of the Clark Fork Valley all the way to Missoula, Montana. At least once, and possibly three or four times, the ice dam broke and huge floods occurred. These floods swept across eastern Washington toward the southwest and formed such features as Palouse Falls and Spokane Falls. These falls were barriers to post-glacial dispersal of fishes from the lower Columbia River, such as Pacific salmon and steelhead trout. Falls on the Pend Oreille and Kootenai Rivers acted as similar barriers.

For sake of this discussion, Idaho is divided into six areas including 1) North Idaho, 2) Salmon-Clearwater, 3) Snake River above Shoshone Falls, 4) Snake River below Shoshone Falls, 5) Isolated drainages and 6) Bear River (see map below).



Map created by Brent Thomas, IDFG, 2007

North Idaho

Priest River
Photo courtesy, Idaho Travel Council

Major river drainages of North Idaho include the Kootenai, Pend Oreille, and Spokane. The Kootenai River is the most northern river system in Idaho. Native game fish species include westslope cutthroat trout, inland rainbow trout, bull trout, mountain whitefish, white sturgeon, and burbot, while nongame species include lake chub, peamouth, northern pikeminnow, longnose dace, redside shiner, longnose sucker, largescale sucker, slimy sculpin, and torrent sculpin. The white sturgeon and burbot are unique to the Kootenai River system. The Kootenai River is the only drainage in Idaho where burbot are native, while the white sturgeon population is genetically distinct from the Snake River population.

The Pend Oreille River system in Idaho includes the Priest and Pack rivers, and Lightning Creek. Lake Pend Oreille is the largest natural lake in Idaho at nearly 90,000 surface acres reaching almost 1,200 feet deep. Priest and upper Priest Lakes are glacial lakes located just south of the border with Canada. Westslope cutthroat trout, bull trout, pygmy whitefish, and mountain whitefish are the only salmonids native to the Pend Oreille drainage of Idaho. Also present are native cyprinids, cottids, and catostomids.

Major tributaries of the Spokane drainage are the St. Joe, St. Maries, and Coeur d'Alene rivers, which all drain into 31,487-acre Coeur d'Alene Lake. Native game species include westslope cutthroat trout, bull trout, and mountain whitefish. Cyprinids, cottids, and catostomids are also present.

Salmon-Clearwater

The Salmon River drainage and its major tributary the Snake River encompass much of central Idaho, a vast region of forests, mountains, rivers, and wilderness. These large drainages provide much of the remaining habitat for Idaho's anadromous salmon and steelhead trout, and remnant populations of Pacific lamprey. Native fish species include spring/summer runs of Chinook salmon, steelhead trout, Pacific lamprey, westslope cutthroat trout, bull trout, mountain whitefish, inland redband trout, cyprinids, cottids, and catostomids. White sturgeon are found in the lower reaches of the Salmon River.

Snake River above Shoshone Falls

The Snake River, above Shoshone Falls, is the historical range for Yellowstone cutthroat trout, one of three subspecies of cutthroat trout in Idaho. Yellowstone cutthroat trout inhabit all of the major tributaries to the Snake River above Shoshone Falls. Mountain whitefish are the other common salmonid species native to this part of the Snake River drainage. Other native species include cyprinids, cottids, and catostomids.

Snake River below Shoshone Falls

The Snake River, below Shoshone Falls, encompasses a huge area of southern Idaho. Once it reaches the Idaho-Oregon border, it makes an abrupt turn to the north as it forms the state boundary to the Lewiston, Idaho area. Shoshone Falls is the upstream terminus for the historical range of white sturgeon, spring/summer and fall runs of Chinook salmon, steelhead trout, and inland redband trout. White sturgeon are the largest freshwater fish in North America reaching lengths over 10 feet. Fall Chinook salmon spawn in the mainstream Snake River while spring/summer runs spawn in tributaries along with steelhead trout. Steelhead trout are the anadromous form of inland redband trout. Other native species include cyprinids, cottids, and catostomids.

Shoshone Falls, near Twin Falls, Idaho
Photo courtesy, Idaho Travel Council

Isolated Drainages

Isolated drainages that no longer have a connection to the Snake River in eastern Idaho include the Big and Little Lost river drainages, and Birch, Medicine Lodge, Beaver, and Camas Creeks. The streams of these basins originate from four major mountain ranges in eastern Idaho and flow generally east and south, eventually sinking into the fractured basalts of the Snake River Plain. These drainages are collectively known as the Sinks. The origin of aquatic fauna in the Sinks drainages remains unclear. Genetic data suggest that mountain whitefish in the Big Lost River originated from the upper Snake River drainage. Yellowstone cutthroat trout are native and present in Medicine Lodge, Beaver, and Camas creeks and most likely entered the drainage from the Henrys Fork Snake River drainage via Dry Creek. The distribution pattern of shorthead sculpin (Cottidae) within and around the Sinks drainages suggest that the shorthead sculpin within the Sinks drainages originated from the

The Big Lost River Range, near Arco, Idaho
Photo courtesy, Idaho Digital Atlas

Salmon River Basin. The presence of shorthead sculpin in all of the Sinks drainages suggests this species had entered the Sinks drainages prior to or during the most recent existence of Lake Terreton, about 10,000 years ago. Piute sculpin (Cottidae) appear to be native to the Big Lost River but it is unclear how or when this species entered the basin. Mottled sculpin (Cottidae) in the Sinks drainages likely originated from the Henrys Fork Snake River drainage within the same period and through the same mechanism as Yellowstone cutthroat trout. Whether or not bull trout and rainbow trout are native to any of the Sinks drainages remains unclear. However, if they are native, they likely entered the basin from the Salmon River basin via headwater connection.

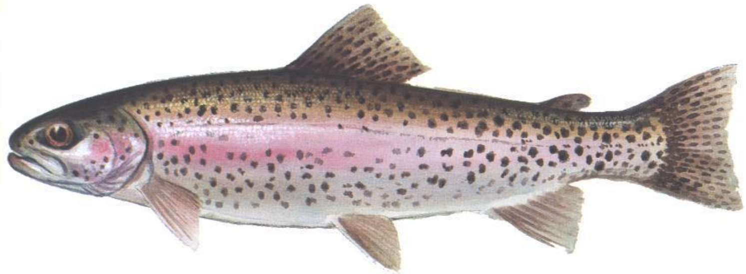
Bear River

Bonneville cutthroat trout are native to the Bonneville Basin in Idaho, Nevada, Utah, and Wyoming. In Idaho, this trout is only found in the Bear River drainage. The Bonneville Basin covers approximately 51,216 square miles and once contained Lake Bonneville, a huge pluvial lake that covered over 20,000 square miles, comparable to the size of current Lake Michigan. During the Pleistocene Era, about 25,000 to 35,000 years ago, the Bear River was a tributary to the Snake River. Lava flows diverted the upper Bear River south into the Bonneville Basin. When the Bear River was a tributary to the Snake River, trout from that system (Yellowstone cutthroat trout) gained access to the Bonneville Basin and colonized it. There is a strong taxonomic similarity between Yellowstone and Bonneville cutthroat trout. When climatic change dried Lake Bonneville, about 8,000 years ago, many tributaries became isolated and their fish faunas began to evolve independently. Given the relatively short time of geological separation, the demonstrated close affinity of present day Bonneville cutthroat trout in the Bear River with Yellowstone cutthroat trout of the Snake River is not surprising.

In the Bear River, within Idaho, other native fish species that evolved with Bonneville cutthroat trout include mountain sucker, leatherside chub, Utah chub, redside shiner, longnose dace, speckled dace, mottled sculpin, Piute sculpin, and mountain whitefish. In Bear Lake, which straddles the border of Idaho and Utah, Bonneville cutthroat trout evolved with endemic Bear Lake whitefish, Bonneville whitefish, Bonneville cisco, and Bear lake sculpin.

Shapes of Fishes

Fishes come in a huge variety of shapes and sizes. The body form of a fish can be used to surmise their way of life. In other words, like many things in nature, *form follows function*. Fishes must expend a lot of energy in the aquatic environment overcoming the forces of water against their bodies. A common body form of fast-swimming, open water fishes like tunas is called *fusiform*. This body form is characterized by an ultra-streamlined configuration with an elliptical cross section. This shape minimizes the impedance of water to locomotion. Although more laterally compressed than tunas, trout are similar in body shape. These shapes are inherent in fishes that are active, fast-swimmers.

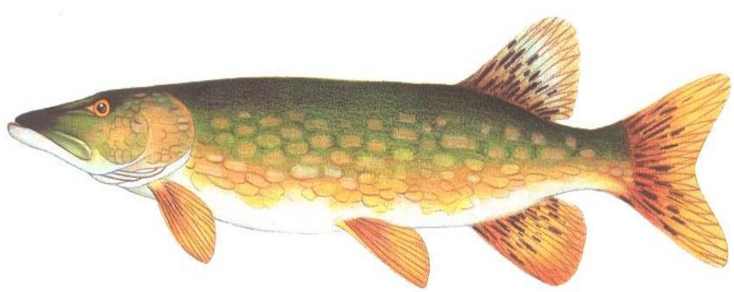


Rainbow Trout has a common fusiform shape.
Illustration by Joseph Tomelleri

Fishes suspended in water, but swim slowly, are less constrained by the forces of water and assume a greater variety of shapes. Eel-shaped fishes are called *anguilliform.* Many fishes, that are not constantly moving, but which are capable of short bursts of speed, and markedly compressed laterally, are called *compressiform.* This includes sunfishes, snappers, and flounders. Fishes that are flattened dorsoventrally (like a pancake) are termed *depressiform* and include fishes such as skates, angel sharks, and toad fish. This shape suits fish for life on the bottom, but the greatly flattened mantas and eagle rays have adapted to a flight-like swimming above the bottom.

Idaho's Bluegill is an example of a fish with a compressiform shape.
Illustration by Joseph Tomelleri

Other terms used in connection with body shape are *filiform* for thread-shaped fishes such as snipe eels; *taeniform* for the ribbon-like shape of gunnels, pricklebacks, and cutlassfishes; *sagittiform* for the arrow-like shape of pikes and gars; and *globiform* for fish such as the lumpsuckers. Not all fishes have body forms described by these terms, but many are.

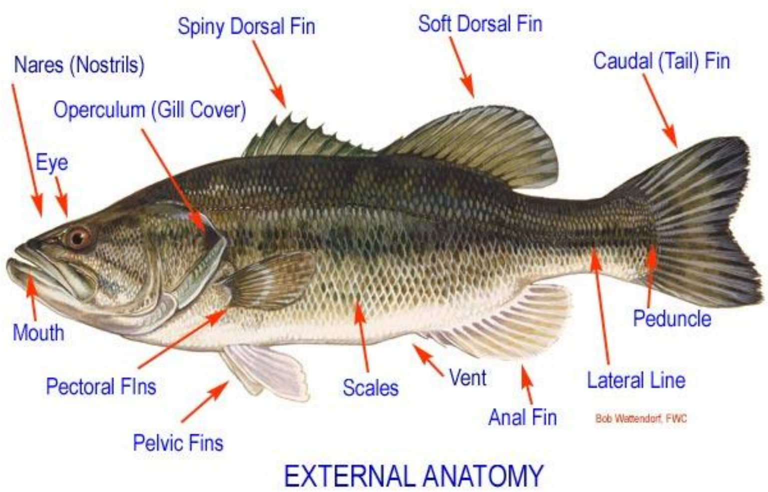


Saggiform describes the arrow-like shape of the Pike.
Illustration by Joseph Tomelleri

In summary, the shape of fishes is related to a number of factors in their particular habitat and the ultimate shape is a compromise among a host of issues concerned with movement, feeding, and staying alive. With a basic idea of the environmental constraints of different habitats, it is possible to examine the shape of a fish and to predict where it lives.

The shape is also determined by the genetic potential of the fish species. If the fish species does not have the genetic blueprint for a particular shape, the shape will not happen. For instance, ray-finned fishes, for the most part, are not depressed or flattened but apparently, there is a need for a flattened shape in benthic or bottom habitats. To compensate, one group of fishes have become compressed and then lie on their side to approximate a depressed shape. These fishes are the flatfishes, which include flounders, halibut, and sole. They start out their lives very much compressed but during development, one of their eyes migrates to the other side of the head and they assume a benthic existence by laying on either their right or left side. These fishes are truly unique among the vertebrates in being asymmetrical in shape. We can learn much by examining the shape of fishes and predicting their habitats, and realizing that evolution does not always follow the simplest path. The path followed is related to the genetic potential of the particular fish group.

Anatomy of a Fish

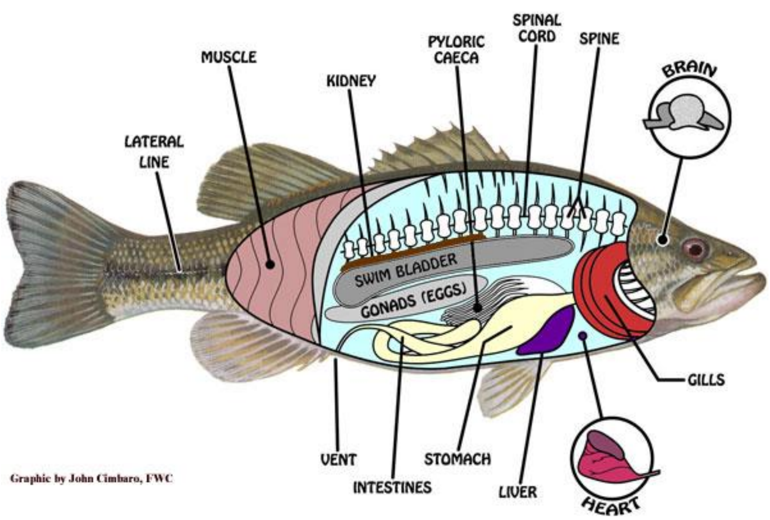


Graphic from Florida Fish and Wildlife Conservation Commission (permission pending).

Some of the key parts of a fish body include the operculum, which covers the gill openings. The narrow "handle" of the fish just forward of the tail is the caudal peduncle. The conspicuous line along each side of a typical fish is called the lateral line, which is a continuation of the network of sensory canals on the head. The fins are conspicuous features on the fish body. These are supported by the skeleton and composed of two groups, unpaired and paired. The unpaired fins are the dorsal along the back, the caudal or tail fin and the anal fin. The paired fins are the pectorals pelvics (ventrals). Fins are stiffened by structures called rays, which can be soft and flexible or modified into spines. Caudal fins in particular, come in a variety of shapes and sizes, and often reflect evolutionary levels and relationships more than the other fins.

Why do different fishes live in different places?

Fishes are, for the most part, restricted to aquatic environments. Very few regions of the world lack fishes. Some fishes can live, for extended periods, out of the water. In freshwater, fishes are found in low oxygen swamps, ephemeral water bodies, torrential streams, and vernal pools. Some fishes occur in highly saline waters and others live in acidic environments. Fishes that live in anaerobic waters obtain their oxygen by means of lungs or other highly vascularized tissue that is brought into contact with the air. Fishes that live in temporary ponds resemble insects in that they grow and reproduce during the rainy periods but assume an inanimate state during dry periods. As the water dries up, their fertilized eggs drift to the bottom and go into an arrested development until the rains return. As the water rises, they undergo rapid development, and mature and spawn before the next drought. Fishes that live in torrential mountain streams like in the Andes of South America or Himalayas in Asia have flattened bodies, sucker-like mouths, and sucker-like fins or entire bodies that enable them to resist the water currents and to feed on the algae growing on the stream bottom. Fishes living in acidic waters have special hemoglobin that enables them to capture oxygen from the water. Idaho does not possess these sorts of challenging environments for fish to live in, but there is considerable variation in aquatic environments across Idaho that correlated with precipitation and stream flow, and the distribution of fish species reflects these factors.



In marine waters, fishes live from exposed tidal flats to depths of 8,000 meters, and from the tropics to polar latitudes with temperatures below -2 C. Fishes that spend much time above the water on the mud flats (mudskippers) obtain oxygen by means of vascularized organs, have thick integument that resists desiccation, and eyes that are adapted for sight on land. They gather their food on land and go into the water only to avoid desiccation or terrestrial predators. Fishes that live at great depths live in almost complete darkness, under extreme pressure, and in a very food poor environment. They have very reduced eyes, lack swim bladders, and have poorly calcified skeletons. Eyes are metabolically expensive and are greatly reduced or totally lost in environments in which they are not needed. On the other hand, these fishes have very acute senses of smell and touch. Because of the great pressure, fishes are unable to keep gas in their swim bladders, and there is little available calcium for skeletal structures. Fishes that live in super cooled arctic waters have an antifreeze system in their blood that prevents them from freezing. The antifreeze is a protein that lowers the freezing point of the tissue below that of the water in which these fishes live.

How have fishes adapted to their environment?

The other groups of vertebrates display a wide array of feeding modes, but none rivals the fishes. Fishes range from omnivores (eating a variety of things), carnivores (eating meat), herbivores (eating plants), to parasites (feeding on another living organism), and the variety of feeding modes within each category is astounding. There are straightforward carnivores that hunt down their prey. Others lie and wait predators that lurk in the shadows or weed beds or lie buried in the sand and ambush unsuspecting prey. Many of the ambush predators are aided with great suctorial mouths to engulf prey or electric organs to stun their prey. Another group of fishes has a dorsal fin spine modified into a fishing lure to entice their prey within range. The relative size of prey varies tremendously. Some of the largest fishes such as the manta rays, basking sharks, and whale sharks feed on minute zooplankton that is filtered out of the sea. Deep-sea viperfishes are able to articulate their jaws, have greatly distensible stomachs, and engulf fishes larger than themselves. Many pelagic sharks and piranhas have cutting teeth and are able to take bites out of their prey. Pipefishes and seahorses have syringe-like mouths and suck individual zooplankton out of the water column. The archerfish dislodges terrestrial insects, from plants above the surface, by spitting water at them.

A large number of fishes are herbivorous (eating only plants). Most consume algae because much of it is rather easy to break up and digest compared to vascular plants. Few, if any, fishes are able to digest cellulose or have resident bacteria in their guts that can break down cellulose. Most herbivores simply graze and browse algae off substrates.

Parasitic fishes have a wide variety of ways to obtain nutrients from their host. A majority of lampreys attach themselves to other fishes by means of their suctorial discs. They rasp holes in the sides of their host, and live on the body fluids. The other jawless fishes, hagfishes, use their rasping jaws to burrow into dead and dying fishes and consume their hosts from the inside. A deep-sea eel feeds in a similar manner but, unlike the hagfish, has mandibular jaws. There are several fishes in tropical freshwaters that live on scales removed from their hosts. Some of the cichlid fishes from the great lakes of Africa make their living by parasitizing the scales, flesh, or young of mouth brooding fishes. In some cases, the parasite fishes closely resemble their host fishes thus enabling them to approach within striking distance. Aggressive mimicry is also practiced by a blenny that resembles the cleaning wrasses that set up feeding stations on coral reefs. The blenny, however, removed pieces of flesh and scales rather than parasites from its host.

Reproduction

Fishes have evolved many ways of reproducing. The vast majority of fishes are single sexed, males or females, and broadcast their sperm or buoyant eggs into the water. The sperm fertilizes the eggs and the fertilized eggs float off and are on their own. The adult fish end their parental involvement after spawning. This type of reproduction results in high mortality of eggs. Thus, fish species, like yellow perch, that practice broadcast spawning without nest construction, produce many eggs in hopes of some surviving to adulthood. Other species invest less energy in producing gametes (eggs and sperm) and more energy into ensuring that their fertilized eggs have a reasonable chance of survival. A number of fishes produce large sticky eggs that are fertilized and deposited in places relatively free of predators. Eggs are deposited on aquatic plants, shells, or buried in the bottom.

Idaho’s native trout spawn in the spring during high water runoff conditions from mountain snowmelt. Spawning takes place in high velocity areas such as riffles in gravel substrate. Female trout dig a nest or redd in the stream bottom, lay their eggs. An attending male or males fertilize them. Then, the female covers the eggs back up with gravel where they receive a steady supply of oxygen and hatch out in the early summer. Cutthroat trout and bull trout oftentimes migrate upstream (rarely downstream) from large rivers and lakes to spawning locations in small tributaries, a journey often exceeding 20 miles or more.

White sturgeon live in large river systems and spawn in the spring during periods of runoff. Interestingly, only a small percentage of mature adults reach reproductive readiness in any given year. Females deposit their small, sticky eggs in broadcast fashion in swift currents where they eventually stick to suitable substrate for development. A large female can produce millions of eggs.

One of the more remarkable feats of reproduction is that undertaken by *anadromous* salmon and steelhead in the Pacific Northwest of the United States. Anadromous refers to a lifestyle where a fish spends most of its life in the ocean and migrates to freshwater to reproduce. Idaho’s salmon and steelhead migrate downriver to the ocean as young fish from their natal rivers and streams. They spend anywhere from one to three years in the ocean environment growing to adult size. Then, remarkably, they undertake a grueling upriver migration to the same streams and locations where they were born to reproduce in one of nature’s premier exhibits of “survival of the fittest.” In Idaho, these migrations can approach 900 miles. Fittingly, Pacific salmon die after spawning as every ounce of their reserves is drained from their bodies following this exhausting and harrowing journey. Their carcasses decay and provide nutrients that contribute to the food chain of river ecosystems or other creatures that eat them. This is nature’s way of recycling valuable resources.

Catadromous refers to a lifestyle where a fish spends most of its life in fresh water and migrates to the ocean to breed. The American eel is one such fish that demonstrates a catadromous lifestyle. American eels ascend streams from the Atlantic Ocean as elvers, the males remaining mostly in the lower sections and females traveling great distances upstream. Fresh water life lasts from four to seven years for the females and a shorter period for the males. After they descend the streams and enter the ocean, they virtually disappear.

How do fishes function in ecosystems?

Although fishes are generally considered to be near the top of the food chain, they occupy a number of trophic (food chain) levels from herbivores (bottom of the food chain) to top carnivores (top of the food chain) and tend to dominate a number of aquatic environments. In most habitats, fishes are more diverse in number of species than all other multi-cellular animals. Fishes also have a definitive effect on the other multi-cellular organisms through predation. In the oceans, large rivers and lakes, a number of fishes (planktivores) consume zooplankton by filtering them out of the water column. Larger fishes, mammals, or birds in turn, consume these fishes. Thus, fishes play a critical role to the well-being of the upper end of the food chain.

A number of freshwater and brackish water fishes consume larvae of terrestrial insects such as mosquitoes. Mosquitoes are vectors for disease. Thus, the fishes that consume mosquitoes are often important in the control of diseases.

Anadromous fishes are very instrumental in the transfer of nutrients as mentioned earlier. Their progeny and all other organisms benefit from their ultimate sacrifice. The migrating salmon also serve as an important food source for bears and humans.

The role of fishes in a particular habitat can be very subtle but crucial. A diverse group of herbivorous fishes occupies coral reefs. These herbivores keep algae closely cropped. The algae need the light to photosynthesize. A dense covering of algae will inhibit this process and result in the death of the coral polyp. If the reef-building coral dies, the reefs will erode away, and the entire ecosystem will be lost. Thus, the herbivores enable the reef building coral to stay ahead of the algae.

Fishes can also have direct impacts on humans. They are major food items of humans, serve as important recreational activities, and are objects of a very large pet industry. The worldwide harvest of fishes is 100 million metric tons. This total is thought to be at or slightly above the maximum sustainable level. In other words, the world catch of fishes cannot be further expanded without negatively effecting the populations of the exploited species.

What are some conservation concerns for fishes?

Fishes and Humans

Like other groups of organisms, fishes have been negatively impacted by humans and will be increasingly impacted as human populations expand and compete for resources. The history of fishes is a long story of exploitation. Through improvements in technology, humans have greatly increased the efficiency of harvesting fishes, and greater efficiency leads to exploitation. In many cases, fish species that were abundant prior to exploitation have not returned to their former abundance decades after the collapse of the fishery. Several species, such as some of the whitefishes of the Great Lakes in the Midwestern United States, have gone extinct due largely to overfishing. Management of fisheries is a difficult proposition. The initial population size and structure of exploited stocks is often not known and management measures are not generally put into place until the resource is in decline.

Dams have had a major impact on fish. Across the western United States, most, if not all, native game fish species and their habitats adversely affected by dam construction and operations. Dams on the Columbia and Snake River drainages, impact migrating adult and juvenile salmon and steelhead. Before the arrival of European man to the United States, millions of anadromous fish would enter the Columbia River on their migration to spawning areas upriver. In the modern era, dams have fragmented the migration corridors of Idaho-bound salmon and steelhead making an already long and arduous journey much more difficult. All of Idaho's native anadromous fish species are federally listed under the Endangered Species Act. Similarly, Atlantic salmon, on the eastern seaboard of the United States, have been impacted. The huge white sturgeon of the Snake River has met a similar fate. These goliaths of North American fishes would historically swim freely throughout the Columbia and Snake rivers. With all the dams now in place, these fish are restricted to segments of their former range without the ability to interact with their own kind in other reaches. Dams on the Colorado River in Colorado, Utah, Nevada, and Colorado are responsible for the decline of many unique native fishes such as Colorado River pikeminnow, humpback chub, and razorback sucker.

In addition to blocking fish migration, dams have a major impact on fish habitat. Dams convert rivers to slack water environments. Many riverine fish species do not thrive in such conditions. The water temperature profile of a reservoir is drastically different that a riverine environment. The water temperature in a river is generally the same from the top to the bottom (vertically uniform). This is very different from a reservoir where the temperature of water varies with depth as does dissolved oxygen content. Dams severely restrict the flow of sediments such as gravels that create habitat for aquatic invertebrates that fish feed on and spawning and rearing habitat for fishes. Reservoirs also tend to become nutrient rich, which can lead to algal blooms, and oxygen deficits, the result of which can be major fish kills. The operations of dams for irrigation, flood control, or hydropower also can have significant impacts on fish and fish habitat.

Irrigation reservoirs capture river flows for storage and release them to meet irrigation demand. This results in abnormally low fall and winter flows below dams, shifts in the timing of the hydrograph, and altered thermal regimes. Flood control operations depend on snowpack in the mountains. During years of heavy snowpack, reservoir operators draft large volumes of water to make space in reservoirs to capture snowmelt. These flood release flows can occur earlier than historic peaks and are discordant with natural flow patterns. Hydropower operations can vary but generally are run-of-river where inflow typically matches outflow where reservoir levels do not fluctuate greatly, or they can be power peaking operations. Power peaking is done to meet power demands at high use seasons such as winter and summer. Flows releases are decreased at the dam while water is stored in reservoirs to create maximum head, and then released to generate power through turbines in the dam. During off-times, flows are increased and reservoirs are drained to predetermined levels. These artificial flow fluctuations can alter a river ecosystem. All of these changes can have drastic impacts on fish.

In Idaho, a number of factors have affected fish, other than dams and water management. These include timber harvest, agricultural practices including livestock grazing, mining, overharvest, and non-native fish species. A rising factor in the decline of native species is due to past fishery management practices of introducing non-native fishes such as rainbow trout, brown trout, and brook trout. Additionally, these species are invading new areas inhabited by native species. In the case of native trout species like cutthroat trout, inland redband trout, and bull trout, interactions with non-native species are generally negative resulting from competition for food and space, as well as hybridization.

References and Credits

Simpson, J.C. and R.L. Wallace. 1978. Fishes of Idaho. The University of Idaho Press. Moscow, ID.

U.S. Fish and Wildlife Service, U. (2001). 2001 National Survey of Hunting, Fishing and Wildlife-Associated Recreation. Retrieved May 6, 2006, from:

http://www.census.gov/prod/2003pubs/01fhw/fhw01-id.pdf#search='idaho%20hunting%2C%20fishing%20and%20wildlifeassociated%20recreation%20survey'

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