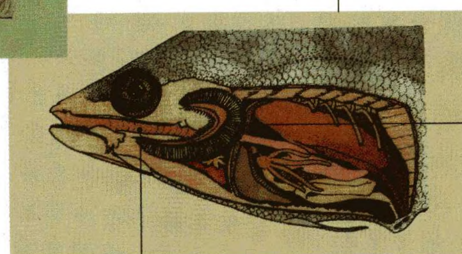
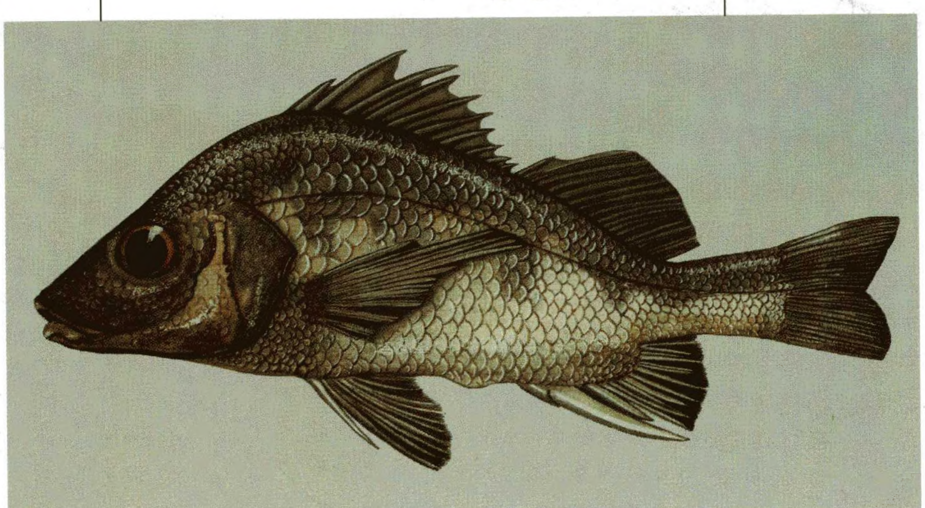
An Illustrated Dissection Guide To The...*Mexican Gray*

Perch





by Peter Reinthal

A Guide to the Dissection of Pomadasys magranthans

I. INTRODUCTION

The bony fish (Class Osteichthyes) is the most speciose and structurally diverse group of vertebrates. Current estimates place over 20,000 species in this group - this makes the bony fish over 40% of living vertebrate species. This wide array of diversity makes it impossible to say exactly what a 'typical' bony fish is or describe all the morphological variation found in these fishes. There are, however, certain features that we consider typical of bony fishes and certain features that are specialized for the particular species in question.

The species that we are using here to represent bony (teleost) fishes is *Pomadasys magranthans*, also known as the Mexican Gray Perch. This species is a member of the Order Perciformes, Suborder Percoidei, Superfamily Haemuloidea, Family Haemulidae, and Subfamily Haemulinae and are commonly known as grunts. Grunts are mostly marine fishes and are abundant in the Atlantic, Pacific and Indian Oceans. A few species are found in brackish water and rarely are they in fresh water. Currently, there are seventeen genera with about 175 species recognized in this family. Fourteen of these genera are in the Haemulinae and eleven of these are found in the New World. All these species are found in tropical and sub-tropical coastal waters either near or on reefs or on soft substrates.

The yellow Perch, *Perca flavescens*, for a long time has been used as an example of a bony fish in laboratory dissections. Largely through the influences of humans (over-fishing, habitat degradation and introduced species), the yellow Perch is becoming increasingly scarce, especially in the Great Lakes of North America. Other examples of bony fish, such as the Pomadasys, are very abundant and are not threatened by human fishing or other activities. The Mexican Gray Perch also provide outstanding examples of the structures and functions that are demonstrated with the dissection of a teleost fish. Many students and teachers have said that they find the gray Perch easier to work with and that it shows many structures better then the yellow Perch.

Further Reading:

For those interested in an excellent detailed study of the anatomy and evolution (phylogenetic study) of the group of fish that the Pomadasys are a member of, see Johnson, G.D. 1980. The Limits and Relationships of the Lutjanidae and Associated Families. Bulletin of the Scripps Institution of Oceanography of the University of California, vol. 24. University of California Press, Berkeley, CA. ISBN: 0-520-09642-8.

It maybe useful to use a yellow Perch dissection guide while working with the Pomadasys since many of the structures are similar. There are a wide variety of yellow Perch dissection guides available.

A very good advanced ichthyology text book is: Evens, D. H. (ed.) 1993. The Physiology of Fishes, CRC Marine Science Series. CRC Press, Boca Raton. ISBN 0-8493-8042-1

II. External Features: ANATOMICAL TERMS

Dissection: For best results with dissection it is important that care and correct dissection tools are used. The recommended tools that you will need are:

1. Large dissecting tray
2. Surgical scissors with one blunt tip
3. Scalpel with new, sharp blade
4. Forceps
5. Pins (T-pins work well) to hold back flaps of skin
6. Dull probe
7. Dissecting needle
8. Latex gloves

When doing dissection, the only way to learn the material and to improve your dissection skills is to carefully work through the material. Please read the section that you are working on before undertaking the dissection. Structures that appear to be readily apparent in drawings can often be more difficult to locate on the actual specimens. Everyone can become very good at dissection and anatomy - all it takes is practice and patience. Work slowly and do not cut too deeply. You do not learn as much from watching someone else dissect the fish - you have to get involved and do the actual dissection. Good luck.

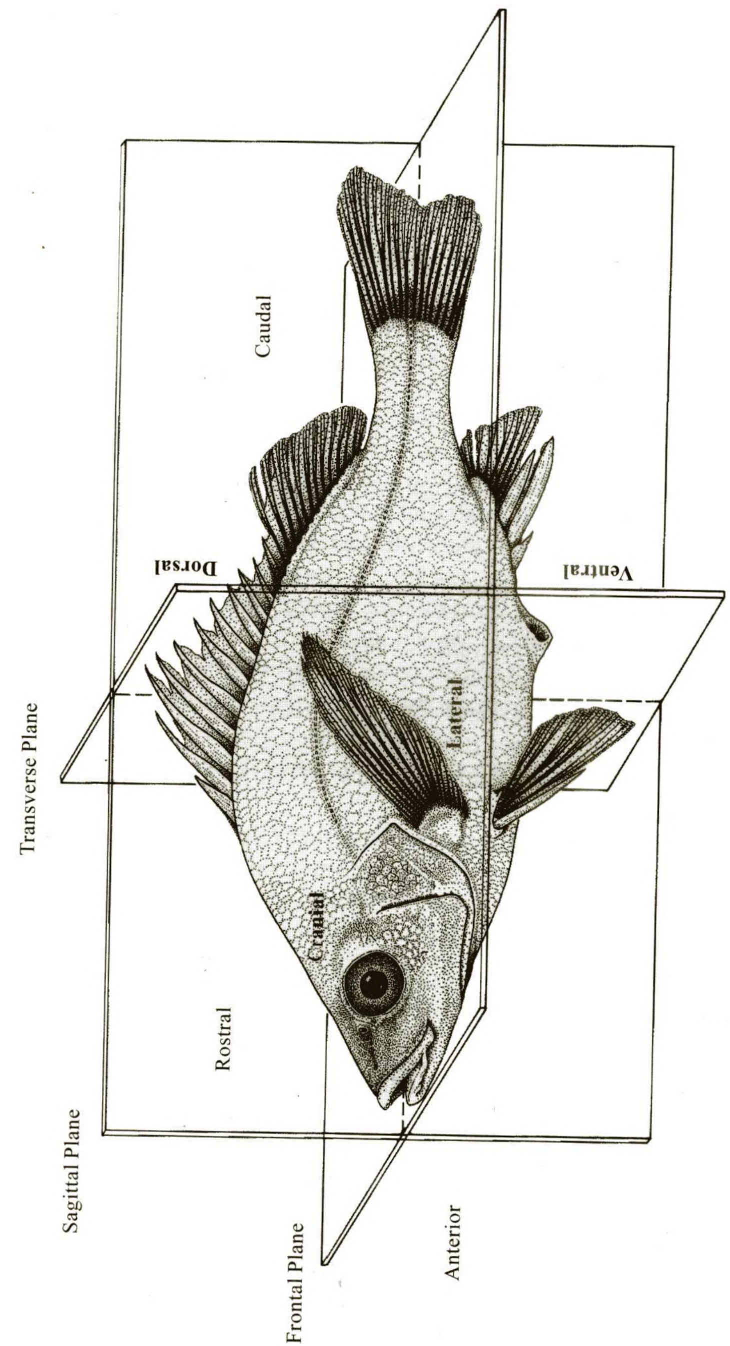


Figure 1. Anatomical Directions and Planes.

Before starting the dissection, it is important that you become familiar with anatomical term. Take the time to learn these now and the rest of the dissection will go much smoother.

The commonly used anatomical terms, orientations and planes are given in Fig. 1. Familiarize yourself with the following external features. Basic terms are used to describe both the planes through an organism and for sections obtained by the cuts in these planes (Fig. 1). The transverse or cross section (from the Latin transvertere = to direct across) is the vertical plane or section that is at right angles to the longitudinal axis. The frontal or horizontal section (Latin frontis = front) is the horizontal plane or section that is parallel to the longitudinal axis. The sagittal section (from the Latin sagitta = arrow) is a vertical plane or section perpendicular to the longitudinal section. A mid-sagittal section divides the fish into right and left halves.

There are certain terms that describe the positions of structures and the orientation of planes of the sections through the fish. Anterior, cranial, cephalic, and inferior are all synonyms for toward the front or head of the fish. Toward the rear or tail is referred to as posterior, caudal or inferior. The frontal section divides that animal along the dorsoventral axis. Ventral is the lower or belly surface of the fish that is below the frontal plane and dorsal is the upper or back surface of the fish that is above the frontal plane. A direction that is towards the side of the body is known as lateral and toward the interior or middle of the fish is medial. Relative terms describing the state of being close to and away from the center of the body along any axis are proximal and distal.

Test yourself by applying these terms to the specimen.

Remember you are working with preserved materials. The lab should have adequate ventilation to minimize vapors. Students should wear both goggles and thin protective rubber gloves while working on the specimen. Be careful when using a scalpel, scissors or needles. The spines of the Pomadasys are also very sharp.

II. External Features.

Head Region *(Fig. 2)*

The position of the mouth of the gray Perch is referred to as terminal; it is directly in front of the body. The function of the mouth is fairly evident, to take in food and water for breathing. These functions will be discussed in greater detail when we examine the internal anatomy. The teeth are located on the premaxilla bone in the upper jaw and the dentary bone of the lower jaw. The snout is the region between the eye and the anterior tip of the upper jaw. A pair

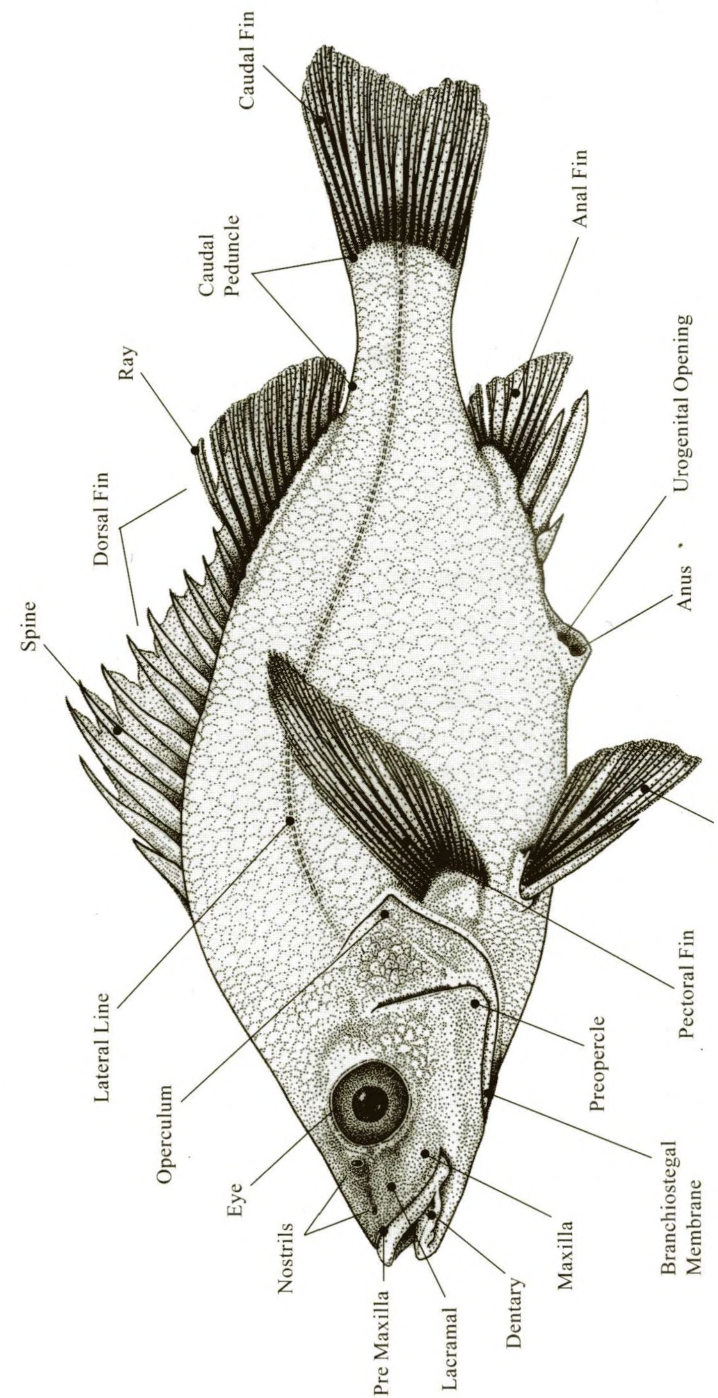


Figure 2. External Features of P. magranthans.

of nostrils are located on the snout of the fish dorsocaudally to the mouth and are used to take in water for olfaction. Each nostril has a pair of apertures; water enters through the anterior nasal apertures and leaves by the caudal aperture as there are no internal openings. The eyes do not have eyelids and are located on the sides of the head. Below the front edge of the eye is the lacrimal region, named for the lacrimal bone. Directly behind the eyes are the opercular covers (operculum) - this is where water passes out of the buccal (oral) cavity. The branchiostegal membrane and associated branchiostegal rays are below the operculum. Cut the branchiostegals free from the operculum and count the seven branchiostegal rays. A sensory canal system on the head that responds to water movement can be recognized by rows of pores in the skin and bone, especially along the ventral surface of the head.

Trunk Region *(Fig. 2)*

Extending from the dorsal-caudal edge of the operculum is an unbroken lateral line that continues all the way to the caudal fin. The lateral line is part of the lateralis system and is important in detecting motion. This is also an important character that is used in identifying many fishes.

There are three unpaired fins and two sets of paired fins on the gray Perch. The unpaired fins are the dorsal fin(s), located along the mid-dorsal line; the caudal or tail fin, and the anal fin, between the anus and the tail. The dorsal and anal fins function to prevent the body from yawing: turning around the vertical axis, and rolling: turning around the longitudinal axis. The dorsal fin is divided into two sections, the spinous (unbranched) first dorsal and the soft-rayed (branched) second dorsal. Count the spines and rays on the dorsal fins. There should about be 12 spines and 13 rays - these are variable features. The anal fin is located caudal to the anal and urogenital openings and has both spines and rays. There are three spines, the first being short, the second spine is very long, and the third is intermediary. Be careful not to jab yourself with the sharp spines.

The section of the body starting at a line ventral to the caudal most portion of the dorsal fin to the anterior most portion of the caudal fin is called the caudal peduncle.

The structure and shape of caudal fins show considerable variation in fishes. The type of tail that the grunt and most other bony fish have is known as homocercal - the dorsal and ventral lobes are about equal and the tail appears to be externally symmetric. Alternatively, heterocercal tails, with the dorsal lobe being longer than the ventral fin, are commonly found in sharks. Heterocercal tails are markedly asymmetric externally and thought to provide

increased lift for the sharks. Because the bony fish have evolved gas bladders to assist them with buoyancy, the tail does not have to provide as much lift but can provide more thrust for forward motion. The shape of the grunt caudal fin is known as indented.

The two sets of paired fins are the pectoral and pelvic fins. The pectoral fins are higher up on the trunk of the fish and are just behind the gill openings. The pelvic fins are ventral and just caudal to the pectorals.

The skin consists of an outer layer, the epidermis, and an inner layer the dermis. Scales are derived from the dermis. Pomadasys have what are known as ctenoid scales.

IV. MUSCULATURE *(Figure 3).*

The musculature of a fish is very complicated but knowledge of muscle anatomy is important to understand how a fish functions in an aquatic environment. The muscles included here represent most of the important muscles and functions but does not include all the muscles. In learning the names of the muscles it is important to remember that an abductor muscle is a muscle that draws a structure away from the midline of the body. An adduction muscle is a muscle that draws a structure inward toward the median axis of the body.

Trunk—Cut the skin behind the opercul[illegible] along the dorsal midline following as close to the dorsal fin a[illegible]le. Try not to penetrate too deeply into the muscle - you only war[illegible] the skin in order to remove it. Then slice the skin just behind the head and caudal to the operculum, starting at the dorsal midline and moving ventrally to the ventral midline. You should then be able to remove the skin from the trunk starting in the anterior dorsal region of the trunk by pulling it back using fingers, forceps and scalpel in order to expose the ventral side of the fish. You may have trouble separating the skin from the muscle in the ventral region.

The main body mass of the fish is in its body musculature. Look at the bundles of muscles. Each of these bundles is called a myomere. Myomeres are separated from each other by myosepta. Try tracing myomeres along their myosepta in order to determine their shape.

The myomeres are divided into three portions. The horizontal septum divides the myomeres into hypaxial muscles and epaxial muscles. The hypaxial muscles make up the ventral mass of muscles that lies below the horizontal septum and the epaxials are the dorsal muscle mass. A third lateral mass, the lateralis superficialis, is found at the midline of the body

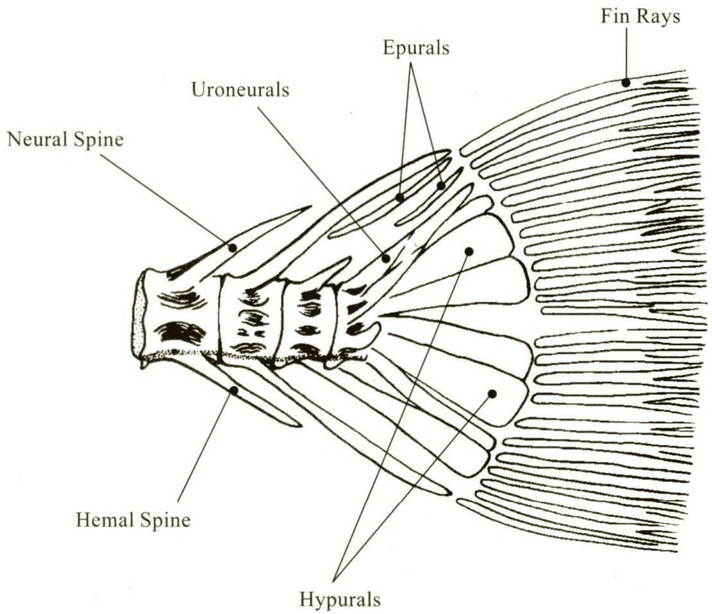


Figure 8. Caudal fin and tail skeleton.

Axial skeleton

All teleost fish have two major types of vertebrae *(Fig. 9)*. The abdominal (precaudal) vertebrae are found in the trunk region of the fish and the Pomadasys has ten of these vertebrae. The caudal vertebrae are found in the tail portion of the fish and bear the hemal arches and hemal spines. You will be able to examine these after removing the internal anatomy. The number of vertebrea are important diagnostic characters scientists count by x-raying the fish in order to get a good look at the bones. You can try to count sixteen of these in the gray Perch for a total of 26 vertebrae. The vertebrae are made up of a centrum, a barrel-shaped vertebral body. The projections on the dorsal side of the centra are neural arches that fuse to form the neural canal for the spinal cord. The neural spine is the dorsal projection of the arch. The hemal arches are projections on the ventral side of caudal centra and fuse to form the hemal canal for the caudal artery and vein. The hemal spine is the ventral projection of the arch. The abdominal vertebrae have projections of the neural arch that bear ribs and intermuscular bones. The atlas vertebrae is the anterior-most vertebra and is specialized for articulation with the skull.

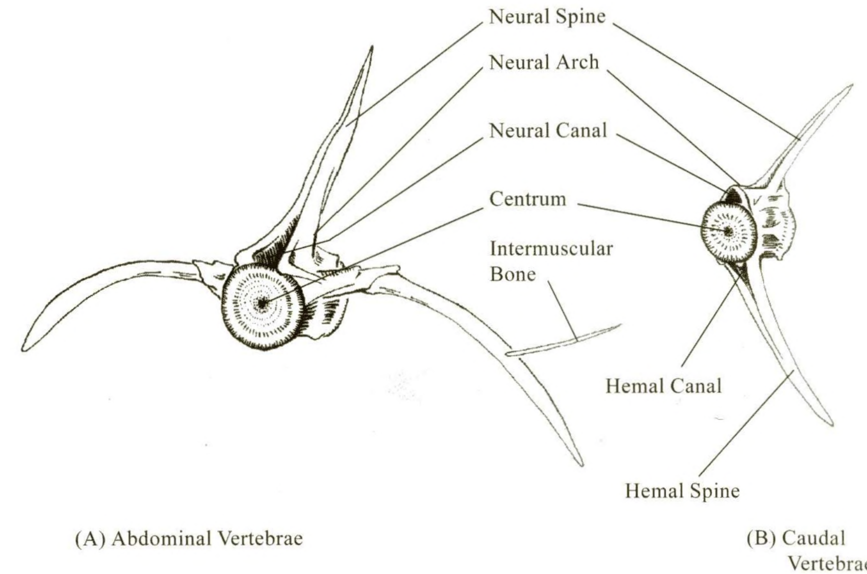


Figure 9. The abdominal (precaudal) and caudal vertebrae.

VI. INTERNAL ANATOMY

Now cut from behind the pelvic fin to the anus along the ventral mid-lateral line *(Fig. 10)*. Continue around the pelvic and pectoral musculature in order to be able to lift up the whole muscle mass and bone. The internal anatomy of the body cavity should now be exposed. Open the peritoneal cavity ventro-laterally below the ribs.

The second goal is to remove the jaw and the cheek bones from the side of the head. Quickly review the external anatomy. First cut the premaxillaries apart along the ascending process. Note the rostral cartilage that the premaxilla sits on. Cut along the posterior edge of the maxilla and premaxilla. Next cut the lower jaws apart by cutting along the chin at the mandibular symphasis.

Trace the longitudinal divisions of the digestive tract from the mouth to the anus. Examine the mouth with the toothed jaws and pharynx. The esophagus is a short, straight, very muscular tube that connects the pharynx and stomach. The remainder of the digestive tract is within the coelom or body cavity. The stomach has a larger straight fundic portion that is continuous with the esophagus and is thinner than the smaller more muscular pyloric portion. Where

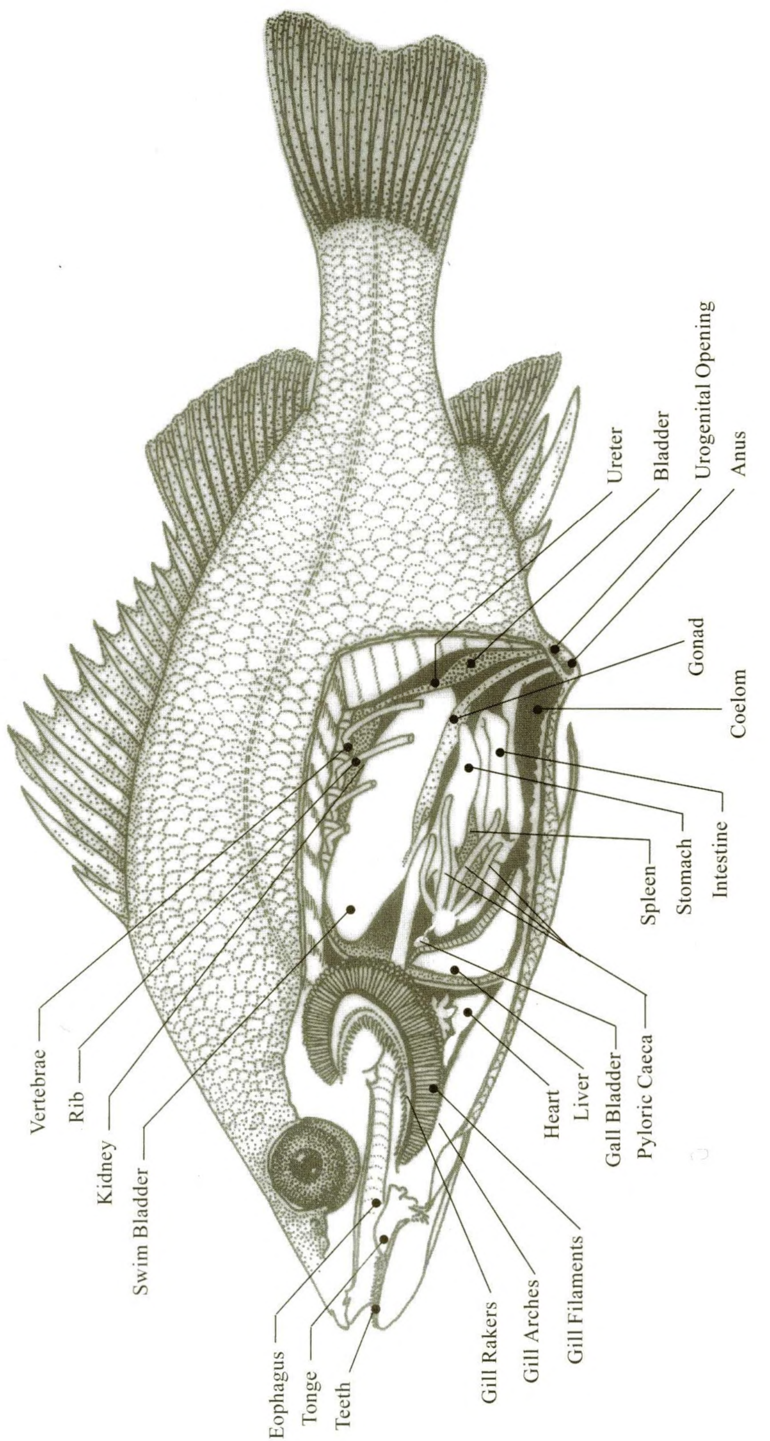


Figure 10. Internal Anatomy of Pomadasys magranthans.

the pyloric stomach leads into the intestines at the pyloric valve. You should notice the pyloric caeca, a series of finger like projections that enter the intestine at the proximal end of the stomach at the junction with the duodenum. The functions of the pyloric caeca probably involve both digestion and absorption. The duodenum is a short muscular constriction in the intestine. Follow the intestines to the cloaca. At the end of the intestines see if you can find the common cloacal sac. The gonads and tubes from the kidneys also drain into this sac.

The liver is the dorsal most structure that surrounds the stomach. It is attached to the myomeres and vertebral column by connective tissue. The liver secretes bile which is routed to the gall bladder through a series hepatic duct from each lobe. In addition to bile secretion, another important function of the liver is glycogen storage. The liver is also the major site for ammonia and urea production and storage of Vitamin D.

The pancreas contains islets of endocrine tissue among trypsin-producing (digestive enzyme) cells. The major hormones produced by the islets are insulin and glucagon.

The spleen, a red, oblong structure, lies near the posterior end of the stomach and functions in red blood cell destruction and formation and as a storage reservoir for red blood cells. The later is important during periods of low oxygen. The spleen will release extra red blood cells to increase the oxygen carrying properties of the blood.

The gas bladder (also referred to as the swim bladder) is a large, tough sac found in the dorsal most part of the coelomic cavity, directly below the kidney and is one of the most notable features of the coelomic cavity in the Perch. The bladder has many functions in different teleost groups including hydrostatic balancing, sound production and reception, and respiration. The Perch is a fish that has lost the connection of the gas bladder and esophagus and can only regulate gas by secretion and reabsorption into the blood. Gas is secreted into the bladder at the gas gland. Note the muscle attachments in the anterior region of the swimbladder and the close contact with the spinal column. This indicates that the bladder is probably used in sound production and reception in the Pomadasys but this has yet not been demonstrated . The swimbladder has three layers. The middle layer, the submucosa, gives the swimbladder the silvery/ pearly appearance due to it being packed with guanine crystals that make the swimbladder much less permeable to gases.

CIRCULATION

If you have not already done so cut away one of the pelvic fins in order to expose the heart *(Fig. 10)*. Be careful when cutting so as not to damage the tissue and vessels around the heart. A schematic diagram of the circulatory system of the gray Perch is shown in *Fig. 11*.

The branchial heart is contained in a tough, pericardial sac and consists of four chambers. The deoxygenated blood returns to the sinous venosus, is pumped sequentially to the atrium, the ventricle and the bulbous arteriosus. The bulbous arteriosus is the most anterior, funnel shaped portion of the heart. The entire cardiac output of blood is distributed to the respiratory system (gills) from the bulbous arteriosus via the ventral aorta to the afferent branchial arteries. The ventral aorta is directly in the ventral midline of the branchial basket and you will have to remove some of the pharyngeal muscles to follow it. The blood passes along the length of the gill filament through an afferent filamental artery to the respiratory gas exchange site, the lamellae, to the efferent filamental arteries and efferent branchial arteries. All blood goes from

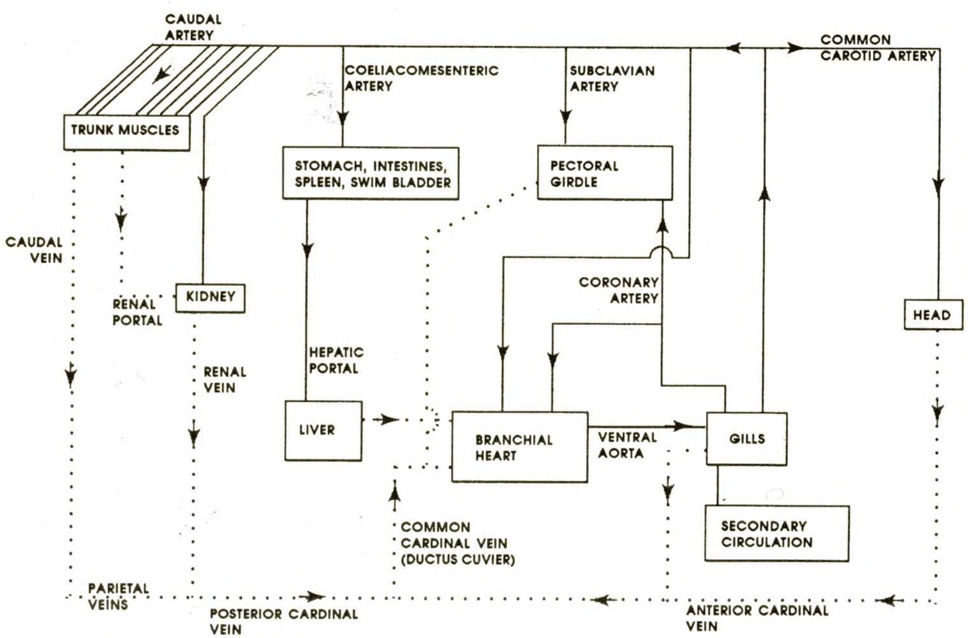


Figure 11. Schematic diagram of the Gray Perch circulatory system. (Adapted from Farrell 1993 in Evans 1993)

the gills directly to systemic (body) circulation either anteriorly via the carotid arteries or posteriorly by the dorsal aorta. The dorsal aorta supplies blood to the pectoral girdle via the subclavian artery, the stomach, intestines, swimbladder and spleen via the coeliacomesenteric artery, and the trunk muscles via the caudal artery and segmental arteries. Blood leaves the gills via the coronary artery to the heart and pectoral girdle.

Carefully remove the branchial basket by cutting through the heavy pharyngeal musculature that is attached to the ventral neurocranium and the anterior most muscle attachments that are easily removed. Save the branchial basket for detailed examination but cut off one complete gill filament for detailed examination.

Blood from the head and gills return directly to the heart via the anterior cardinal vein and the inferior jugular vein to the common cardinal vein (also known as the ductus cuvier) to the sinous venosus. Blood that flowed to the stomach/intestines area flows to the liver through the hepatic portal. From the liver, the blood returns to the sinous venosus through the hepatic vein. The kidney is supplied with blood from the trunk muscles by the renal portal and drains via the renal vein. The trunk muscles also drain by the caudal vein that feed the parietal vein. The renal and parietal veins join to form the posterior cardinal vein which flows into the common cardinal vein.

RESPIRATORY and OSMOREGULATION

Respiration in the Perch involves the following features: (1) water flow through the branchial and opercular cavities, (2) water flow over single gill arches, each with two rows of gill filaments and (3) gas exchange at the lamella.

Water flow is generated in the Perch by a combination of action of a buccal pump, generated by the suspensorium and hyoid bar, and an operculum suction pump. These pumps operate out of phase so that there is somewhat of a continuous flow of water over the gills. Water flows into the oral cavity through the mouth when the suspensorium expands and the hyoid drops, creating an expansion of the buccal cavity. Examine the buccal cavity of the Perch and move the operculum and suspensorium. This is a good opportunity to review their anatomy.

The gill arch *(Fig. 6)* consists of a series of bones that support two rows of gill filaments and a row of gill rakers and are protected by the operculum cover. Review the anatomy of the gill arch bones from the skeleton section. The gill filaments are divided into fine plate-like folds called lamella. Blood flows through the lamella where gas exchange occurs. The sharp, spinous gill rakers are finger-like projections on the oral surface of the arch that are thought to be used in capturing food and protecting the gill arches.

Blood transports oxygen in two forms: physically dissolved oxygen and oxygen chemically bound to the respiratory pigment hemoglobin.

A major problem confronting the gray Perch (and all other fish) is osmoregulation. Freshwater fishes face the problem of an influx of water volume and salt loss while the salt water fishes, like the Pomadasys, are potentially water volume depleted and salt loaded. The Perch osmoregulates using two major structures: the gills and the kidney. We have already discussed the basic anatomy of the gills in earlier sections. The gills are used to actively excrete both Na^+ and Cl^- into the seawater via cells known as chloride and accessory cells. These cells are found in the gill filaments. The gills also have a very high permeability and the fish lose a lot of water across the gills. In order to balance this loss of water, the Perch must drink large volumes of the surrounding seawater. Much of the Na^+ and Cl^- is absorbed in the esophagus and then excreted through the gills.

The kidneys *(Fig. 10)* are long slender bodies that lie along the dorsal midline. Identify the kidneys and they will be discussed in more detail in the next section.

EXCRETORY and REPRODUCTION

The excretory and reproductive systems are discussed together because they share a common urogenital opening. They have little else in common.

All organisms breakdown amino acids that results in the production of waste products that have to be removed from the body. Ammonia is the major end-product, most reduced and energy efficient nitrogen product of the biological breakdown of amino acids and proteins in the Perch but is very toxic. The kidney is the major structure that removes these waste products and is also involved in osmoregulation. The kidneys are long slender brown granular bodies that lie along the dorsal midline *(Fig. 10)*. The kidneys are drained by opisthonephric ducts that lead to a urinary bladder. The urinary bladder then empties into the cloaca.

The reproductive systems varies greatly with the age, size, condition and sex of the individual. Make sure that you look at some of the other specimens if available in order to become familiar with this variation. Gonads consist of germ cells, that produce gametes, and somatic cells. The somatic cells support the development and growth of the germ cells.

The male reproductive system consists of the testes, paired, bilateral structures that connect anteriorly to the liver/swim bladder area and empty into a common cloacal sac via the vas deferens.

The female reproductive system consists of paired structures, ovaries, that are attached to the body cavity by dorsal mesentery. The eggs are expelled from the ovaries via an oviduct.

NERVOUS SYSTEM

The Central Nervous System.

Carefully remove the skin, muscle and the skull from the head to expose the brain *(Fig. 12)*. The brain is divided into five major sections:

1) **Telencephalon**—The most rostral portion of the brain are the olfactory bulbs (not pictured) that blend into the olfactory nerve. These bulbs serve to relay and process olfactory stimuli from the olfactory nerve. The enlarged forebrain caudal to the olfactory bulbs are the structures known as the cerebral hemispheres that are often referred to as the telencephalon. Their functions are also believed to involve olfactory stimuli.

2) **Diencephalon**—In the Perch, the pineal is transformed into a very small photoreceptor connected to the diencephalon by the pineal stalk. The pineal stalk should be apparent along the dorsal midline of the telencephalon.

3) **Mesencephalon**—The dorsal part of the mesencephalon or midbrain (caudal to the telencephalon) contains the major visual and auditory centers. Most apparent are the optic lobes. The auditory centers are not visible superficially in non-mammals but lie deep in the optic lobes. The optic nerves can be traced from the ventral surface of the optic lobes. Just caudal to the optic nerves on the ventral surface is the pituitary (not pictured).

4) **Metencephalon**—Caudal to optic lobes is the cerebellum. This develops from the roof of the metencephalon and is concerned with fine control of body movements and balance. The nuclei of the trigeminal nerve is found in the metencephalon.

5) **Myelyncephalon**—The most caudal portion of the brain is the medulla oblongata. The medulla is where the remaining cranial nerves can be associated with columns in the medulla according to their function.

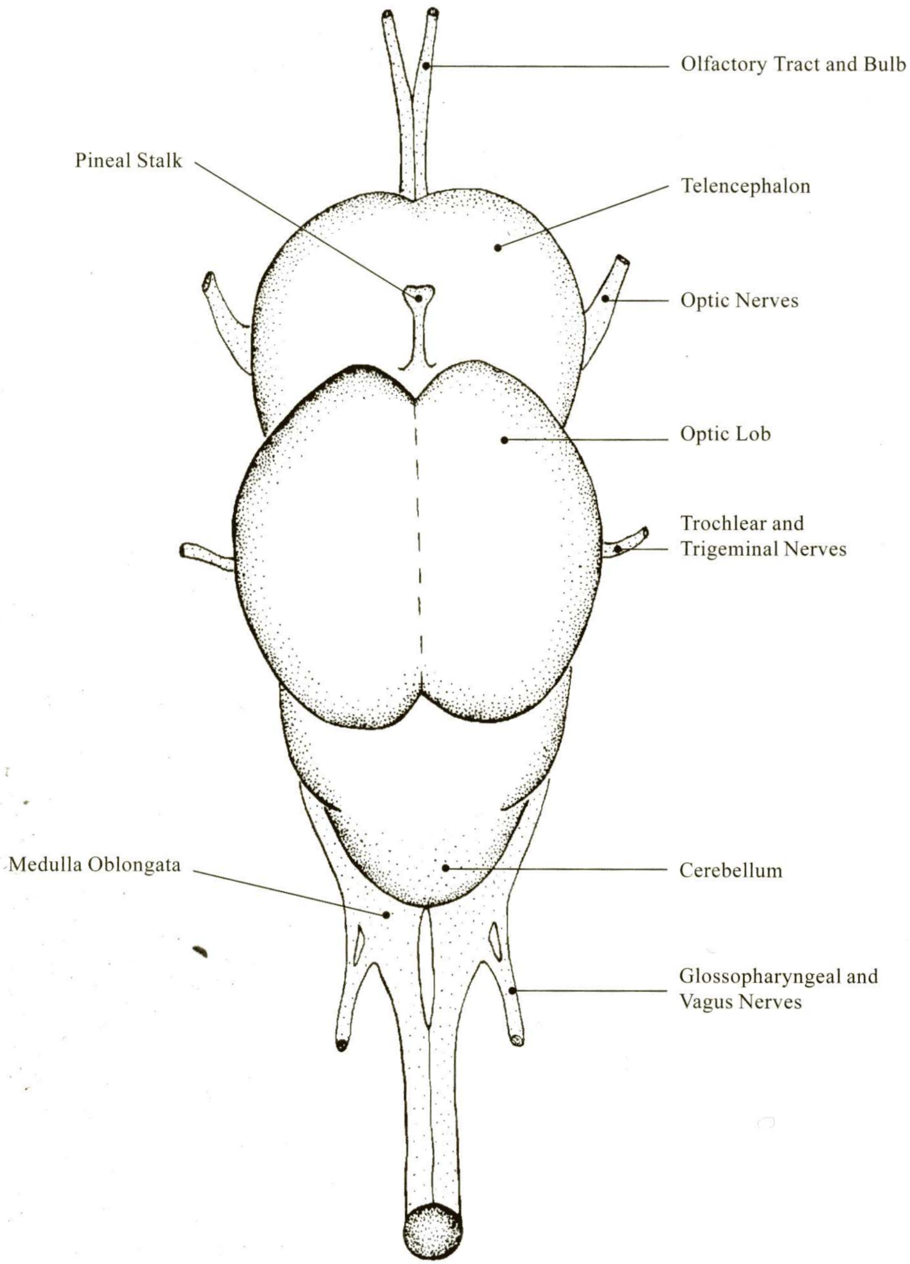

Olfactory Tract and Bulb
Pineal Stalk
Telencephalon
Optic Nerves
Optic Lob
Trochlear and
Trigeminal Nerves
Medulla Oblongata
Cerebellum
Glossopharyngeal and
Vagus Nerves

Figure 12.