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# Sustaining America's Aquatic Biodiversity
# Freshwater Fish Biodiversity and Conservation

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## Introduction

Over 1,200 native fish species in 36 families inhabit the freshwater rivers, streams, and lakes of the United States and Canada. North America has the most diverse temperate freshwater fish fauna in the world. Only about 5 percent of these are the familiar sport or game fishes like trout and bass. The remaining 95 percent are little known, but colorful, nongame (not sport fish) fishes such as darters, minnows, shiners, and dace.

About one-third of North American fishes are in the minnow family (Cyprinidae), and about one-fifth are in the darter and perch family (Percidae). The Eastern United States has nearly four times as many fish species as the western states, yet the Southwestern deserts have a remarkable fish fauna. The Southeastern United States harbors the greatest diversity of native freshwater fish, with over 600 native fishes. States with the richest diversity of fish include Tennessee, Kentucky, and Virginia.

Nongame fishes, although not pursued by anglers, are nevertheless important. They serve us in many ways and deserve our protection. Nongame fishes are an important ecological link in the food chain, feeding on insects and serving as prey for sport fishes, birds, and other wildlife. They also are important indicators of water quality and ecosystem health. For example, a fish kill or the disappearance of fishes from a stream can alert citizens to water pollution.

Unfortunately, nongame fishes have declined sharply in abundance and diversity in the last 30 years. Fifty-seven species or subspecies of fishes have become extinct during the past century, including four in Virginia. At least 16 species of fish have become extinct in the United States since 1964. Nearly all of the fishes in the Colorado River are endangered or threatened. At present, nearly 20 percent of the native freshwater fishes in North America are imperiled, meaning that they are endangered, threatened, or of special concern.

## What Is a Fish?

Fish are cold-blooded animals with a backbone (vertebrates), gills for breathing underwater, and paired fins for swimming. They live underwater and are dependent on water for dissolved oxygen, support, food, and shelter. Marine mammals (whales, dolphins, seals, sea otters), reptiles (turtles), amphibians (frogs and salamanders), shellfish (oysters, clams, and mussels), and aquatic invertebrates (crayfish, starfish, lobster) are not fish. Although they may not look like fish, seahorses and eels actually are fish.

The three main groups of fish are

- jawless fish (lampreys),
- cartilaginous fishes (sharks and rays), and
- bony fishes (most fish species).

The first two groups are primitive, ancient fishes, whereas the bony fishes are more recent, advanced fishes.

Fish exhibit the greatest biodiversity of the vertebrates (animals with backbones) with over 33,000 species. Of these, about 58 percent are marine, 41 percent are freshwater species, and 1 percent move back and forth between salt- and freshwater. As expected, marine fishes are the most diverse because saltwater covers 70 percent of the earth. Only 1 percent of the earth is covered by freshwater. This small area is home to 15,000 species of freshwater fishes.

Anglers prefer sport fish (trout, bass, and pike) for their fighting or food value. In contrast, nongame fish are not commonly sought by anglers because they are small fish (minnows, darters, and dace) or not particularly good eating (carp, goldfish, bullheads, lamprey, and gar). Ninety-five percent of fish are nongame fish. For example, of the 226 species of fish found in Virginia, only 25 are considered game fish.

The science and study of fish is called ichthyology (from the Greek word for fish, **ichthyes**). Fish have been raised and studied for centuries, beginning with the early Chinese, Egyptians, and Greeks. The farming of fish and other aquatic animals is called aquaculture.

## Structure and appearance

Fish exhibit a variety of body forms. Some are streamlined, torpedo-shaped (trout, sharks, and sailfish), allowing them to slip easily through the water. Others are flattened top to bottom (flatfish and rays) for living on the bottom and making surprise attacks on prey. Some fish are flattened laterally (sunfishes) so they can make quick turns. Long, thin, needle-shaped fish (gar and pike) are adapted for high forward speed to catch prey. Pipefish and angelfish mimic the leaves of waterweeds for camouflage.

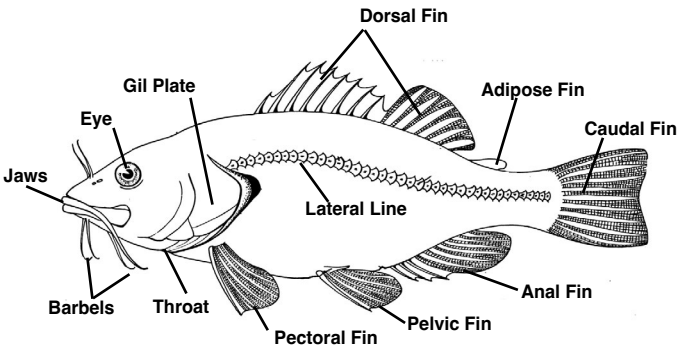



**Figure 1. External featues of a Composite fish**

Fish vary in size more than any other group of vertebrates. The world's biggest fish is the whale shark which reaches over 50 feet in length and is reported to weigh over 20 tons. The smallest fish is the pygmy goby, which reaches only 0.3 inch in length.

How do fishes breathe? All animals need oxygen to survive. Land animals breathe atmospheric air that contains 21 percent oxygen. However, oxygen is not always available in water. Dissolved oxygen levels in water can range from 0 percent to over 100 percent saturation, depending on water temperature, elevation, air pressure, other dissolved gases, and water quality.

Fish extract dissolved oxygen from the water using their gills. In breathing, fish first gulp a mouthful of water, then close their mouths and pressurize the water, forcing it over the rich red blood supply of gills and out the opercula (gill-flaps). Oxygen is absorbed directly into the fish's blood supply and distributed throughout the body via the circulatory system.

Some fishes have an internal, inflatable air (swim) bladder that evolved as an outgrowth of the intestine. The air bladder can be inflated or deflated to regulate buoyancy and depth. Some fish use their air bladders to amplify underwater sound, and thereby increase their ability to hear. Gar and lungfishes use their air bladders to gulp and breathe atmospheric oxygen. They can survive in low-oxygen water for long periods.

Nearly all fish have a protective slimy mucus covering their skin. This outer coating reduces friction and increases swimming speed. It also protects fish from parasites and diseases and permits salt balance (osmoregulation). Removing the mucus layer by netting and handling fish can increase their susceptibility to disease and disrupt their salt balance.

Many fish are armored with transparent plates called scales that overlap like roof shingles. Some fish have no scales. Others have scales that reflect silvery light to confuse predators. Scales are used to identify some fish species and to age many fish. By counting the number of scales along the lateral line (mid-body hearing organ), ichthyologists can often identify fish species. Under the microscope, growth rings on scales can be counted like tree rings to determine the age of a fish.

Fish use their fins to stop, start, steer, turn, swim backward and forward, chase and catch food, and migrate. The large, powerful tail (caudal) fin is important for forward speed. All fins, including the dorsal (top), pectoral (chest), and pelvic (abdominal) fins, are used in swimming and maneuvering. The dorsal, caudal, and anal fins are median, unpaired fins. The pelvic and pectoral fins are paired.

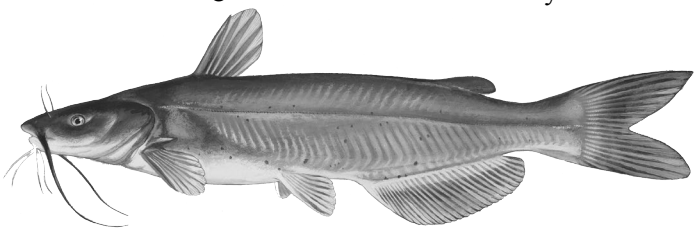
Fin shape and location are important for swimming and maneuvering. Fast swimming fish (tuna and swordfish) have long pointed and crescent-shaped fins that fold into body slots to reduce drag. Flying fish have long, broad wing-shaped fins that allow them to jump and glide long distances above the surface. Puffer and box fish have small, rapidly-beating fins for fine maneuvering.

Fins contain supporting fin rays that can be soft, hard, or a combination of both. Hard, sharp fins can deliver a painful (even toxic) jab when erected (some catfish). Pectoral fins can be large and broad as in flying fishes for gliding, or pointed as in fast swimmers like tuna, or rigid, diving planes as in sharks. Fast swimming, predatory fish often have long, large dorsal fins.

## Where do they live?

Fish can be found in aquatic environments everywhere. They live in high, cold mountain-top lakes; deep, dark ocean depths; warm, tropical swamps; salt marshes; freezing Antarctic waters; shallow Arctic streams; hot desert springs; salty coastal bays; large muddy rivers; and crystal clear cold springs.

Salt balance (osmoregulation) is very important in the internal chemistry (physiology) of both freshwater and marine fishes. Marine fish drink lots of saltwater and produce a very concentrated (salty) urine in order to flush out excess salt. In contrast, freshwater fish drink lots of freshwater, and produces a dilute (unsalty) urine in order to conserve essential salts. Because of these two very different salt-balance systems, most fish live exclusively in either fresh- or saltwater, although a small number of species are adapted to live in waters of intermediate salinities. The 32 species of fish that live year-round in the Chesapeake Bay are well-adapted to such intermediate conditions. A few fish have a wide salt tolerance and can move between salty and freshwater.



Salmon, American eels, and a few other fish can migrate between fresh- and saltwater. Salmon are anadromous fish that are born in freshwater, migrate to and live in the ocean, and then return to freshwater (often their birth stream) to reproduce (spawn) and die. Eels are catadromous fish. They are born in the ocean and migrate to freshwater to live, only returning to the ocean to spawn.

The rich diversity of fish (33,000 species) is due to the diversity of aquatic habitats and the range of water quality in which they can live. It also results from immense isolation in time and space (fish evolved over millions of years in oceans worldwide).

Fish diversity is greater in streams than in lakes. Frequently two to ten species of fish can be found in small streams, 15 to 30 species in an intermediate-sized stream, and 20 to 40 fish species in a river. An exceptional diversity of fishes is found in the Southeastern United States, where as many as 90 species of fish may live in a single river.

## What do they eat?

Fish diets consist of aquatic insects, zooplankton, plants, and other fish. The mouth structure and its location provide clues to what and where fish eat. Predator fish (pike and pickerel) have large, sharp teeth and a long pointed snout on the front of the head for grasping prey. Shellcracker sunfish have strong blunted teeth for crushing snails, mussels, and crayfish. A sucker's mouth is located on the bottom of the head in order to vacuum up bottom-dwelling worms and insects. Topminnows have an upper-facing mouth for sucking prey from the water surface. Surface-feeding fish (trout) eat drowning flies and insects floating or flying near the surface. Some fish, like the stoneroller, use their horny lips to scrape algae from rocks on the river bottom.

Most fish grow continuously throughout their lives, but growth slows with age. Fast growth is an indicator of healthy fish and abundant food. Some fish (sturgeon) can live for 50 years or more, whereas others may live less than one year.

## How do they reproduce?

In most fish, spawning (egg laying) and egg fertilization are external, completed in the water. Male and female fish simultaneously release sperm (milt) and eggs (roe) into the water where fertilization occurs. Some species scatter millions of eggs in the water where they are left unattended, whereas others lay only a few eggs and provide close parental care. Male sunfish and catfish, for example, aggressively defend their nest and young from predators and intruders.

Fish lay their eggs in many places, including in elaborate floating bubble nests, in bank hollows, and in clean bottom gravel. Others build spawning mounds of gravel or attach sticky eggs to aquatic plants, while others lay eggs in underwater caves and cavities.

Some fish are live-bearers. Reproduction is internal and embryos develop within the female fish. The young are born fully formed.

## What Good Are Fish?

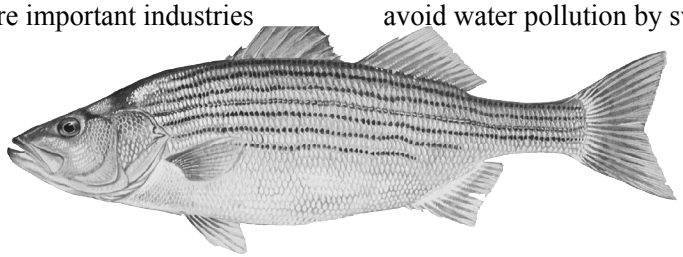
Sport fishing is a popular recreational activity pursued by millions of adults and children. About 30 percent of the people in the United States are recreational anglers. Some spend considerable money and time trying to catch fish. Many of these anglers practice catch and release fishing to assure good fishing for future generations.

Fish are an important ecological link in the food chain. They serve as food for other fish, herons, eagles,

ospreys, alligators, turtles, otters, minks, raccoons, bears, other wildlife, and humans.

They also are important indicators of water quality and ecosystem health. For example, a fish kill or the disappearance of fishes from a stream can alert citizens to water pollution. Because of habitat loss, siltation, water pollution, dams, mining, and human development, fish diversity has been reduced. Fish, as do all aquatic life forms, serve as "sentinel" species, alerting people that water quality is changing.

Wild and farmed fish are an important source of human food. Commercial fishing for wild fish and the aquaculture of farmed fish are important industries worldwide.



Fish is an ideal human food. It is nutritious; high in protein, minerals, vitamins, and beneficial omega oils; and low in fat and cholesterol. The demand for seafood and fresh fish is increasing as more people are realizing the health and fitness value of eating fish. Even fish eggs (caviar from sturgeon, paddlefish, and shad) are luxury foods that command premium prices.

## Fish Watching

Like bird watching, observing fishes in clear water streams and lakes, on coral reefs, and in aquaria are satisfying hobbies. In the field, you can walk along the shoreline looking down into a stream or lake. Swimming and snorkeling with fish also is a good way to observe them. Underwater, humans appear less threatening to fishes, which often are curious and closely approach underwater observers. Additionally, keeping a home fish aquarium is a great hobby enjoyed by millions of people.

## Threats

Many factors contribute to the loss of fish species and the degradation of their habitat. These include:

- dams and impoundments;
- water pollution, especially spills of toxic wastes (i.e., oil and petroleum products, industrial acids, pesticides, and fertilizers);
- sedimentation from agriculture, construction, and logging and mining;
- introduction of invasive species;
- overfishing;
- climate change; and
- increasing water temperatures.

Dams block fish spawning migrations and isolate fish from upstream spawning and nursery areas, causing populations of anadromous and catadromous fish to decline. As streams and rivers are transformed into lakes and reservoirs, alterations in downstream water flows and water temperatures negatively impact fish communities. River fish that have evolved and adapted to inhabit free-flowing rivers may not survive in lakes and reservoirs.

Water pollution threatens fish. Heated water (thermal discharge), low dissolved-oxygen levels, toxic chemicals (gasoline and oil), and coal-mine acids impact water quality and fish. Fish may temporarily avoid water pollution by swimming into small, clean tributary streams. However, they cannot live continuously in a polluted stream.

Invasive fish (e.g. snakehead) also stress native species. They compete with natives for habitat, spawning sites, and food. Invasive fish like the snakehead are aggressive predators that eat native fish. Aquarium pets should never be released into the wild where they can threaten native aquatic animals.

Conservation efforts and recovery projects by state and federal agencies to artificially culture and reintroduce native fishes and improve their habitats are underway.

## What Can You Do?

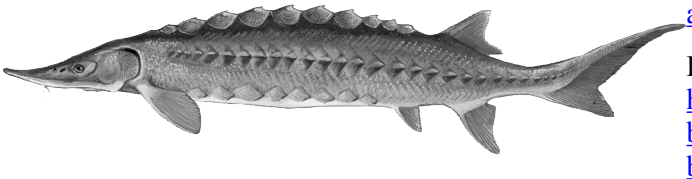
Your help is needed to foster healthy and diverse native fish populations, and to safeguard rivers and streams for future generations. One way to do this is to learn about fish, fish habitats, and the dangers they face. You can also become a "river or stream watcher" and promptly report any water pollution problems to your state natural resource agencies.

Be alert to the following symptoms of water pollution:

- muddy water
- oil slicks
- fish and mussel kills
- algae and weed problems
- odor and gas
- unusual flows
- discolored water,
- foaming water, and
- litter.

Organize a local “river watchers” group to keep an eye on your streams and conduct stream improvement projects.

Get involved in programs that restore coastal and streamside areas. Planting native trees and shrubs along riverbanks protects water quality and improves wildlife habitat.



Catch-and-release fishing allows anglers the enjoyment of catching fish and, then, freeing them to be caught another time by another angler. Use barbless hooks, wet your hands when handling fish, keep fish in the water, and avoid touching the gills. Cut the line if the fish is hooked deeply (stomach acids will dissolve the hook). Revive a tired or semi-conscious fish by gently flushing water through its gills until it is able to swim normally. Only take home the fish you need.

# Fish References and Web Sites

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Fishes of Iowa: http://www.iowadnr.gov/fishing/Iowa-Fish-Species.

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# Aquaria Web Sites

Monterey Bay Aquarium: http://www.montereybayaquarium.org.

Steinhart Aquarium: http://www.calacademy.org/exhibits/steinhart-aquarium.

The Florida Aquarium: http://www.flaquarium.org.

Waikiki Aquarium: http://www.waikikiaquarium.org.

John G. Shedd Aquarium: http://www.sheddaquarium.org.

National Aquarium in Baltimore: http://www.aqua.org/.

New England Aquarium: http://www.neaq.org/exhibits/animals/.

Belle Isle Aquarium: https://www.belleisleconservancy.org/bia.

Adventure Aquarium: http://www.adventureaquarium.com.

New York Aquarium: http://www.nyaquarium.com.

North Carolina Aquariums (Fort Fisher, Pine Knoll Shores, Roanoke Island): http://www.ncaquariums.com/.

South Carolina Aquarium: http://www.scaquarium.org.

Tennessee Aquarium: http://www.tnaqua.org.

The Dallas World Aquarium: http://www.dwazoo.com/.

San Antonio Zoological Gardens & Aquarium: http://www.sanantonioaquarium.net.

The Seattle Aquarium: http://www.seattleaquarium.org/.

Virginia Aquarium and Marine Science Center: https://virginiaaquarium.com.

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