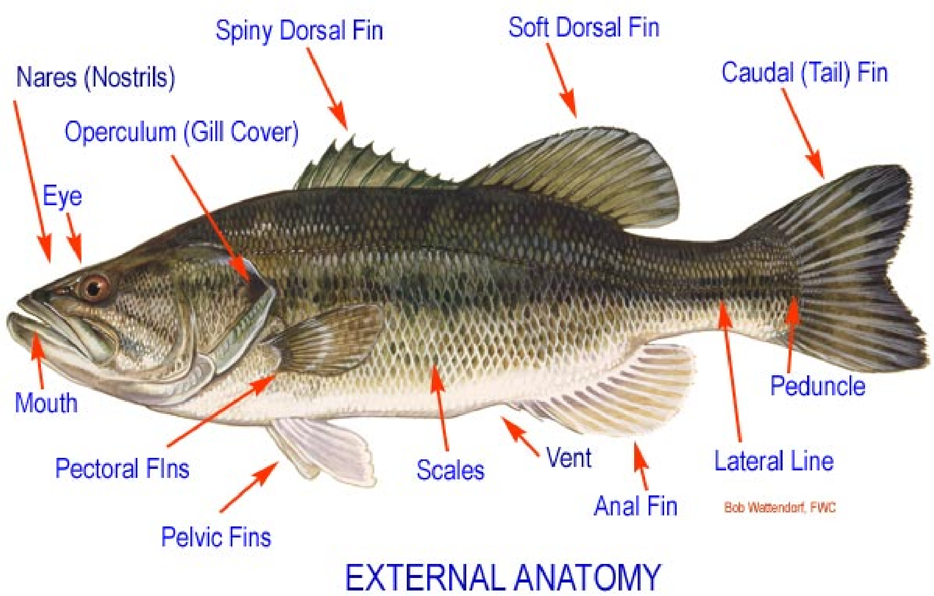
FISHERIES BIOLOGY AND MANAGEMENT

External Fish Anatomy

The following illustration of a largemouth bass shows some of the common external features that are used to describe the differences among fish species.

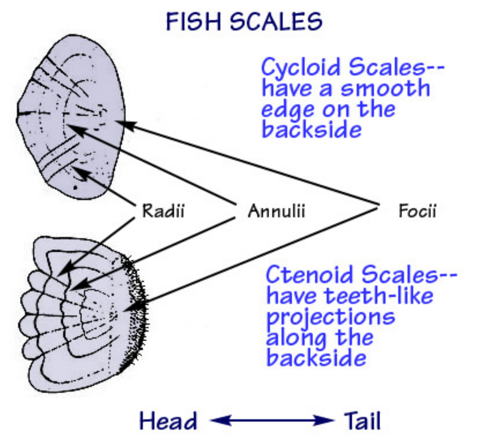


Fish are animals that are cold-blooded, have fins and a backbone. Most fish have scales and breathe with gills. There are about 22,000 species of fish that began evolving around 480 million years ago. The largemouth bass illustrated above has the typical torpedo-like (fusiform) shape associated with many fishes.

Fins are appendages used by the fish to maintain its position, move, steer and stop. They are either single fins along the centerline of the fish, such as the dorsal (back) fins, caudal (tail) fin and anal fin, or paired fins, which include the pectoral (chest) and pelvic (hip) fins. Fishes such as catfish have another fleshy lobe behind the dorsal fin, called an adipose (fat) fin that is not illustrated here. The dorsal and anal fins primarily help fish to not roll over onto their sides. The caudal fin is the main fin for propulsion to move the fish forward. The paired fins assist with steering, stopping and hovering.

Scales in most bony fishes (most freshwater fishes other than gar that have ganoid scales, and catfish which have no scales) are either ctenoid or cycloid. Ctenoid scales have jagged edges and cycloid have smooth rounded edges. Ctenii are tiny, comblike projections on the exposed (posterior) edge of ctenoid scales. Bass and most other fish with spines have ctenoid scales composed of connective tissue covered with calcium. Most fishes also have a very important mucus layer covering the body that helps prevent infection. Anglers should be careful not to rub this "slime" off when handling a fish that is to be released.

In many freshwater fishes the fins are supported by spines that are rigid and may be quite sharp thus playing a defensive role. Catfish have notably hard sharp fins that anglers should be wary of. The soft dorsal and caudal fins are composed of rays, as are portions of other fins. Rays are less rigid and frequently branched.



Fish scales are composed of connective tissue covered with calcium. Typically, soft-rayed fish have smooth cycloid scales and spiny-rayed fish have ctenoid scales. Scales can be used for aging fish. The annulii, or growth rings like on trees, are counted from the focus (where growth starts) outward. By measuring the distance between annulii, along a radius, the growth rate of the fish can even be estimated.

Wattendorf; FWC

The gills are the breathing apparatus of fish and are highly vascularized giving them their bright red cover. An operculum (gill cover) that is a flexible bony plate protects the sensitive gills. Water is "inhaled" through the mouth, passes over the gills and "exhaled" from beneath the operculum.

Fish see through their eyes and can detect color. The eyes are rounder in fish than mammals because of the refractive index of water and focus is achieved by moving the lens in and out, not distorting it as in mammals.

Paired nostrils, or nares, in fish are used to detect odors in water and can be quite sensitive. Eels and catfish have particularly well developed senses of smell.

The mouths shape is a good clue to what fish eat. The larger it is the bigger the prey it can consume. Fish have a sense of taste and may sample items to taste them before swallowing if they are not obvious prey items. Some are primarily piscivorous (eating mostly other fish). The imported grass carp is one of the few large fishes that are primarily herbivorous (eating plants). Fish may or may not have teeth depending on the species. Fish like chain pickerel and gar have obvious canine-shaped teeth. Other fish have less obvious teeth, such as the cardiform teeth in catfish which feel like a roughened area at the front of the mouth, or vomerine teeth that are tiny patches of teeth, for example, in the roof of a striped bass' mouth. Grass carp and other minnows have pharyngeal teeth modified from their gill arches for grinding that are located in the throat.

The lateral line is a sensory organ consisting of fluid filled sacs with hair-like sensory apparatus that are open to the water through a series of pores (creating a line along the side of the fish). The lateral line primarily senses water currents and pressure, and movement in the water.

The vent is the external opening to digestive urinary and reproductive tracts. In most fish it is immediately in front of the anal fin.

Internal Fish Anatomy

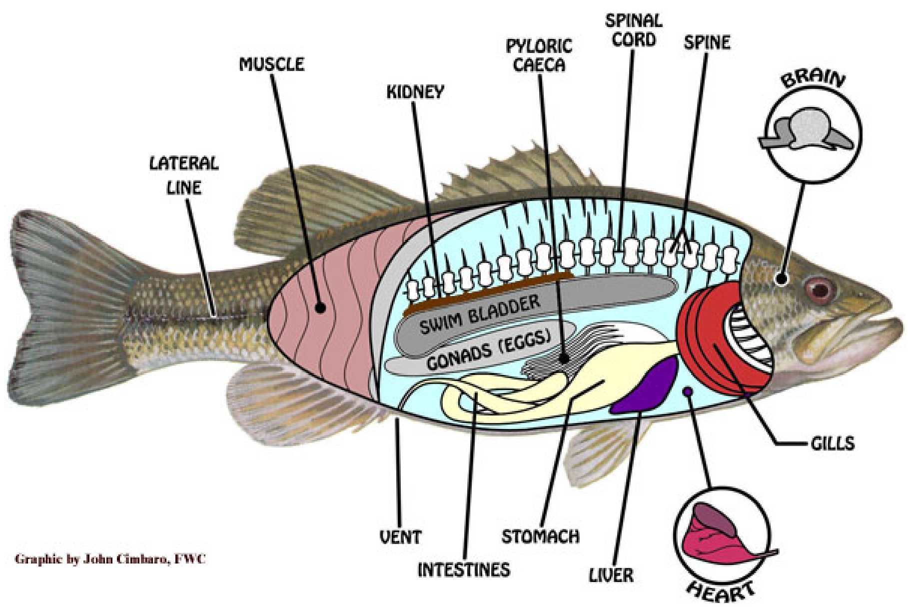
The following illustration of a largemouth bass shows some of the common internal features that are used to describe the differences between fish that are described in more detail below.

SPINE:
The primary structural framework upon which the fish's body is built; connects to the skull at the front of the fish and to the tail at the rear. The spine is made up of numerous ***vertebrae***, which are hollow and house and protect the delicate spinal cord.

SPINAL CORD:
Connects the brain to the rest of the body and relays sensory information from the body to the brain, as well as instructions from the brain to the rest of the body.

BRAIN:
The control center of the fish, where both automatic functions (such as respiration) and higher behaviors ("Should I eat that critter with the spinning blades?") occur. All sensory information is processed here.

LATERAL LINE:
One of the fish's primary sense organs; detects underwater vibrations and is capable of determining the direction of their source. (See Issue 8 of The City Fisher for more information.)



Graphic by John Cimbaro, FWC

SWIM (or AIR) BLADDER:
A hollow, gas-filled balance organ that allows a fish to conserve energy by maintaining neutral buoyancy (suspending) in water. Fish caught from very deep water sometimes need to have air released from their swim bladder before they can be released and return to deep water, due to the difference in atmospheric pressure at the water's surface. Species of fish that do not possess a swim bladder sink to the bottom if they stop swimming.

GILLS:
Allow a fish to breathe underwater. These are very delicate structures and should not be touched if the fish is to be released!

KIDNEY:
Filters liquid waste materials from the blood; these wastes are then passed out of the body. The kidney is also extremely important in regulating water and salt concentrations within the fish's body, allowing certain fish species to exist in freshwater or saltwater, and in some cases (such as snook or tarpon) both.

STOMACH AND INTESTINES:
Break down (digest) food and absorb nutrients. Fish such as bass that are ***piscivorous*** (eat other fish) have fairly short intestines because such food is easy to chemically break down and digest. Fish such as tilapia that are ***herbivorous*** (eat plants) require longer intestines because plant matter is usually tough and fibrous and more difficult to break down into usable components. A great deal about fish feeding habits can be determined by examining stomach contents.

PYLORIC CAECA:
This organ with fingerlike projections is located near the junction of the stomach and the intestines. Its function is not entirely understood, but it is known to secrete enzymes that aid in digestion, may function to absorb digested food, or do both.

VENT:
The site of waste elimination from the fish’s body.

LIVER:
This important organ has a number of functions. It assists in digestion by secreting enzymes that break down fats, and also serves as a storage area for fats and carbohydrates. The liver also is important in the destruction of old blood cells and in maintaining proper blood chemistry, as well as playing a role in nitrogen (waste) excretion.

HEART:
Circulates blood throughout the body. Oxygen and digested nutrients are delivered to the cells of various organs through the blood, and the blood transports waste products from the cells to the kidneys and liver for elimination.

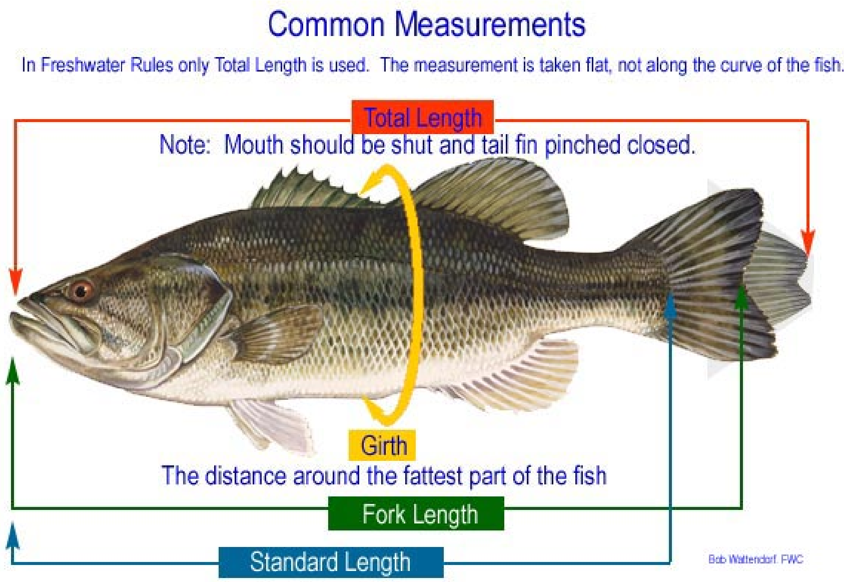
GONADS (REPRODUCTIVE ORGANS):
In adult female bass, the bright orange mass of eggs is unmistakable during the spawning season, but is still usually identifiable at other times of the year. The male organs, which produce milt for fertilizing the eggs, are much smaller and white but found in the same general location. The eggs (or ***roe***) of certain fish are considered a delicacy, as in the case of caviar from sturgeon.

MUSCLES:
Provide movement and locomotion. This is the part of the fish that is usually eaten, and composes the fillet of the fish.

Measuring a Fish

There are several commonly used measurements for fish. The total length is the maximum length of the fish with the mouth closed and the tail fin pinched together. The best way to obtain this length is to push the fish's snout up against a vertical surface with the mouth closed and the fish laying along a tape measure, then pinch the tail fin closed and determine the total length, do NOT pull a flexible tape measure along the curve of the fish.

Conversely, most marine (saltwater regulations) refer to the "fork length", and scientists often use "standard length" which is to the end of the fleshy part of the body. "Standard length" has the advantage of not being affected by minor damage to the tail fin, nor does it give too much credit to a fish for the relatively light weight tail when calculating a fish's condition.



"Girth" is best measured with a fabric ruler, such as tailors use. It can also be determined by drawing a string around the fish at its widest point marking where the string overlaps and then measuring the distance between the overlapping points on a conventional ruler. Knowing the girth is important when trying to certify a fish for a record, and provides useful information to biologists about the relative condition of a fish.

Using total length and girth you can get a rough estimate of a fish's weight using various formulas.

Length-Weight Formulas to Estimate Fish Weights

The primary estimate is derived from a rather complex formula, which is what Commission biologists use. The equation is:

Log (weight in grams)= -4.83 + 1.923 x Log (total length in millimeters) + 1.157 x Log (girth in millimeters). A 22" long bass with a girth of 15" weighs about 6.0 pounds using this formula.

A quick, though very rough, estimate of torpedo shaped fish like young bass can be obtained by using: Total Length (in inches)-squared, times girth (in inches) divided by 1200. A 22" long bass with a girth of 15" weighs about 6.1 pounds using this formula.

Another common option used for estimating bass weights is: Girth (in inches)-squared, times length (in inches) divided by 800. A 22" long bass with a girth of 15" weighs about 6.2 pounds using this formula.

How Fish Swim

Many fishes swim by contracting and relaxing a succession of muscle blocks, called myomeres, alternately on each side of the body, starting at the head and progressing down toward the tail. The alternate shortening and relaxing of successive muscle blocks, which bends part of the body first toward one side and then toward the other, results in a series of waves traveling down the fish's body. The rear part of each wave thrusts against the water and propels the fish forward.

This type of movement is quite clearly seen in the freshwater eel. Because movement of the head back and forth exerts drag, which consumes additional energy and slows travel, a great many fishes have modified this snakelike motion by keeping the waves very small along most of the length of the body, in some cases showing no obvious movement at all, and then increasing them sharply in the tail region. It is the end of the traveling waves that moves the tail forcefully back and forth, providing the main propulsion for forward motion. A simpler form of tail propulsion is seen in such inflexible-bodied fishes as the trunkfish, which simply alternates contractions of all the muscle blocks on one side of the body with those on the other side, causing the tail to move from side to side like a sculling paddle.

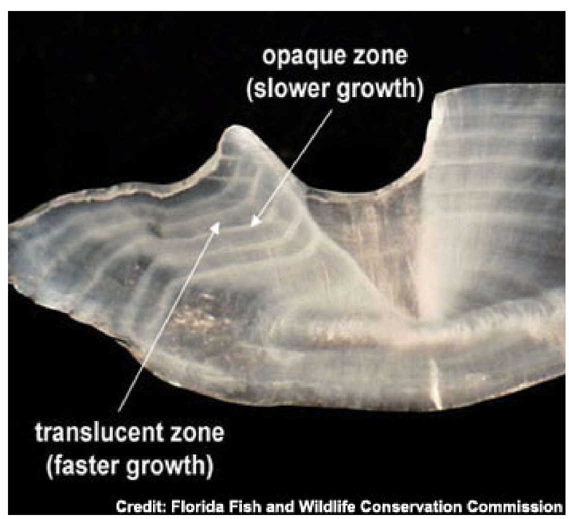
Some of the predatory bony fishes are the fastest swimmers; they can cruise at speeds that are between three and six times their body length per second and may be able to reach 9 to 13 body lengths per second in very short bursts. Some fishes, such as the blenny, which has been timed at 0.8 km/hr (0.5 mph), swim very slowly; others, such as the salmon, which may reach a sustained speed of 13 km/hr (8 mph), move much faster; and it has been estimated that tuna may reach speeds of 80 km/hr (50 mph), and swordfish, 97 km/hr (60 mph).

Introduction to Aging Fish: What Are Otoliths?

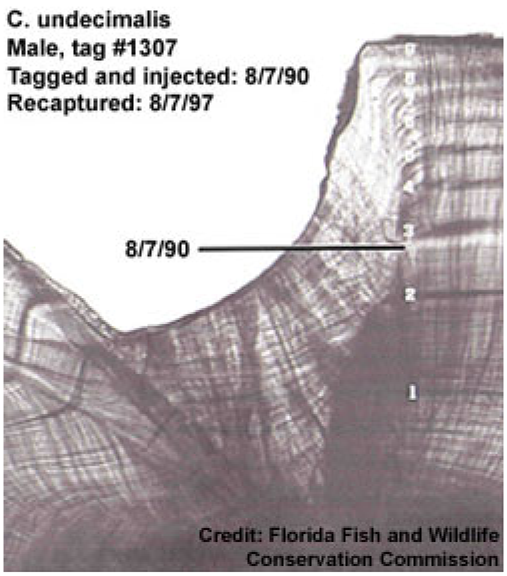
Otoliths, commonly known as "earstones," are hard, calcium carbonate structures located directly behind the brain of bony fishes. There are three types of otoliths, all of which aid fish in balance and hearing:

1. **Sagitta—**the largest of the 3 pairs of otoliths; involved in the detection of sound and process of hearing, or converting sound waves into electrical signals
2. **Asteriscus—**involved in the detection of sound and the process of hearing
3. **Lapillus—**involved in the detection of gravitational force and sound (Popper and Lu 2000)

There are many different shapes and sizes of otoliths among different species. Cartilaginous fishes, which include sharks, skates, and rays, do not have otoliths. Otoliths are important to scientific age and growth studies. This figure shows the growth rings of a sagittal otolith section viewed under reflective light. The darker area or "translucent zone" represents a period of fast growth. The whiter area or "opaque zone" represents a period of slower growth. The age of the fish is estimated by counting the annuli, or opaque bands, of the thin sections, as one would count rings on a tree to determine its age.



Before age data can be used, the method of estimating age by counting annuli must be validated for each species to which it is applied. There are several ways to validate age, or prove that "one annulus is equal to one year." Most obvious might be to simply rear fish from spawn, sacrifice the fish after a few years, and compare the number of rings to the known age of those fish. This process can be time consuming and expensive. It also creates the possibility of abnormal growth patterns caused by laboratory settings (Campana, 2001). Although this method may not be practical for validating annular ring formation, a similar method is effective in validating daily ring formation (Campana and Neilson, 1985).



To avoid the effects of long-term laboratory exposure, tag and release of wild fish can be useful in validating annulus deposition. This figure shows the fluorescent tag of a common snook otolith. A captured common snook was injected with oxytetracycline (OTC), a chemical that is incorporated into calcium-rich structures including otoliths. The fish was then tagged and released. Seven years later, the fish was recaptured, sacrificed, and processed for aging. The OTC, which binds to the calcium in the otolith, appears as a glowing band when the otolith is viewed using fluorescence microscopy. The number of annuli between capture and recapture is also seven. Information like this is key to linking a single annulus to one year of growth, but such information relies heavily on time and chance. The age data gathered from otolith examinations allow scientists to model growth rates, maximum age, age at maturity, and the trend of future generations.

Literature Referenced

Florida Fish and Wildlife Conservation Commission. http://www.floridamarine.org/features/view_article.asp?id=21978 and http://myfwc.com/Fishing/Fishes/anatomy.html. Fish and Wildlife Research Institute, 100 Eighth Avenue SE, St. Petersburg, Florida 33701-5020.