# Culturing Finfish

# 8

## KEY CONCEPTS

Finfish account for 50% of global aquaculture production. In the United States, finfish accounts for 74% of total aquaculture production. In order to successfully culture finfish, we must have a good understanding of the biology, ecology, anatomy, and life cycle of the species in question. Catfish are, by far, the most commonly cultured fish in the United States (47%). These warmwater species are cultured in freshwater ponds in southern areas of the country. In cool, northern waters, the most commonly cultured finfish are salmonids (trout and salmon). Currently in Maine, salmon, steelhead trout and char are the only finfish cultured for commercial sale. However, many aquaculturists are learning how to commercially grow other fish such as cod, haddock and flounder.

## LESSON OVERVIEW

Students will learn about culturing finfish in Maine. They will learn how to use a dichotomous key to identify several fish found in Maine. By counting growth rings on scales, students will determine the age of fish. Students will become familiar with the external and internal anatomy of a bony fish through dissection.

## LEARNING OBJECTIVES

After completing this chapter, the student will be able to:

- List the major finfish cultured in Maine.
- Distinguish between jawless fish, cartilaginous fish, and bony fish.
- Describe how fish are classified.
- Describe the basic physiology of the fish.
- Describe the life history of the Atlantic salmon.
- Determine the age of a fish by examining scales.
- Identify the internal and external structure of finfish.
- Determine the function of various internal and external features of finfish.
- Demonstrate effective use of a microscope.
- Demonstrate dissection skills.

## LEARNING RESULTS

### KEYING OUT FISH

A. **Classifying Life Forms**: Students will understand that there are similarities within the diversity of all living things.
   2. Describe similarities and differences among organisms within each taxonomic level.

J. **Inquiry and Problem Solving**
   1. Make accurate observations using appropriate tools and units of measure.

### AGING FISH

J. **Inquiry and Problem Solving**: Students will apply inquiry and problem solving approaches in science and technology.
   1. Make accurate observations using appropriate tools and units of measure.
   2. Verify, evaluate, and use results in a purposeful way.

BONY FISH DISSECTION

J. **Inquiry and Problem Solving**
   1. Make accurate observations using appropriate tools and units of measure.
   2. Verify, evaluate, and use results in a purposeful way.

K. **Scientific Reasoning**
   3. Develop generalizations based on observations.

## MATERIALS

Photocopies of the following student handouts: *Culturing Finfish in Maine, Key Out These Fish, Bony Fish Dissection, Bony Fish Dissection Diagram, Gill Diagrams, Scale Types and Growth Rings, Generalized Bony Fish External Anatomy*; hand lens or dissecting microscope, compound microscope slides, coverslips, various species of fish and scales provided by teacher, metric ruler, projector, microprojector or slide projector, plastic sheeting, empty slide, newspaper or table covering material, disposable latex/rubber gloves, tweezers/forceps, scissors, scalpel, eye dropper/pipette, commercial quick blood smear stain, alcohol or bunson burner.

## BACKGROUND

***Classification***

Fish are divided into three groups:
1. Jawless fish *(Agnatha)* (e.g., hagfish and lampreys)
2. Cartilaginous fish *(Chondrichthyes)* (e.g., sharks, skates, rays, and chimeras)
3. Bony fish *(Osteichthyes)* (e.g., lobe-finned fish, lungfish, and ray-finned fish)

For the purpose of aquaculture, we are primarily concerned with the bony fish, and more specifically, the ray-finned fish. There are over 20,000 species of ray-finned fish, an extremely diverse group found in fresh, salt and brackish waters. Most ray-finned fish, such as salmon, trout and carp, have protective scales covering their skin. Catfish, however, do not. All ray-finned fish have gills which are used to remove oxygen from the water and release carbon dioxide. The gills are usually covered by a plate-like structure called the *operculum.*

Fish produce mucous through their skin which makes them feel slimy and serves a variety of functions. It allows the fish to move smoothly and quickly through the water by reducing friction, it helps make the skin waterproof, and it protects the fish from bacteria and other small organisms which can cause infections.

All bony fish have fins, although the number, shape, and purpose of those fins vary greatly. Fish are equipped with teeth which help them catch their prey, but they don't use them for chewing; they must gulp their food down whole. Fish are cold-blooded which means their body remains the same temperature as their surroundings. The bony or ray-finned fish are an extremely diverse group made up of many different shapes, sizes, and colors.

Female fish lay eggs, which are fertilized with sperm from the males. Some fish build "nests" along the bottom which they "guard" until the eggs hatch. A few fish, including some tilapia, guard their eggs in their mouth; they are called mouth brooders. Fish may lay thousands of eggs, but usually only one out of 100 survives to become an adult fish. Most eggs and young are eaten by other aquatic animals, thus contributing to the food chain. When fish hatch, they are equipped with a *yolk sac* which provides them with nourishment for the first couple of days, after which time the yolk sac becomes absorbed and fish must fend for themselves.

***Physiology of the fish*** (the study of body functions)
All animals have nine body systems:
1. Skeletal 2. Muscular 3. Digestive 4. Excretory 5. Respiratory 6. Circulatory 7. Nervous
8. Sensory 9. Reproductive

In aquatic animals, such as fish, these systems are adapted to a water environment.

1. **Skeletal:** Fish have an internal or *endoskeleton* which provides shape, support, and protection for internal organs and muscles which attach to the skeleton.

2. **Muscular:** By contracting and releasing muscles, fish can move through the water (locomotion), capture food, pass water over their gills for oxygen, and eliminate waste.

3. **Digestive System**: Digestion is a process which converts food into a usable form for growth, maintenance, and reproduction. A fish's digestive system differs depending on whether it is an herbivore, carnivore, or omnivore. The digestive system usually consists of a mouth, esophagus, stomach, intestines, and anus.

4. **Excretory System:** The excretory system eliminates waste from the body and usually consists of the gills, kidneys, urinary ducts, bladder, and opening.

5. **Respiratory System**: Gills are the respiratory organs of the fish. Water is pumped over the gills and dissolved oxygen present in the water diffuses into the blood stream. This oxygen is delivered to the tissues and cells of the body and exchanged for carbon dioxide, which is then expelled as a waste product through the gills and into the water.

6. **Circulatory System:** The circulatory system includes the heart, veins, and arteries and is responsible for circulating blood throughout the body. Oxygenated blood travels to the cells and tissues where it is exchanged for carbon dioxide. This de-oxygenated blood travels back to the gills, is released into the water, and is replaced with oxygen.

7. **Nervous System:** The fish's nervous system consists of a well-developed brain, spinal column, nerve fibers and sensory receptors. Through electrical-chemical impulses, the nervous system supplies the fish with information about its internal and external environment.

8. **Sensory System:** The sensory system relays information through the nervous system using the five senses: sight, smell, touch, taste, and hearing. The *lateral line* is an external sensory organ which runs down the length of the fish and helps it maintain balance and position in the water. Some fish, like catfish, have **barbels** which help them feel around the bottom for food.

9. **Reproductive System:** Fish reproduce sexually to create offspring. Males have testes which produce sperm and females have ovaries which produce eggs.

## STUDENT HANDOUT
### Culturing Finfish in Maine

#### *Culturing Salmon and Steelhead Trout*

The most popular fish to culture in the Gulf of Maine is the Atlantic salmon. Maine aquaculturists have been raising salmon since the 1970s. Hatcheries throughout the state produce 3.5 million fish each year for net-pen salmon farming operations along the coast.

While private industry continues to farm Atlantic salmon for profit, there are also public hatchery programs aimed at restocking Maine's rivers and streams. **Native** salmon populations have been in decline for some time. Since there is concern that the Atlantic salmon may disappear from Maine's rivers completely, the federal and state government has been trying to protect the salmon through stricter fishing regulations, improvement or restoration of salmon river habitat, and hatchery stocking programs.

The Atlantic salmon is an **anadromous** species which means they are born in fresh water, spend most of their life at sea, and return to fresh water to **spawn** or produce young. In the wild, most of an adult salmon's life is spent in the ocean. During the spring of the fourth or fifth year, the adult fish will return to the river where it was born in order to spawn.

#### *Life Cycle of the Atlantic Salmon*

In salmon and steelhead farms, some adult fish are kept for **broodstock**. These fish supply the eggs and the sperm to produce all the hatchery fish. Spawning occurs between mid-November and mid-December. A 12-pound female fish produces an average of 10,000 eggs each season. These eggs are collected and **fertilized** with sperm from the males by mixing the two together. The fertilized eggs are then **incubated** at a freshwater **hatchery**. The eggs hatch and eventually develop into free-swimming **fry**. After the **yolk sac** is absorbed, the fish begin to eat food on their own.

During the first year of life, fish develop vertical stripes on their sides. They are now called **parr**. For the first 18 months of their life cycle in the hatchery, parr are **graded**, vaccinated against diseases, and their health and growth is monitored. After two to three years in fresh water, young salmon undergo major changes that enable them to live in salt water. Their kidneys adapt to excrete salt, rather than retain it, and their skin becomes silvery so the fish will be less visible to predators in the ocean. Changes also occur in the eyes, blood plasma, musculature, and fat. This whole process is called *smoltification*. The **smolts**, roughly five inches long, are transferred to floating pens in the sea, typically between mid-April and mid-May.

The steelhead trout, also called the sea run rainbow trout, belongs to the same family (the **salmonids**) as the Atlantic salmon. The steelhead has been referred to as the saltwater version of the rainbow trout. The life cycle of the steelhead is essentially the same as the Atlantic salmon, except that the steelhead does not go through true smoltification. In the wild, both Atlantic salmon and steelhead trout return to fresh water to spawn. The steelhead looks similar to the Atlantic salmon, but usually has an iridescent sheen; hence the name "rainbow." This rainbow sheen becomes brighter when the steelhead returns to fresh water to spawn.

#### *Salmon Farming*

Young salmon are raised in freshwater hatcheries. When they undergo smoltification, they are then transferred to salt water salmon farms. In these grow-out facilities, salmon are housed in net pens which are generally 20 feet deep. These large pen systems, held in place with moorings, may cover several acres of surface water. In the pens, fish are fed pellets of fish meal, vitamins, and minerals. To prevent the spread of disease, fish are inoculated or antibiotics added to the fish feed. After about two years in the pens, fish grow from smolts weighing 3 to 5 ounces (80-120 grams) to fish with a market weight of 6 to 12 pounds. A farming operation with 2-1/2 acres of net pens can produce about 50,000 fish each year for market. When the fish reach an appropriate size, they are harvested, cleaned, and shipped to wholesale and retail markets.

Eight commercial freshwater hatcheries in Maine produced about 3 million young salmon and 100,000 steelhead in 1995. There are 30 saltwater grow-out sites, located primarily in Washington and Hancock counties, where excellent water quality, protected bays, water temperatures of 0 to 15°C ( 32-59°F), strong currents, and high tides provide ideal conditions for raising salmon. In 1995, fish farming generated more than $53 million in gross sales revenue, and the salmonid aquaculture industry has brought much needed aid to economically depressed communities. Increasingly, fishermen who depend on wild fish stocks for their livelihood are considering putting their skills to work in aquaculture to supplement their incomes.

Another economic benefit of salmon and steelhead trout farming is the increase in the number of family-owned smoke houses, where the fish are processed for a gourmet market. Furthermore, a health-conscious public creates a demand for salmon and steelhead, which are excellent sources of protein, omega-3 fatty acids, and vitamins A, B, D, and E. These fish species are also low in sodium, rich in potassium, and are natural sources of selenium, iodine, and fluorine.

Salmon farming depends on, and demands, a clean environment. One of the largest dangers to salmon farming is industrial and municipal waste which enters the marine environment. This pollution may contain hazardous chemicals, heavy metals, and untreated sewage which then make eating fish or shellfish hazardous to humans. In order to protect the salmon farms, pollution inputs from industrial or municipal sources must be very carefully monitored and regulated. Protecting the salmon pens from pollution, can help protect the marine environment as a whole.

***Culturing Other Finfish in Maine***

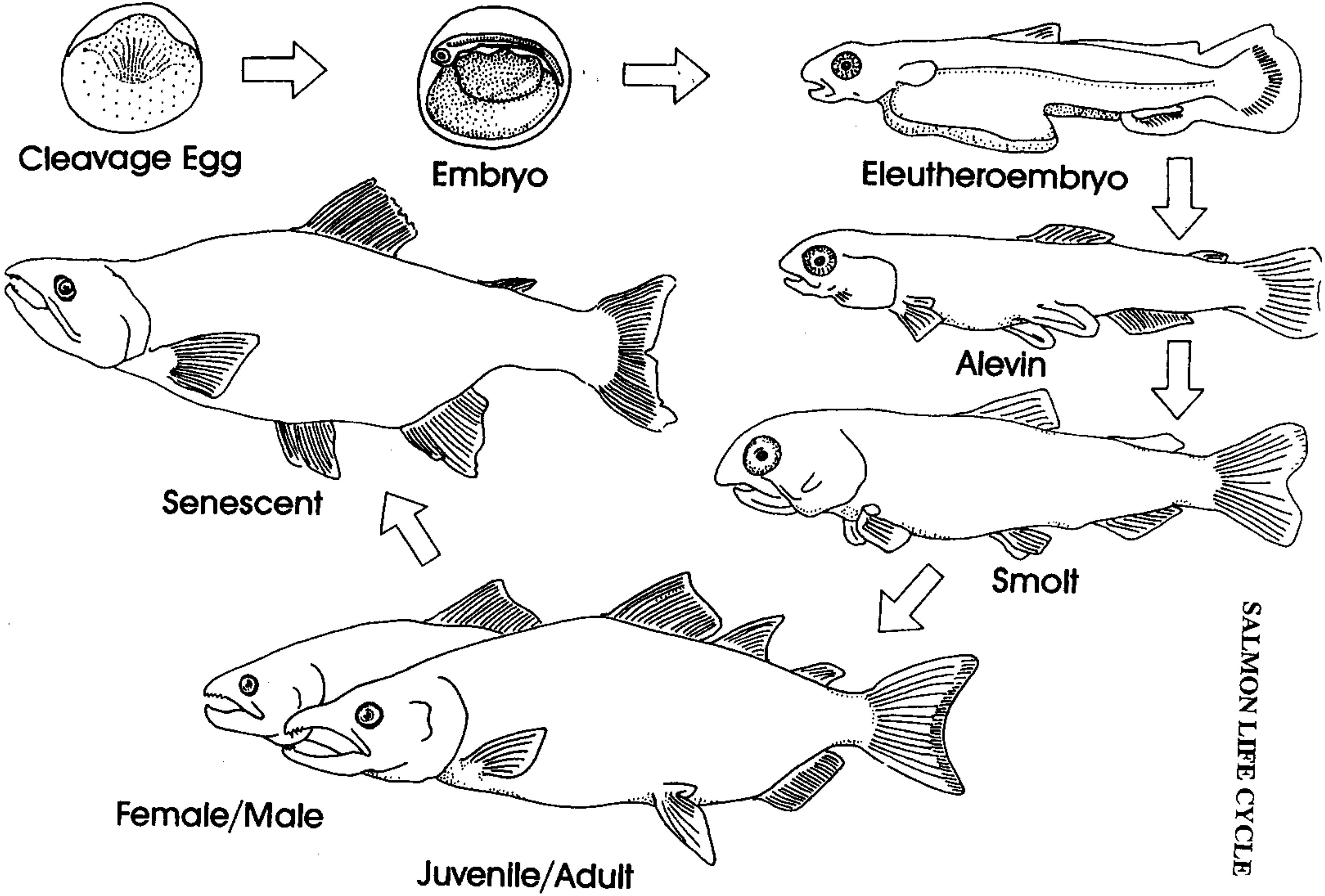
With the decline in wild **groundfish** populations, there is considerable interest in developing efficient techniques for raising cod, halibut, and haddock on fish farms. Researchers at the University of Maine recently began studying both the nutritional needs of larval cod and haddock, and the type of food to maximize healthy growth in the early stages of these fish. Atlantic Aquafarms in Franklin and the Maine Hatchery Technology Association on Swan's Island are experimenting with different ways of hatching and raising cod and haddock on a commercial scale. Some of the young fish will be used for restoring the natural groundfish populations in the waters offshore; the rest will be raised in pens until they are market size. Both projects are good examples of cooperation between aquaculturists and traditional fishermen.

High in demand, low in supply, halibut (*Hippoglossus hippoglossus*) could be a good candidate for aquaculture. Halibut is more resistant to **superchill** than salmon. Maine aquaculturists have successfully captured young halibut and are rearing them for future broodstock for the Maine aquaculture industry.

Halibut (which can achieve a weight of more than 100 pounds in the wild) present special challenges for pen culture. As an experiment, young fish that weighed from seven to 10 pounds were caught by longline fishermen and donated to the broodstock project. Raised in pens, these fish grew three times faster in captivity than in nature. Now researchers are testing new "Malloch-style" cages, made of tightly drawn nylon mesh, and designed by growers at the Marine Technology Center in Eastport. By the fall of 1996, 27 fish were held at Maine Salmon Company's Shackford

Head lease site in Eastport while researchers waited for them to mature. Scientists expect to study broodstock management, experiment with halibut egg incubation, and continue to investigate the growth patterns and larval feeding habits of halibut.

SALMON LIFE CYCLE




Successive developmental stages of the salmon.

## ACTIVITY 1: KEYING OUT FISH

**Information**

A fish key is a series of questions or statements that may be asked about the characteristics of a fish. If you do not know the scientific name (genus and species) of a fish, you can observe the fish and answer the questions in the key to find the scientific name. At the end of each question that pertains to your particular fish is a number directing you to the next question. When you have answered enough questions, you eventually find the scientific name of your fish.

**Procedure**

Choose a fish and carefully answer each question, proceeding through the key. If a question is answered incorrectly, you will not obtain the correct scientific name. A key is provided and may be copied and handed out to your class.

**Answers to *Key These Fish* Handout**

1) smelt 2) haddock 3) American eel 4) winter flounder 5) ocean sunfish 6) white hake 7) hammerhead shark 8) wolffish 9) sea lamprey 10) Atlantic halibut 11) alewife 12) bluefin tuna 13) American pollock 14) spiny dogfish 15) Atlantic cod 16) Atlantic mackerel

# FISH KEY

| | | |
|---|---|---|
| | | Sample answers for hammerhead shark |
| 1. | a. Does the fish have a body like a snake? **2** | (no) |
| | b. Does the fish not have a body like a snake? **3** | (yes) |
| 2. | a. Does the fish have a jaw? ***Anguilla rostrata*** **(American eel)** | |
| | b. Does the fish not have a jaw? ***Petromyzon marinus*** **(lampreys and hagfish)** | |
| 3. | a. Does the fish have eyes on the same side and a flattened body? **4** | (no) |
| | b. Does the fish not have eyes on the same side and no flattened body? **5** | (yes) |
| 4. | a. Does the fish have a forked tail? ***Hippoglossus hippoglossus*** **(Atlantic halibut)** | |
| | b. Does the fish not have a forked tail? ***Pseudopleuronectes americanus*** **(winter flounder)** | |
| 5. | a. Does the fish have fleshy fins (without rays)? **6** | (yes) |
| | b. Does the fish have fins with rays? **7** | (no) |
| 6. | a. Does the fish have a pointed head? ***Squalus acanthias*** **(spiny dogfish shark)** | (no) |
| | b. Does the fish not have a pointed head? ***Sphyrna lewini*** **(scalloped hammerhead shark)** | (yes) |
| 7. | a. Is the fish body full moon-shaped with a little caudal fin? ***Mola mola*** **(ocean sunfish)** | |
| | b. Is the fish body not distinctly moon-shaped and has a highly visible larger caudal fin? **8** | |
| 8. | a. Is the fish club-shaped like a baseball bat? ***Anarhichas lupus*** **(Atlantic wolffish)** | |
| | b. Is the fish body not club-shaped like a baseball bat? **9** | |
| 9. | a. Is there evidence of a chin barbel? **10** | |
| | b. Does the fish have no chin barbels? **13** | |
| 10. | a. Is the caudal fin not notched or only slightly (just barely) notched? **11** | |
| | b. Is the tail decidedly notched? **12** | |
| 11. | a. Does the fish have three distinct dorsal fins (top side)? ***Gadus morhua*** **(Atlantic cod)** | |
| | b. Does the fish have two distinct dorsal fins? ***Urophycis tenuis*** **(white hake)** | |

12. a. Does the lower jaw extend beyond the upper jaw? **Pollachius virens (American pollock)**
b. Does the lower jaw not extend beyond the upper jaw? **Melanogrammus anglefinus (haddock)**

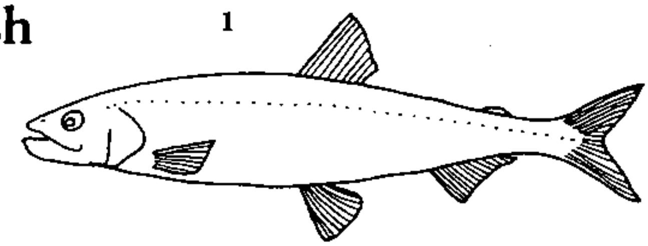
13. a. Does the fish have finlets (small fins like growth between tail and dorsal and anal fin)? **14**
b. Does the fish not have finlets? **15**

14. a. Are the dorsal fins distinctly separated? ***Scomber scombrus* (Atlantic mackerel)**
b. Are the dorsal fins not separated distinctly? ***Thunnus thynnus* (bluefin tuna)**

15. a. Does the fish have a small adipose fin (small fleshy fin between the caudal and dorsal fin)? ***Osmerus mordax* (smelt)**
b. Does the fish not have a small adipose fin? ***Pamolobus pseudoharegus* (alewife)**

# Key Out These Fish

1



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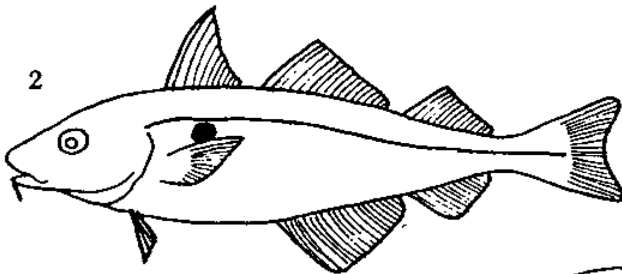

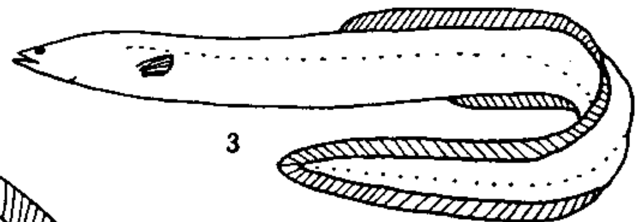

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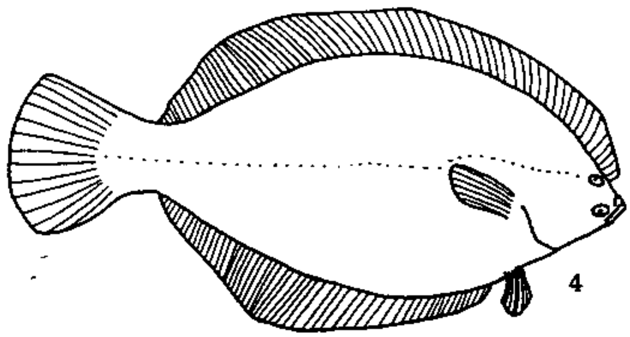

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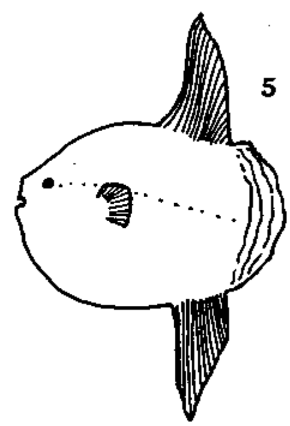

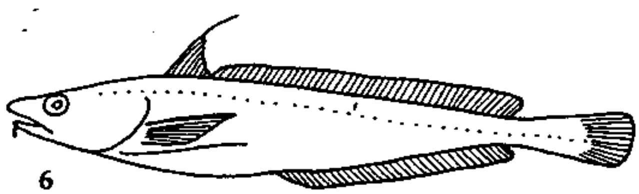

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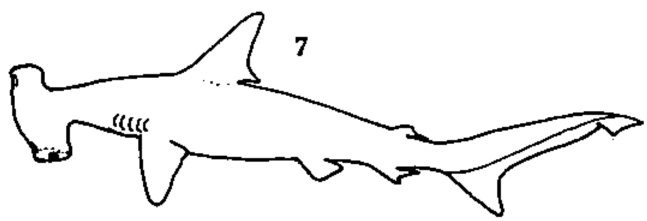

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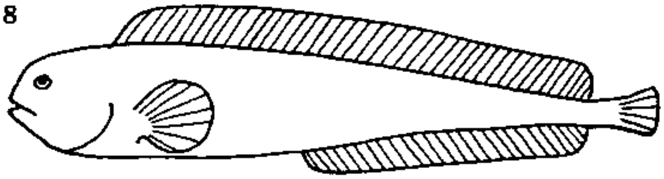
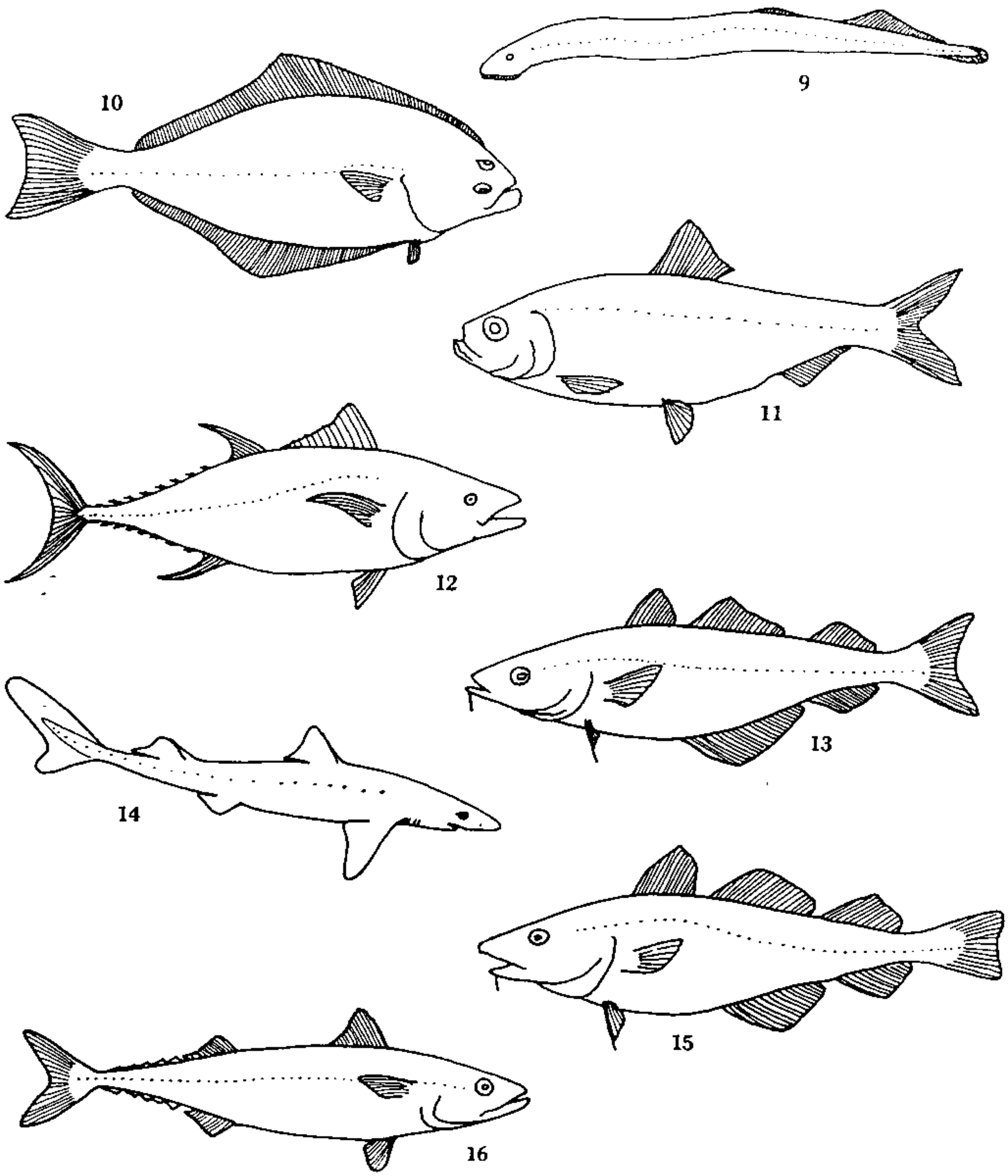


# Key Out These Fish



## ACTIVITY 2: AGING FISH

### Information

Determining the age of fish is very important for fishery biologists and aquaculturists. By examining scales, it is possible to determine an age profile of your present fish population and make predictions for the future. Knowledge of the age structure of a fish population is important for management practices and conservation efforts.

Given adequate food and space, fish will continually grow. In this case the oldest fish would be the largest, but in nature, conditions are less than ideal and fish grow at varying rates. Food, space and other life requirements are not equally distributed in the environment, and some fish are more hardy and grow faster than others.

There are a number of methods to calculate the age of fish. Aging fish by scale counts is the most widespread and straightforward method and can be conducted on live specimens without harming the individual. The limitations of this method is that accuracy depends on the interpretive ability of the examiner and the distinctiveness of the annual layers. Scales grow as the fish grows, producing growth layers which have a ring-like appearance. The scale and other hard parts of the fish grow faster during the heavy feeding months of the summer and slow down during bad feeding seasons, usually winter. When the growth subsides, the rings are closer together and appear darker, when observed under low microscopic magnification (20-40X). Each of these darker rings is an *annulus* and usually demarks one year's growth.

The age of the fish can be roughly determined by counting the rings starting with the clear area of the center called the focus or core. The focus represents the original scale of the young fish. In order to determine the age of fish by studying the scale structure, several terms should be explained:

- **Annulus:** The annual mark or zone on fish scales which is formed once a year.
- **Focus:** The small, clear area near the center of the scale which represents the original scale of the young fish.
- **Ctenoid Scale**: The scale of a bony fish (teleost) which possesses small sharp spines (ctenii).
- **Cycloid Scale**: The scale of a bony fish without spines.

There are variations of these scales. The spines of ctenii and the position of the focus varies with each species of fish. The annulus is recognized in one of the following ways: 1) "crossing over" where the onset of fall or winter causes several ridges or *circuli* to flare outward and end on the side of the scale, rather than circle the focus; 2) "discontinuous circuli" where the individual circuli do not grow together in a complete line because the scale stops growing and 3) extreme crowding of the circuli which occurs first, prior to resumption of growth.

### Preparation

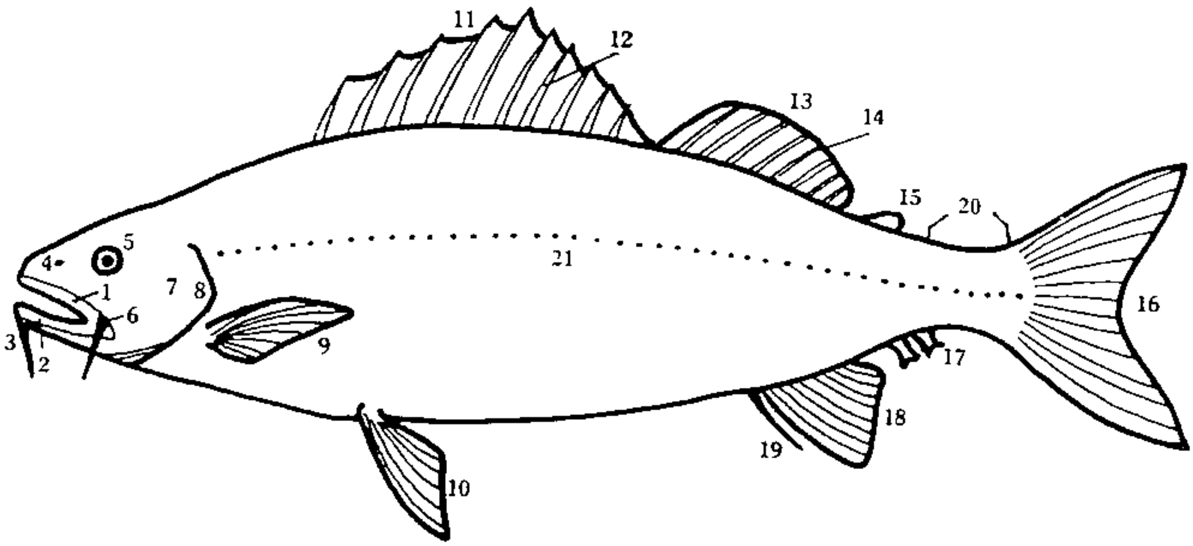
Select fish with large scales. These include fish such as herring, alewife, bass, perch, haddock, cunner, salmon, anchovy, and silversides. Other swift-swimming fish such as the mackerel and tuna have reduced scales to enhance streamlining. The scales of common eels (*Anguilla*) are microscopic or not present. You may obtain some of the above fish from a local fish market, a seafood processing plant, or a local fisherman. Fully-formed scales from each specimen should be selected. When a scale is lost, the regenerated scale does not form the old rings. Also, a false annual ring is produced by females just prior to spawning as reabsorption occurs. In addition, it is difficult to age hatchery fish using this method. Hatchery fish undergo rapid, even growth within controlled environments. Their scales will not have the annual dense groupings found on scales of fish that experience seasonal food deprivation.

To provide uniformity to this procedure, biologists usually select scales from a specific spot on a fish. Follow the back edge of the dorsal fin down towards the lateral line; remove the second scale just above the lateral line. After the scales are selected and removed, they may be stored for later use by placing them in an envelope or by pressing them between pieces of paper. The scales have their own cement called mucus. If possible, the paper that the scale is on should be labeled with the following information: type of species, weight, length, place, sex, and date.
A useful way to examine scales is to place them between two layers of thin clear plastic and mount them in a 35-millimeter (mm) slide blank. Scales are magnified by projecting them with an ordinary 35-mm slide projector. This method facilitates storing and cataloging and can be done by the whole class at once. Scales may also be examined under the stereoscope at 2040X. Detailed examinations of parts of the scales may also be of interest. A compound microscope with 50-100X objectives would be of some use, especially for smaller scales if large ones are not available.

Collecting scales from a large number of different species of fish shows the variety of size and the difficulty of age analysis. Start out with some of the easier specimens first, such as herring or haddock. A comparison of bony fish scales to the scales of sharks would also be of interest. Sharks have a more primitive *placoid* type scale, which does not detach easily. The scale, which is very tiny, gives the skin a sandpaper-like texture. Other types of scales include those of the gar and the Atlantic sturgeon which have *ganoid* scales. Ganoid scales also do not detach easily. Large and pyramid-shaped, they give the skin an armour-like appearance.

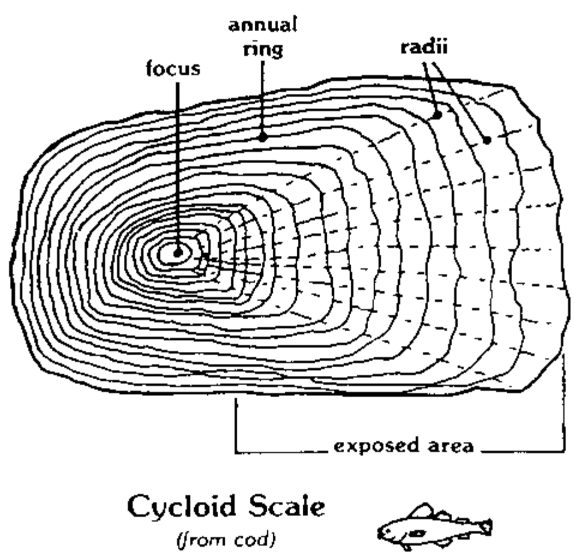
STUDENT HANDOUT

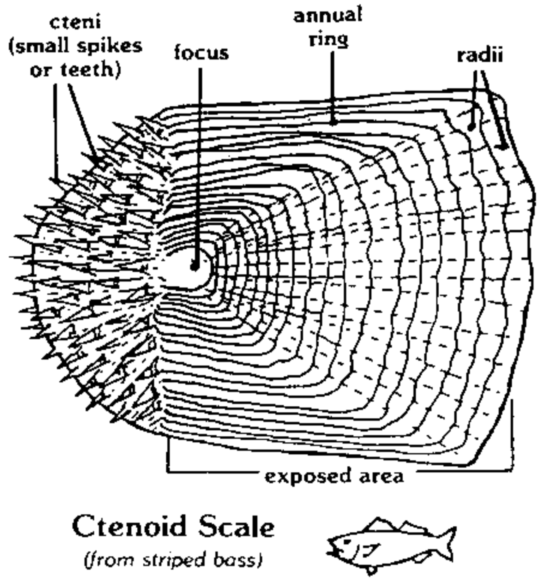
# Generalized Bony Fish External Anatomy




1. Maxilla and premaxilla (Upper jaw)
2. Mandible (Lower jaw)
3. Barbel
4. Nostril
5. Eye
6. Maxillary barbel
7. Cheek
8. Operculum (gill cover)
9. Pectoral fin
10. Pelvic fin
11. Spiny dorsal fin (first dorsal)
12. Dorsal spine
13. Soft rayed dorsal fin (second dorsal)
14. Soft ray (fin ray)
15. Adipose fin
16. Caudal fin (tail fin)
17. Finlets
18. Anal fin
19. Anal spine
20. Caudal peduncle
21. Lateral line

# Bony Fish Scale Types and Growth Rings



## LAB HANDOUT

### Determining the Age of Fish Through Observation of Scales

### Information

With increasing demands on fish stocks around the world, it has become very important to know the age composition of each type of fish. Such knowledge about the amount of growth gained each year, the life span of fish, and the age structure of the population, enables us to harvest fish crops more efficiently and to enact conservation measures effectively. We will age fish by counting the annual growth rings deposited on the scales of fish.

### Terms to know

- **Annulus:** The annual mark or zone on fish scales which is formed once a year.
- **Focus:** The small, clear area near the center of the scale which represents the original scale of the young fish.
- **Ctenoid Scale:** The scale of a bony fish (*teleost*) which possesses small sharp spines (*ctenii*).
- **Cycloid Scale:** The scale of a bony fish without spines.

### Materials

Hand lens or dissecting microscope, compound microscope slides, various species of fish or scales provided by teacher, metric ruler, projector, microprojector or slide projector, plastic sheeting, and empty slide (if demonstrations are desired)

### Procedure

1. Remove a scale from several areas of each specimen. Using a hand lens or microscope and the *Scale Types and Growth Rings* handout, determine if scales are cycloid or ctenoid.

2. If the scale is ctenoid, remove further scales around the area of the pectoral fin. Cycloid scales should be taken from an area between the dorsal fin and the lateral line. Remove three scales from the indicated area of each specimen.

3. Make a wet mount of the scales or place them between two glass slides for microscopic observation. Use both a compound microscope and a stereoscope.

### Observations

Make illustrations of the general features of the scale noting: annuli, focus, circuli, and ctenii (when present). Determine the distance between annuli on the scale by using a metric ruler. To determine the age, each scale should be counted twice, at different times, to arrive at an accurate interpretation. Count one year of growth for each annulus.

### Discussion

Can you differentiate between summer growth and winter growth? How? Each scale tells a story about the life history of that particular fish. Choose a scale and describe its life history.

### Limitations and Sources of Error

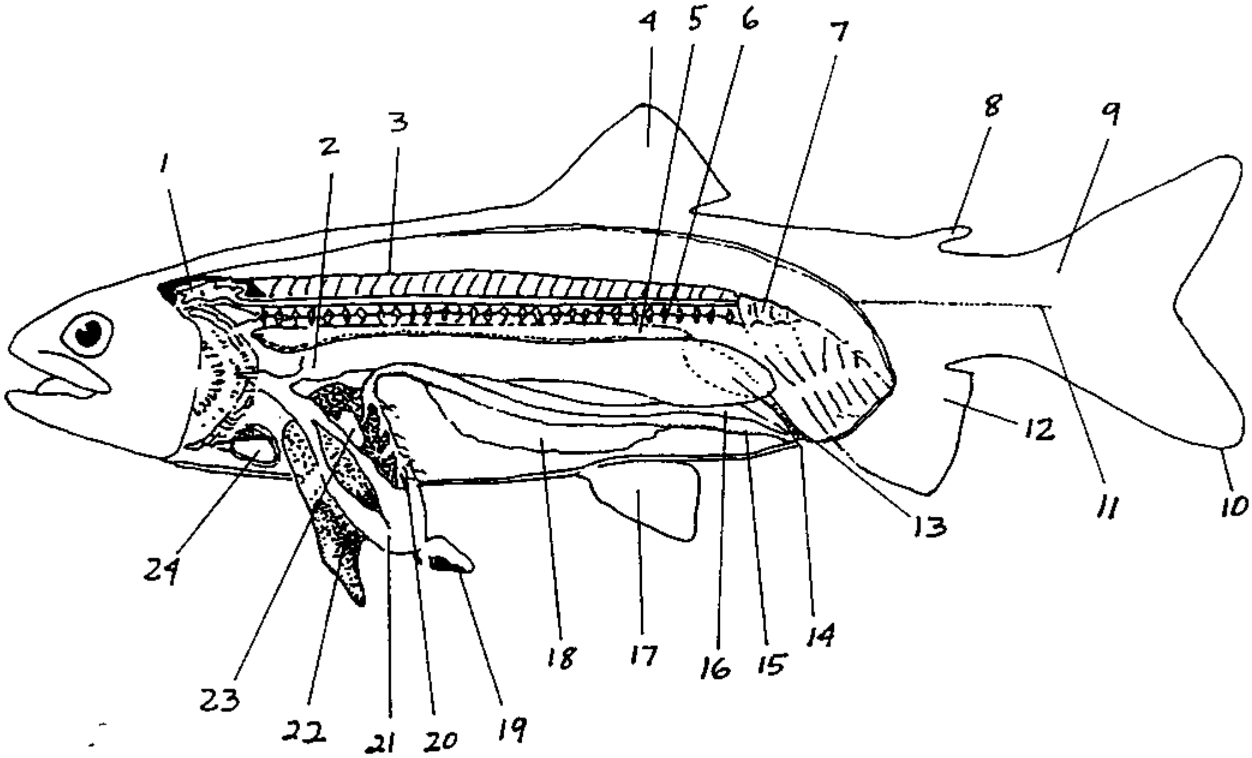
This could result in incorrect reading of scales. Some fish show no definite annuli. Other errors might result in the use of imperfect scale or scales that have been rejuvenated. Errors in age determination increase with the age of the fish. Errors may also be made in determining the location of the first annulus.

## ACTIVITY 3: BONY FISH DISSECTION

**Preparation:**
If possible, select several different specimens and compare their external features. The fish may be fresh or marine, as both have the same anatomical features. A diagram of the internal and general external anatomy of a typical bony fish is provided. Photocopy and distribute copies of the lab handouts *Bony Fish Dissection Diagram, Generalized Bony Fish External Anatomy*, and *Gill Diagrams*. More detailed anatomical figures are available in marine science lab manuals.

**STUDENT HANDOUT**

## Bony Fish Dissection Diagram

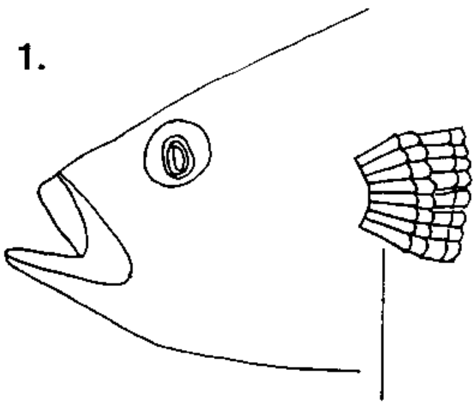



1. Brain
2. Swim bladder
3. Neural spine
4. Dorsal fin
5. Kidney
6. Spinal cord
7. Vertebrae
8. Adipose fin
9. Caudal peduncle
10. Caudal fin
11. Lateral line
12. Anal fin
13. Urinary bladder
14. Anus
15. Colon
16. Gonad
17. Pelvic fin
18. Adipose tissue
19. Spleen
20. Pyloric caeca
21. Stomach
22. Liver
23. Gall bladder
24. Heart

**STUDENT HANDOUT**

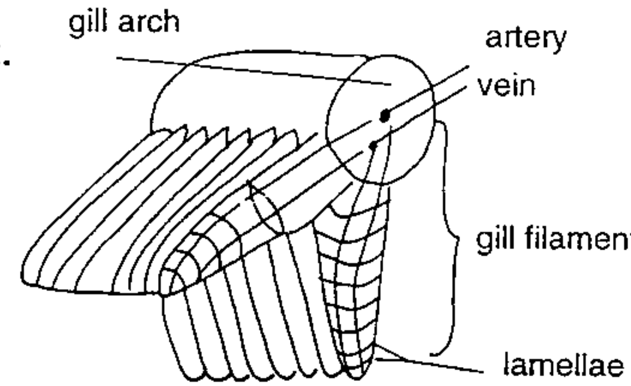
**Gill Diagrams**

1.



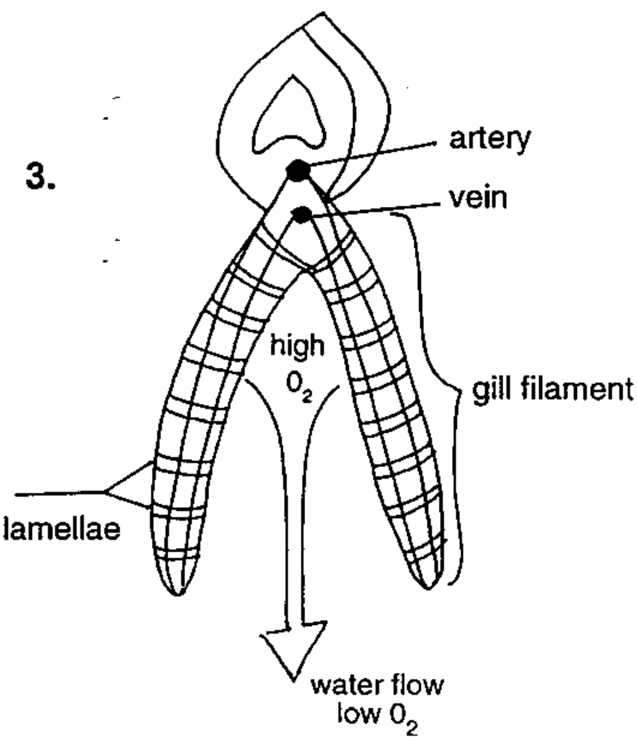
Gill filaments are stacked and layered for increased surface area.

2.



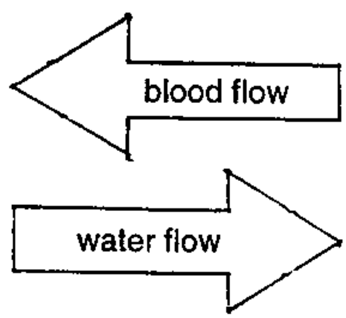

The major parts of the gills include the bony gill arch. The major blood vessels run through the gill arch and along the gill filament. Each filament contains several disc-shaped lamella.

3.




The lamella (folds of tissue) contain the smaller branches of blood vessels known as capillaries. The exchange of gases occurs in the capillaries.

4.




The fish maintains a one-way flow of water through the gills by taking water into the mouth and passing it out through the gill slit or operculum. The water flows over the gills. Specifically, the gill filaments deflect the water so it will flow across the lamella. The blood flows in the opposite direction. The water and blood flow in counter directions across the lamella. This counter current flow enhances the diffusion of oxygen into the blood.

# STUDENT HANDOUT
## Bony Fish Dissection

### Instructions
Carefully read through the following procedures and record observations accordingly.

### Procedures

### External Anatomy

#### Shape
1. Commonly, a fish's body is torpedo-shaped (fusiform) and slightly ovoid in cross-section. However, there are many interesting departures from this idealized case. These range from globe shapes (puffers-globiform) through serpentine (American eels-anguilliform) to thread-like forms (snipes). A flatfish like a flounder is laterally compressed or flattened from the sides, whereas a skate is dorso-ventrally compressed or flattened from the top. ***What is the shape of the fish(s) you are dissecting?***

#### Body Covering
2. Many fish have thick skins which are continuous with the lining of all the body openings. Mucous cells provide a coating which is both protective and effective in streamlining the fish for swimming. ***Does your specimen(s) have a very tough skin? Does it feel slimy?***

3. Scales are usually imbedded in the skin. They may be small or very large. The types of scales (ganoid, cycloid, or ctenoid) serve as characteristics of major bony fish groups. The types of scales and the number of scale rows along or around the body aid in identification. ***What type of scales does your specimen(s) have? Are they small or large?***

**Appendages**

4. The appendages of fish include the various fins and the *cirrhi* (fleshy projections). Fins are categorized as median or paired. The dorsal (top) fins show much variation. They may be continuous, partially divided, or completely divided into separate parts. The dorsal fin may also consist of either spines (soft or hard), rays, or both. Spines usually appear transparent, hard, and sharp at the ends. Rays are soft and appear segmented when held to the light or when viewed under a low-powered stereoscope. The rays may also branch out at the end. ***What type of dorsal fin(s) does your specimen(s) have? Does it have rays, spines, or both? What advantage is there to having spines or soft rays?***

6. Other median fins include the tail (caudal fin) and the anal fin (just behind the vent on the lower side). The trout or salmon-like forms have a fatty adipose fin. Fins also may be reduced to a few disconnected spines as in the stickleback. ***What function do you think the caudal fin serves?***

7. Pectoral fins may vary also. They may be enlarged as in the sculpin, sea raven, or flying fish, or more regular in shape, as in the trout and flounder. ***What function do you think the pectoral fins serve?***

8. Pelvic fins vary in shape and position. Their support comes internally from the pelvic girdle. Most soft-rayed fish have pelvics located abdominally, as in salmonids. They may be located below the pectorals, or they may be under the throat (jugular). Some pelvics are modified, as in the shark and skate, to form claspers used in reproduction. ***Where are the pelvic fins on your fish? What function do you suppose they serve?***

## Internal Anatomy

9. Using a scalpel or strong scissors, carefully cut open the belly cavity, starting at the anal vent and proceeding up to the pectoral fins. For a better view, remove a portion of the body wall by starting again at the anal vent and cutting an arch-shaped line to the pectoral fins. ***Use the internal anatomy diagram to help identify the structures.***

10. Take the gill cover, called the *operculum*, off the left side of the fish and observe the gills. If the specimen is fresh, note the red color produced by blood capillaries. ***Sketch the gill structure.***

11. Identify the major internal organs. ***Make a diagram showing the route of the blood from the heart (two-chambered) to the gills.***

12. Study the digestive tract. Make an incision through the small intestines and a small cross-section. Examine the internal surface area. ***What is the color of the lining of the digestive cavity?*** This lining is called the *peritoneum*. If it is white, the fish is generally a carnivore. Black indicates an herbivore.

13. Observe the swim bladder which is found under the vertebral column and kidneys. Note that it connects to the esophagus. This flotation device is unique among the bony fish and is very important for maintaining buoyancy. ***Can you express any air from the swim bladder?***

14. Cut into the musculature midway along the body. ***Are all the muscles white or are some red? What is the approximate ratio of red to white muscle tissue in this region of the body? What do you think the significance of red muscle cells is for a swimming animal?***

15. Choose an organ like the heart, liver, kidney, or spleen and cut a portion from it. Use forceps to blot the cut surface of the organ on a microscope slide. Allow slide to air dry and then quickly pass the slide once or twice through an alcohol burner flame. (This will fix or stick the blot to the slide). Stain with a commercial quick blood stain for one minute. Rinse slide in tap water and allow to air dry. View under a compound microscope at 40X or 100X. ***Draw a diagram of what you see. Label the red blood cells and the white blood cells.***

## MAKING CONNECTIONS: ADDITIONAL ACTIVITIES AND EXTENSIONS

• Culture Candidates

Divide the class into cooperative learning groups. Using the *ABC Fish of the Gulf of Maine* (obtained from Maine Department of Marine Resources) and the *NOAA Status of the Fishery Resources off the Northeastern United States* (obtained from Woods Hole Oceanographic Institute), identify which species are currently being overfished. Divide the class into cooperative learning groups and have them choose one of the fish (principal groundfish or flounder) to research. Groups should research the past and current status of their species, and its biology, ecology, and potential for culture. Groups will report their findings to the class.

• Cleaning and Dressing Fish

Perhaps you will have the opportunity to go on a class fishing trip, or to obtain fish for the dissection which are suitable for cooking. For information on cleaning and dressing fish, refer to Appendix F.

## GLOSSARY

**Adipose**: Fat tissue.
**Anadromous**: A species which leaves the sea to migrate up freshwater rivers to spawn.
**Barbel**: A tactile sense organ that is a threadlike growth from the jaw of some fish.
**Broodstock:** Adult fish retained for spawning.
**Caudal**: Referring to the tail.
**Caudal Peduncle**: The nerve bundle from the tail region of a fish.
**Circuli**: A ridge on a scale which can take many forms; often used in aging fish.
**Cteni**: Small sharp spines on the comb-like edge of a ctenoid scale.
**Dorsal**: Referring to backside.
**Fertilization**: The union of sperm and egg.
**Food Chain**: The transfer of energy from one organisms to another in the form of food.
**Fry**: The stage in a fish's life from the time it hatches until it reaches 1 inch in length.
**Ganoid**: Diamond-shaped scales that are connected to one another by joints.
**Grade**: To sort fish by size.
**Groundfish**: A marine bottom fish of commercial importance.
**Hatchery**: Location where fish are raised from fertilized egg to juvenile.
**Incubation**: Process by which eggs are placed in a favorable environment form hatching.
**Native**: Species which have historically lived and reproduced in a particular area.
**Operculum**: Gill cover.
**Parr**: A life history stage which marks the first year of a salmonids life cycle.
**Placoid**: Primitive, tooth-like scales found on sharks, so small that they give the shark a sandpaper texture.
**Salmonid**: Taxonomic fish group which contains salmon and trout.
**Smolt**: A life history stage which marks a juvenile salmonid's physiological transformation to life in a marine environment.
**Spawn**: The mating of male and female organisms to produce offspring.
**Superchill**: The low temperature at which a particular species of fish dies.
**Yolk Sac**: Source of nutrition for fish immediately after hatching.

## ADDITIONAL RESOURCES

Atlantic Salmon Federation. *Fish Friends: A Curriculum Supplement for Grades 4, 5 & 6.* St. Andrews, NB: Armour & Associates and Gaynor/Sarty, Huntsman Marine Science Centre, 1995.

Franzen, Nathan and Mark Wiley. *Atlantic Salmon Teaching Guide.* St. Andrews, NB: Atlantic Salmon Federation, 1991.

Iversen, Edwin S. and Kay K. Hale. *Aquaculture Sourcebook: A Guide to North American Species.* New York: Van Nostrand Reinhold, 1992.

Maine Department of Marine Resources. *ABC Fish of the Gulf of Maine.* Augusta: DMR-Education Division, 1987.

National Film Board of Canada. *The Atlantic Salmon* (film). Cat. no. 106C-0178-501.

Northeast Fisheries Science Center. *Status of the Fishery Resources Off the Northeastern United States.* NOAA Tech. Memorandum NMFS-NE-108. Woods Hole, MA. Jan. 1995.

Swift, Donald R. *Aquaculture Training Manual.* Cambridge, MA: Fishing News Books-Blackwell Science Publications, 1993.