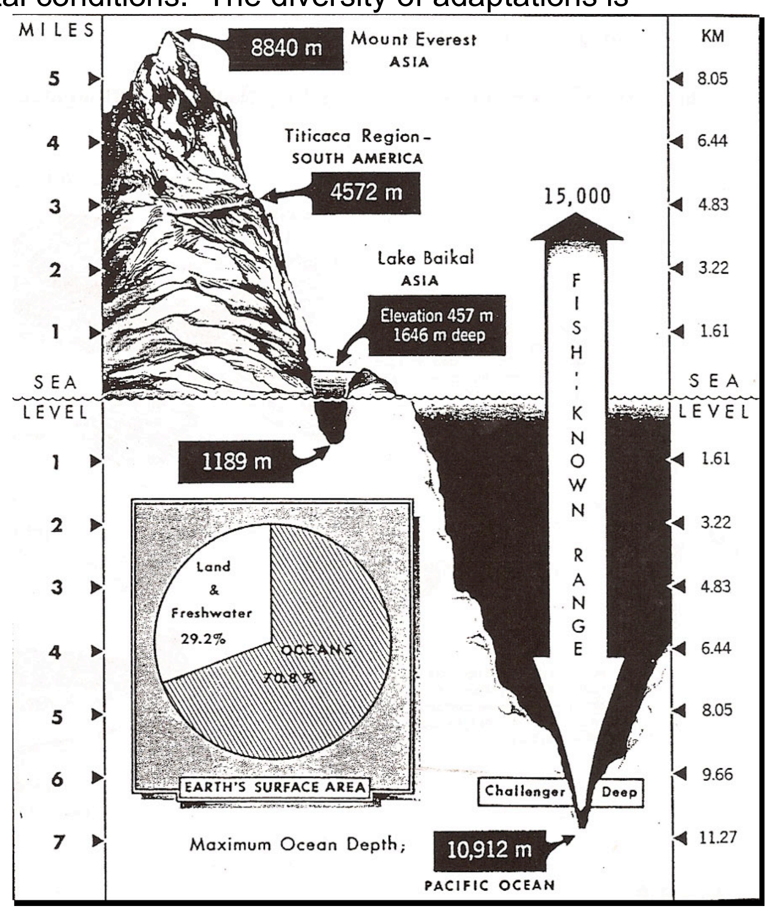
FISH

Fish form the earliest and the greatest group of all the backboned animals. Fish are cold-blooded vertebrates primarily adapted to living in water. “Fish are remarkably various in size, shape, color, physiology, and behavior. They are vertebrates like ourselves, yet we can find species that can change sex in a matter of days. There are species where all individuals are females and males are unnecessary, for young are produced without the eggs being fertilized. In one species of shark, cannibalism inside the mother among her voracious babies usually results in only one large individual being born. There are fish that mimic the background, a floating sea-grass leaf, or a poisonous fish. There is parental care of many kinds – including the delightful little seahorse male brooding his young in a neat pouch. There are fish that can walk on land and fish that can glide for hundreds of meters on gossamer wings.”

The term “fish” is a common name for a group of aquatic animals which are arranged into four classes: Myxini (hagfish), Cephalaspidomorphi (lampreys & allies), Chondrichthyes (cartilaginous fish, such as sharks, rays, and relatives), and Osteichthyes (bony fish, also known as your **basic fish**). There are over 24,300 species and the classification of fish is probably the most changeable of the groups we study. (See chart on p 10) New discoveries of fossil records and living species are constantly being made, especially since their habitat contains one of the few frontiers left to man.

Fish as a whole have spread into every available kind of environment, however, each species has tolerance for only a limited range of environmental conditions. The diversity of adaptations is seemingly endless from the very largest to the smallest: sharks that feed on plankton and very small fish, harmless to humans, yet reaching lengths of over 50 feet and many tons in weight. At the other extreme is the smallest of all living backboned animals; a delicate, transparent goby, only as long as the last joint of your little finger, weighing perhaps one millionth the weight of the largest shark. The variety of fishy form and living pattern seems endless.



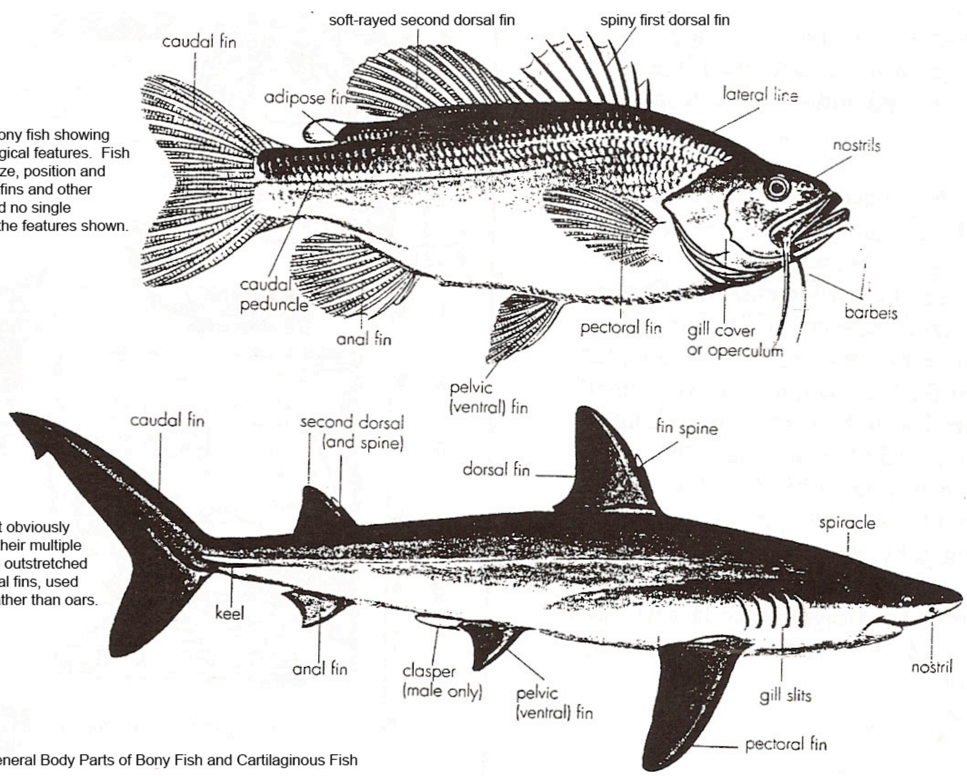
Characteristics that are common to all fish:

- All are aquatic
- Almost endless diversity of characteristics
- Ectothermic (cold-blooded)
- Two-chambered heart
- Most use gills to take oxygen from water
- Most are covered with scales
- All grow throughout their lives
- No jointed limbs (in extant species)

General Biology:

- Distributed worldwide, found in fresh, salt or brackish water

- Cold-blooded; some species tolerate a temperature change of only 15-20 degrees but fish as a whole group tolerate a range of 100 degrees
- Supporting structure down back can be anything from a cartilaginous rod to a partially or completely ossified skeleton depending on the class
- Two-chambered heart
- Most live in either fresh or salt water, not both
- All fish have to regulate body fluids to maintain proper degree of concentration; as water passes through the body for respiration in a fresh water fish, the water osmoses into the cells and must be excreted
- A salt water fish must drink water constantly to replace fluids lost to the salts that are taken in with respiration and must also excrete the excess salt
- Some species can move from fresh to salt water, or salt to fresh at different stages of their life cycle - such fish usually return to the environment from which they came to spawn (i.e. salmon)
- Most are covered with scales
- Senses are well developed and varied; including good vision, hearing, taste, electrical generation and sensitivity to vibration
- Many fish make noise
- All swim; have fins and air bladder
- Sizes range from the whale shark up to 50 feet, 20 tons, to a manta ray at 23 feet wide, to a goby with a body less than 1/2inch long
- Life spans vary from 1 to 80 years
- Fish grow throughout their lives



A generalized bony fish showing major morphological features. Fish vary widely in size, position and arrangement of fins and other appendages and no single species has all the features shown.

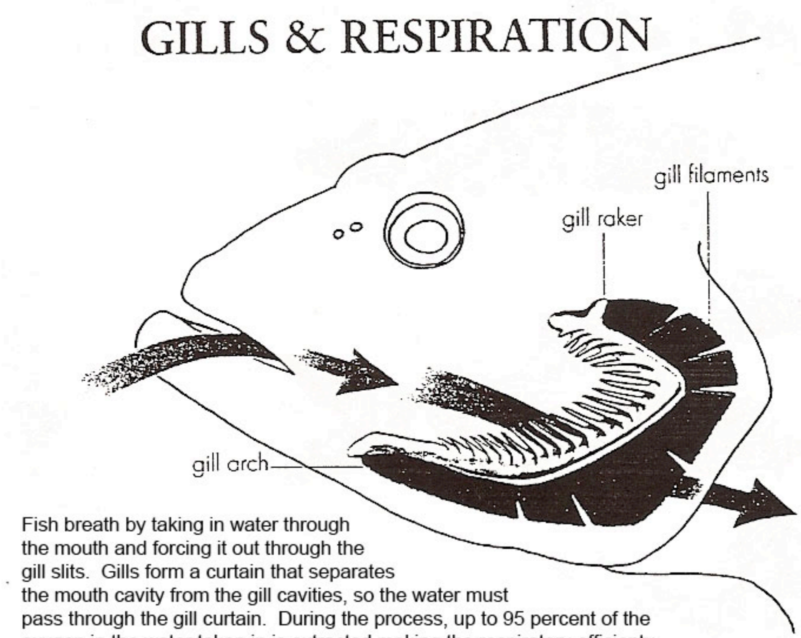
Sharks differ most obviously from bony fish in their multiple gill slits and in the outstretched set of their pectoral fins, used as hydroplanes rather than oars.

General Body Parts of Bony Fish and Cartilaginous Fish

Respiration & Breathing:

- Most use gills to obtain oxygen from water.

- Environment (food, space and temperature) affects the rate of respiration: water is taken in through the mouth with the gill cover closed and then forced out over the gills with the mouth closed.
- Slow swimming fish have to pump harder than fish, which can use the force of their speed to move the water through a simple, efficient respiratory system.
- Thick blood moves slowly from the two chambered heart to the gills and then to the rest of the body, passing through the heart only once instead of twice as in mammals.
- Gills are thin-walled flaps with great network of fine blood vessels and carbon dioxide is given off and oxygen is absorbed in the gills.
- Cold, fast moving water holds more oxygen than sluggish water.
- Many fish use supplementary oxygen from air; lining of pharynx (beta, mudskipper), gill chamber, air bladder (bowfin) or digestive system (plecostomus) can be adapted to absorb oxygen directly from air.
- Some primitive fish have lungs.

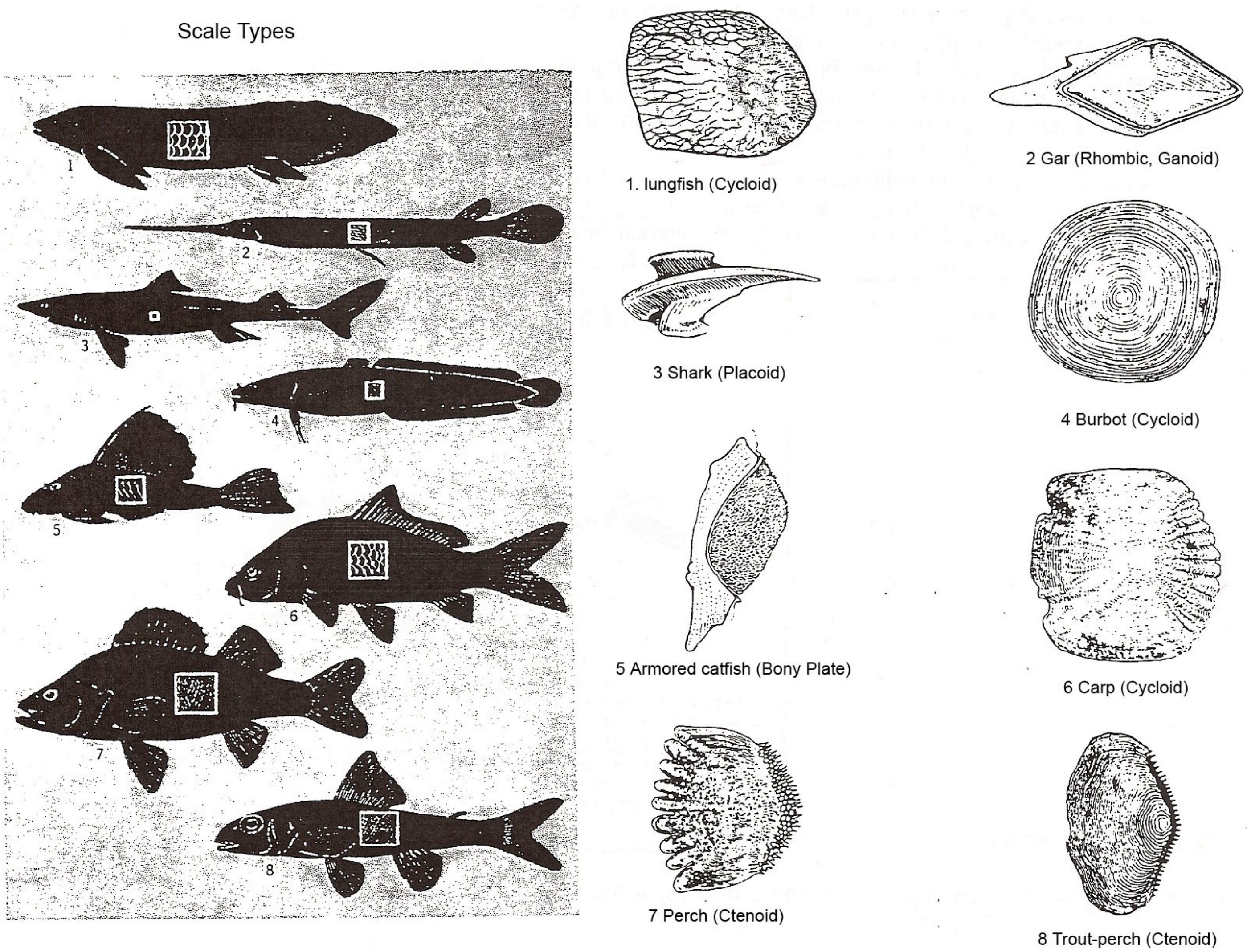


Fish breath by taking in water through the mouth and forcing it out through the gill slits. Gills form a curtain that separates the mouth cavity from the gill cavities, so the water must pass through the gill curtain. During the process, up to 95 percent of the oxygen in the water taken in is extracted,making the respiratory efficienty of fish gills the highest among water-breathing organisms. Indeed, such a high efficiency in capturing oxygen is needed because water is so dense and contains only 1/30 of the oxygen in air.

Skeleton, Scales, Skin:

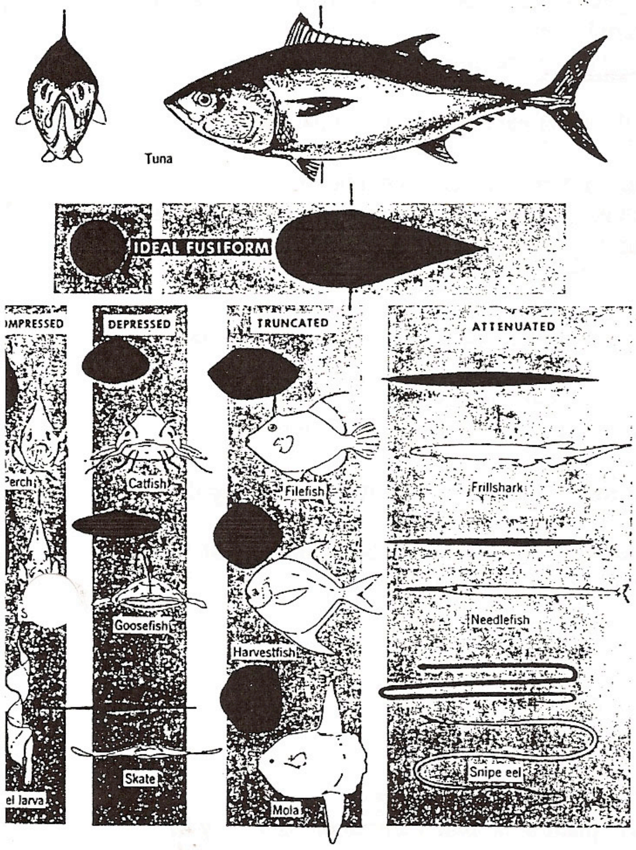
- Skeleton can be cartilage or bone and has three segments; skull, vertebral column with ribs, fin skeleton (separate from the spine).
- Most fish have scales.
- Sharks and rays have placoid (plate-like) scales, which are similar to teeth with enamel covering a body of dentine and pulp.
- Other fish have scales made of thin, translucent bony material, usually overlapping like shingles.
- Bony fish (Osteichthyes) have flat, disk-like scales that are called either cycloid (roughly circular in shape) or ctenoid (with toothed or comb-like edges) depending on their shape.
- Scales can be used to estimate the age of an individual (they have growth rings) and to identify a specimen.
- Skin is an organ, which helps regulate water pressure in the body and produces mucus, which helps keep body fluids constant and protects against infection.
- Fish have both structural and pigmented color.
- **I**ridescent colors come from light being reflected back from dark, underlying colors, such as body tissues or fluids.

- The silvery color is a reflection of crystalized guanine, a waste product of nucleic acid.
- True pigment is embedded in the skin in chromatophores; color changes exhibited by many fish are the result of the concentration or dispersal of pigment granules within these cells.
- Color changes may be displays of aggression or courtship or means of hiding.



Fins and Locomotion:

- Movement in the three dimensional medium of water requires propulsion, lift, and stabilization.
- Paired fins (pectoral and pelvic) serve as stabilizers and brakes.
- Dorsal and anal fins prevent yawing (tilt).
- Lift is provided by the trim of the fins and the air bladder.
- Tail provides forward thrust.
- Fish can reverse and can stand still against a current.
- Body shape can indicate speed and kind of swimming - torpedo shaped body is good for speed, flattened body gives agility.
- Some fish also crawl, leap, "fly", burrow.



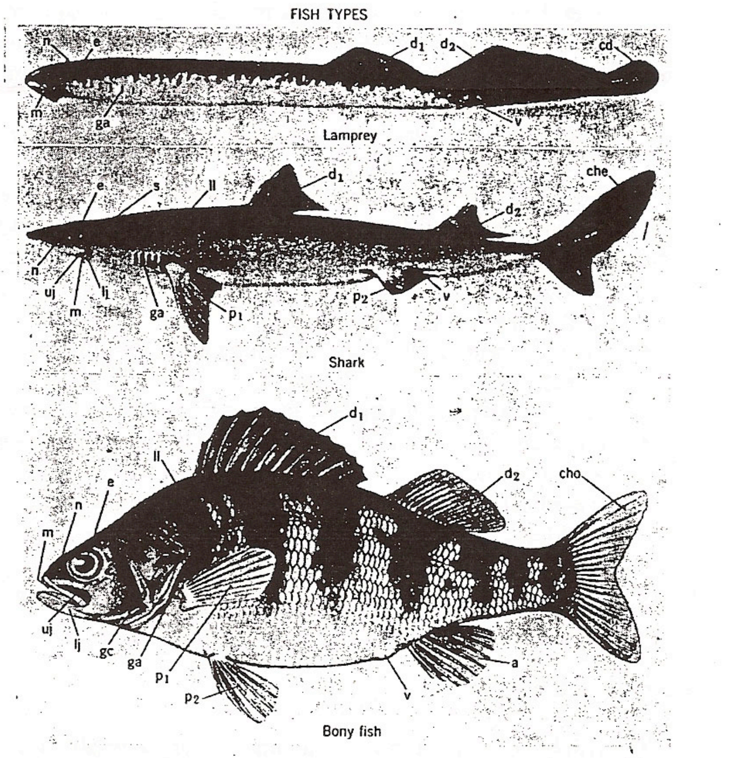


Fig. 3.2 Comparative external anatomy of major groups of living fishes. The following is an index to the labeling. *Appendages:* d_1—first dorsal fin, d_2—second dorsal fin, c—caudal fin (cd, diphycercal caudal; chc—heterocercal caudal; cho—homocercal caudal), a—anal fin p_1—pectoral fin, p_2—pelvic fin; *Sense organs*: N—naris, e—eye, ll—lateral line; *Skeleton* lj—lower jaw, uj—upper jaw, gc—gill cover; *Openings:* m—mouth, s—spiracle, ga—gill aperture, v—anus or vent).

Senses:

- Fish have no eyelids, but do sleep.
- Lens on eyeball is rigid, moves in and out (like camera) to focus.
- Most fish are short sighted.
- Fish have color vision and are sensitive to the same wavelengths as humans, especially red, green and blue.
- Most have fixed, round pupil, which controls the light intake by retracting the light sensing structures in the eye (rods) and increasing the pigment layer around them.
- Field of vision extends to tail, with fused binocular vision in front only.
- Eyes can rotate to some degree to compensate for pitch and roll.
- Fish, which live in caves or underground may lack eyes.
- At great depths, eyes are used to see the light generated by the bodies of some fish (bioluminescence).
- When most fish look out of water, refraction at the surface limits the horizon and ripples produce multiple images.
- Visual orientation must take into account the fish's own movement in relation to environment.
- Visual cues are integrated with receptors in the lateral line & labyrinth (inner ear).
- The lateral line system includes a series of sensory receptors (cells with hairs that are displaced by mechanical forces, i.e. waves) which run down both sides of the body in canals and also may be scattered over the rest of the body. Only found in fish and aquatic stages of some amphibians (tadpoles). Thought to be the origin of the evolution of the inner ear in higher vertebrates.

- Obstacle avoidance and detection of currents and changing pressures are thought to be among the functions of the lateral line receptors.
- In a fluid world, orientation and balance are maintained by the inner ear (labyrinth) in conjunction with the eyes and the lateral line.
- Fish have no outer or middle ear; probably not needed because water conducts sound better than air.
- In some species inner ear is connected to air bladder - which may act as resonator in sound reception--it takes more energy to generate sound waves under water, but they travel very efficiently once started long distance transmission aided by reflections from surface and bottom.
- There is a lot of noise in any body of water.
- Inner ear and air bladder pick up the higher frequencies and far-field pressure waves; non-directional detectors.
- The lateral line picks up low frequencies, near-field pressure waves and resolves direction.
- Fish hear a limited range of frequencies (low frequencies are heard best) but have good sound discrimination.
- Fish make noise by stridulation (rubbing two body parts together, using teeth or bones) or by using the air bladder.
- Most fish have nasal pit or nostrils (usually four openings), which respond to food, body and sexual odors.
- Fish do taste; taste buds can be in mouth, gill cavity, on barbels and fins or all over body.

Feeding and Teeth:

- Fish have evolved to feed on almost every available food source.
- Fome feeding strategies:
  - ❖ Strainers - are indiscriminate feeders, sieve particles of water through gill rakers;
  - ❖ Grazers - take small bites, browsing over an area, may eat plant or animal material or both, may be specialized (i.e. reef fish or scavengers);
  - ❖ Suckers -enlarged lips, suctorial disks, root in sediment, may or may not spit out bad particles;
  - ❖ Predators – big mouths, sharp teeth, most swallow whole, teeth prevent escape (exceptions: sharks & piranhas bite); hunt by stealth, smell, speed, sight, attraction (angler), spitting (archer).
- Fish were the first animals to have teeth.
- Shape, placement and number of teeth varies tremendously and can give clues as to how a fish feeds.
- Some sharks have teeth all over the body, in fact it is thought that teeth evolved from shark scales.
- Some have teeth on pharynx, tongue, roof of mouth.
- Some have molars, incisors, canines, serrated teeth, beaks.
- Stomachs of predators tend to be elongated.
- Omnivores have sack-like stomachs.
- Some fish have something like a gizzard.
- Some grind food so small there is virtually no stomach.

Reproduction:

- Fish may lay eggs, give birth to live young, or hold a fertilized egg inside until hatching.
- Female may lay eggs, which are then fertilized by the milt from the male.
- Some species use internal fertilization.

- Fish may scatter great quantities of eggs, counting on the survival of a few, or they may guard or incubate (mouth-brooders) fewer.
- Some build twig nests (stickleback), mucus or bubble nests, make a scrape or a burrow or lay the eggs on a surface where they stick.
- Some species go through a larval stage when undigested yolk is still attached.
- Young may be extremely different from the adults.
- Most juveniles school even if the adults do not.
- Some species spawn communally, some form pairs.
- Courtship behaviors break down females' barriers, isolate species to prevent hybridization, and function as a selective mechanism.
- Courtship displays involve visual signals, movement and color (sound and smell are probably involved too, but not much is known) and species-specific patterns are performed.
- Can usually tell sex during spawning even if not dimorphic by the shape of female or colors may change.
- Some species are sexually dimorphic; shape, size, color, fin shape.
- Fish species exhibit varying amounts of parental care; those which care for the young the most, lay the least number of eggs, and those which do not care for the young, lay tremendous numbers of eggs.

Global Status of Fish

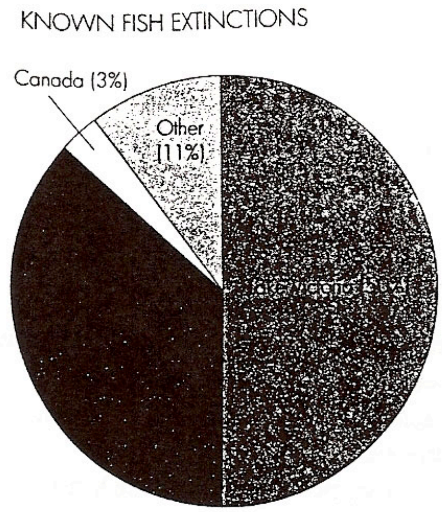
Fish are the largest and most diverse group of vertebrates, not only in their form and size, but also in their biology and ecology. With a few exceptions, however, fish conservation has been sadly neglected. All kinds of fish, big and small, are at risk, and over 700 species and 49 subspecies and populations are currently known to be in danger. See Chart 1, Page 8, for the known extinctions of fish species.

If fish were as easy to see and approach as birds and mammals are, their ecological and biological values would be better understood. Our knowledge of the conservation status of fish is rather limited, but we do know that they are under pressure right around the plant, with threatened species listed from every continent. (See Chart 2, Page 8). Fish from all kinds of environments–rivers, lakes, caves, estuaries, coastal areas, coral reefs, and the deep sea—are threatened. Fish are threatened for a variety of reasons, as follows: restricted distribution (only live in certain areas), pollution and habitat alteration, introduced species, and international trade.

Conservation needs may differ according to species, but generally, a combination of habitat preservation and management, control of pollution, elimination of introduced species, bans on poaching and over-fishing, and stricter trade controls will help ensure the survival of the species now at risk.

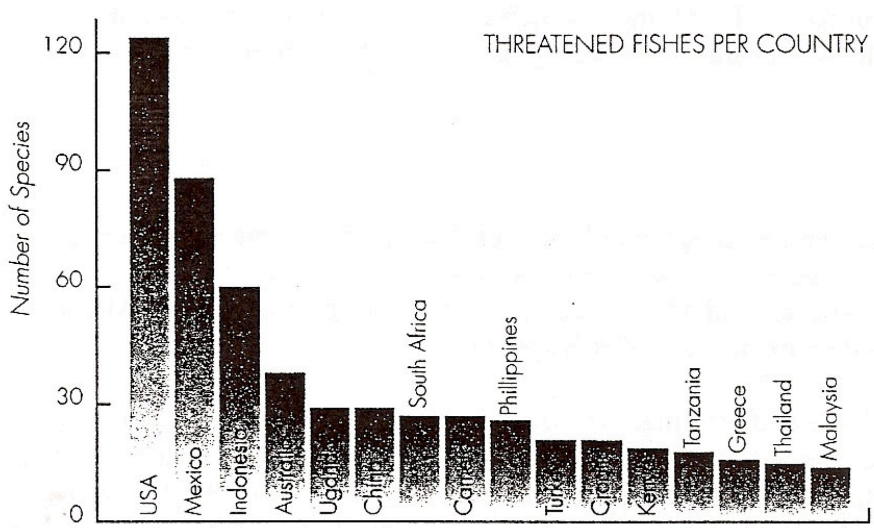
Species conservation alone may not be enough to ensure survival and a more recent approach has been to use threatened species as indicators of key environments in need of protection, such as the African Rift Lakes and coral reef systems, where more than one species is under pressure. This strategy has unveiled a large number of coral reef fish at risk and it is feared that the same may occur with other environments. An ecosystem approach is also being taken in which scientists attempt to evaluate the services that the ecosystem in question is providing, both ecologically and economically. These “hotspots for conservation” may include a combination of animal and plant species. It is in such important conservation sites that our contribution to maintaining global biological diversity will be the greatest.

Chart 1: Known Fish Extinctions



▲ *Known extinctions of fish species (93) can be apportioned as in this pie-chart, but it seems reasonable to suppose that this pattern may be merely an artifact arising from the fact that, potentially, many more extinctions may have gone unrecorded in developing nations. The proportions shown in this pie-chart will most likely change in the future as our knowledge of the status of fishes throughout the world improves.*

Chart 2: Threatened Fishes per Country

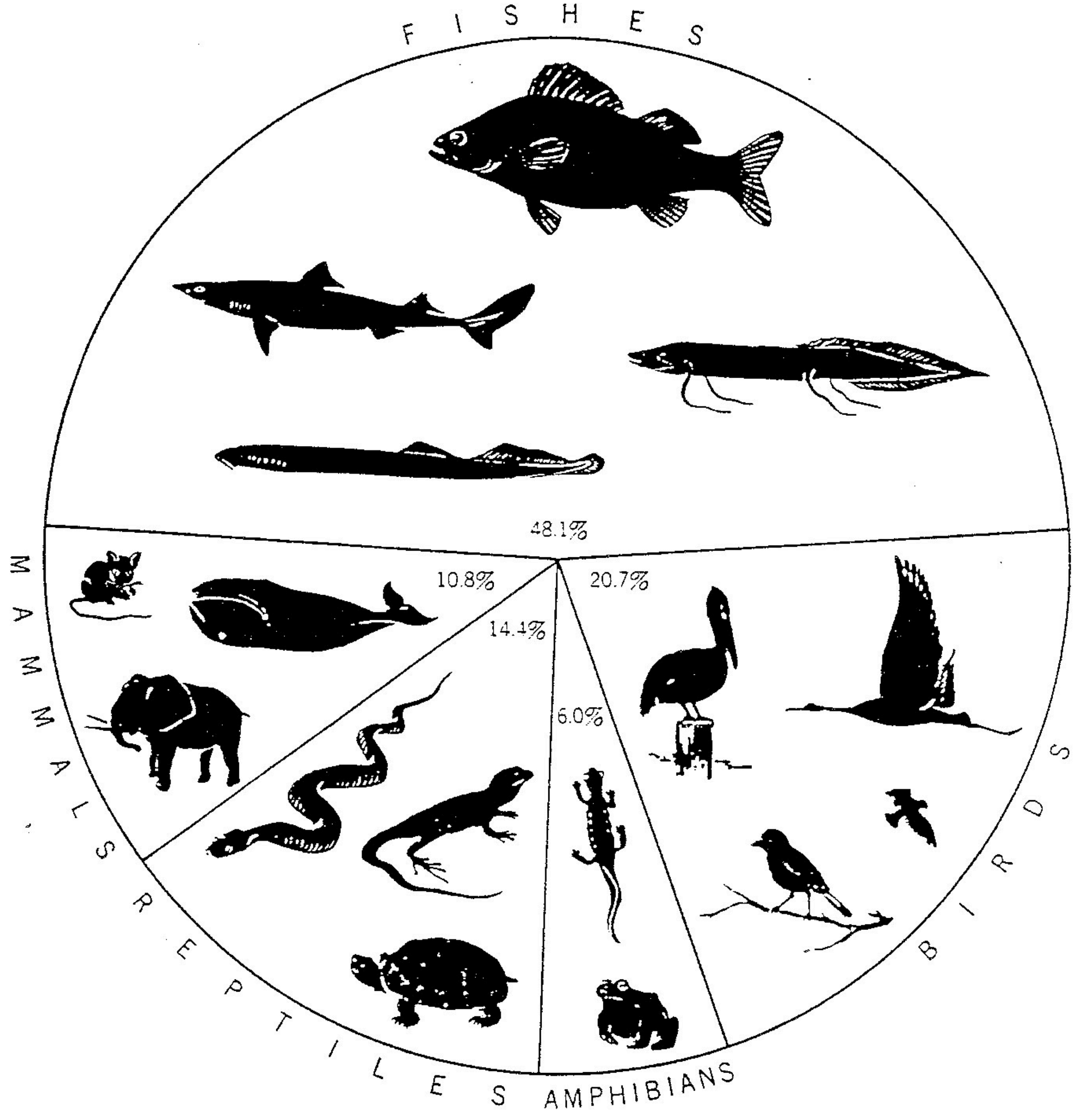


TAXONOMY OF FISH
Based on Fish of the World, 3rd Edition

Superclass: Agnatha
Class: Myxini
Class: Pteraspidomorphi
Class: Cephalaspidomorphi
Superclass: Gnathostomata
Class: Placoder-rni
Class: Chondrichthyes
Subclass: Holocephali
Order: Chimaerifonnes
Subclass: Elasmobranchii
Order: Heterodontiforrnes
Order: Orectolobifor-mes
Order: Carcharhim,fonnes
Order: Lamniformes
Order: Hexanchiformes
Order: Squalliforines
Order: Squantiniformes
Order: Pn'stiophorifonnes
Order: RajiforTnes
Class: Acanthodii
Class: Sarcopterygli
Subclass: Coelacanthimorpha
Order: Coelacanthiformes
Subclass: Porolepimorpha and Dipnoi
Order: Ceratodontifonnes
Order: Lepidosirenifomies
Subclass: Rhizodontimorpha
Subclass: Osteolepimorpha
Subclass: Tetrapoda
Class: Actinopterygii
Subclass: Chrondrostei
Order: Polypteriformes
Order: Acipenseriformes
Subclass: Neopterygii
Order: Semionotiformes
Order: Amiiformes
Division: Teleostei
Subdivision: Osteoglossomorpha
Order: Osteoglossifonnes
Subdivision: Elopomorpha
Order: Elopifonnes
Order: Albuliformes
Order: Anguilliformes
Order: Saccopharyngiformes
Subdivision: Clupeomorpha
Order: Clupeiformes
Subdivision: Euteleostei
Superorder: Ostariophysi
Order: Gonorhynchiformes
Order: Cypriniformes
Order: Characiformes
Order: Siluriformes
Order: Gymnotiformes
Superorder: Protacanthopterygil
Order: Esociformes
Order: Osmeriforines
Order: Salmoniformes
Superorder: Stenopterygii
Order: Stomliformes
Order: Ateleopodifonnes
Superorder: Cyclosquamata
Order: Aulopiformes
Superorder: Scopelomorpha
Order: Myctophiformes
Superorder: Lampridiomorpha
Order: Lampridiforrnes
Superorder: Polyinixiomorpha
Order: Polymixiifonnes
Superorder: Paracanthopterygil
Order: Percopsiformes
Order: Ophidiiforines
Order: Gadiformes
Order: Batracholdifom-ies
Order: Lophiifor-mes
Superorder: Acanthopterygii
Series: Mugilomorpha
Order: Mugiliformes
Series: Atherinomorpha
Order: Atheriniformes
Order: Beloniformes
Order: Cyprinodontifor-mes
Series: Percomorpha
Order: Stephanoberyciformes
Order: Beryciformes
Order: Zeiforines
Order: Gasterosteiformes
Order: Synbranchiforrnes
Order: Scorpaeniformes
Order: Perciformes
Order: Pleurononectifonnes
Order: Tetraodontiformes

VERTEBRATE GROUPS

Percentage composition by group of the approximately 41,600 species of recent vertebrates



Sources:
Encyclopedia of Fish, 2nd Edition; Dr. John R. Paxton & Dr. William N. Eschmeyer, Ed.; 1998
Ichthyology, 2nd Edition; John Wiley & Sons, Publ.; 1977
Thanks to the ***San Antonio Zoo & Aquarium*** for allowing the use of the bullet points from "General Biology through Reproduction." The charts are my additions. *(SCC 04/00)*

NOTE: This is a very rough start to this study guide. Please don't take as gospel until finalized; but it is for your general information only….SCC