

A Teacher's Guide to Marine Life of the Gulf of Maine

Maine Department of Marine Resources
Education Division

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Sea Anemone (*Metridium senile*)



Classification: Phylum: Cnidaria (Coelenterata); Class: Anthozoa

Description: These soft tubular bodied animals live attached to a solid substrate by a muscular pedal disc. They are orange to yellowish brown in color and have up to one thousand tentacles around their mouth.

Habitat: These organisms are found intertidally and subtidally from the Arctic south to Delaware Bay. They are commonly found in deep tidal pools or attached to pilings, rocks and the shells of hermit crabs.

Movement: These animals appear to be sessile but are capable of limited movement. Anemones use their muscular pedal disc to creep along the bottom.

Respiration: Gas exchange is accomplished by direct diffusion through the body wall.

Ingestion: Sticky tentacles, which surround the mouth, trap the anemone's food. The tentacles are drawn into the mouth where the particles are removed and passed to the digestive gut or gastrovascular cavity.

Growth: The body column of this anemone can grow to be four inches in height and three inches in width. Anemones are capable of regenerating aged or damaged body parts. They can live indefinitely if they are well fed and their environment remains healthy.

Excretion: These animals have only one entrance to their body. If something can not be digested, it is passed back out of their mouth.

Nervous System: A primitive system called a nerve net coordinates their body functions. They do not have any specialized sense organs but sensory cells exist in both tissue layers (ectoderm, endoderm).

Circulation: There is no independent circulatory system. The coelenteron serves in this role by circulating nutrients through the body and expelling waste products through the mouth.

Reproduction: Anemones may be sexual or asexual. Asexual development is usually accomplished by fission of the body column or fragmentation of the pedal disc. Sexual individuals may be either hermaphroditic or unisexual. The eggs are fertilized internally or externally, and hatch into free swimming planular larvae.

Common Names: "fringed anemone," "frilled anemone"

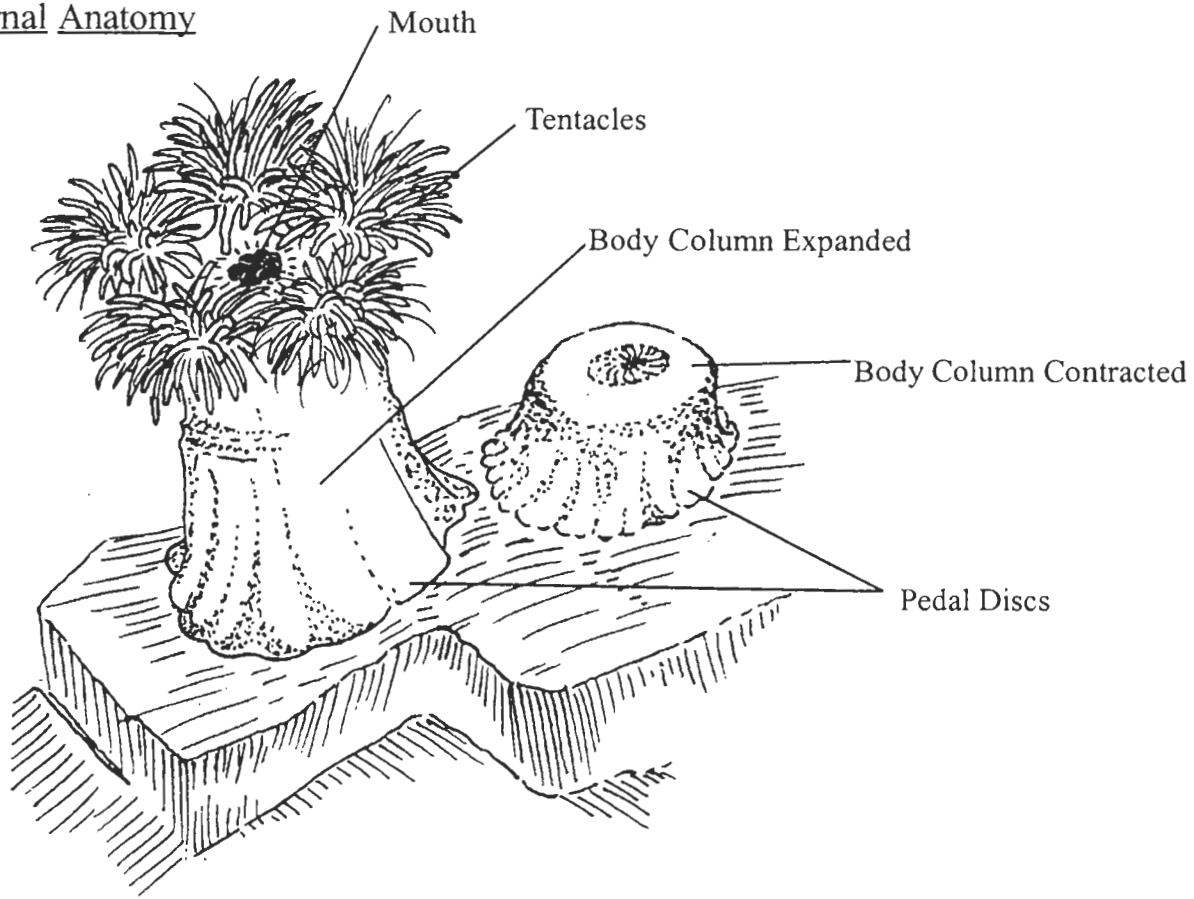
Predators: Certain types of sea slugs or nudibranchs feed upon sea anemones.

Commercial Value: None

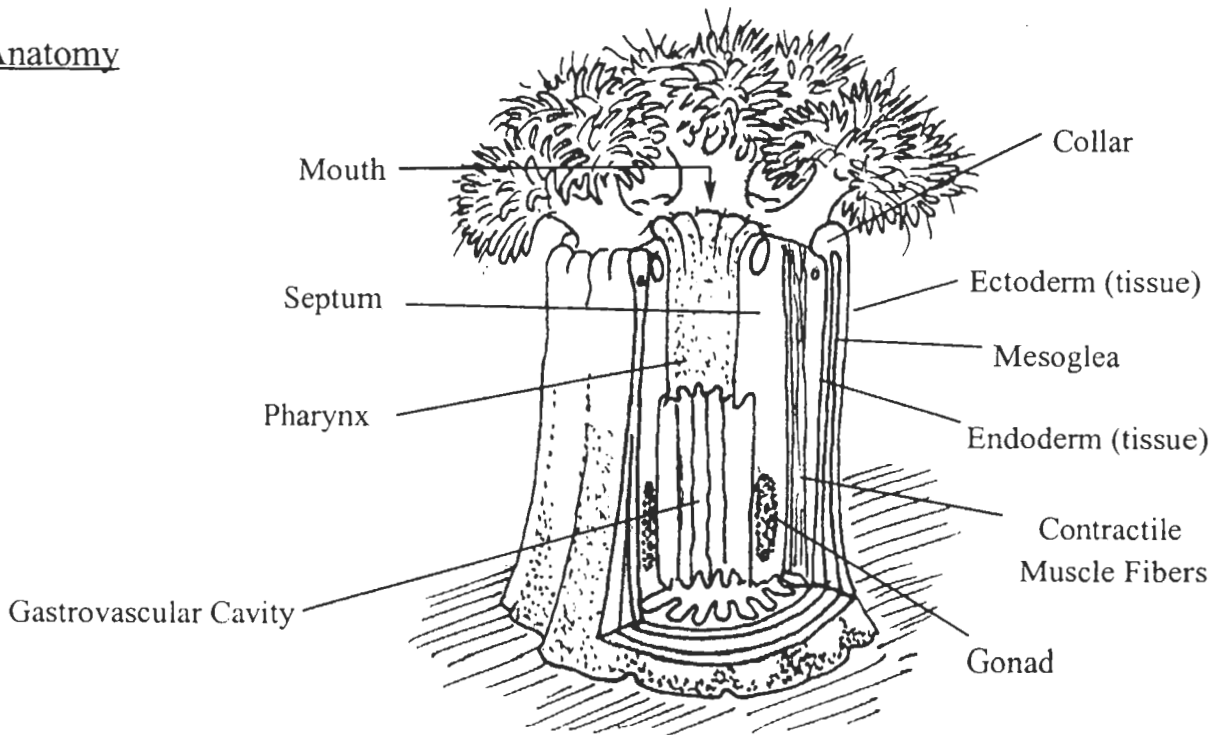
Other Gulf of Maine Species: Burrowing anemone (*Cerianthus borealis*), Ghost Anemone (*Diadumene leucolena*), Striped Anemone (*Haliplanella luciae*), Silver-spotted Anemone (*Bunodactis stella*) and Northern Red Anemone (*Tealia felina*)

Sea Anemone

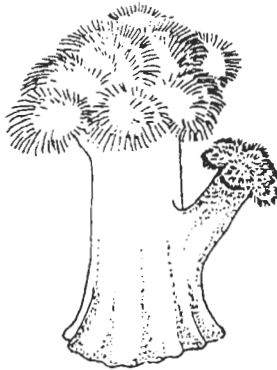
External Anatomy



Internal Anatomy

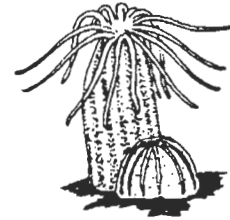


Gulf of Maine Species of Anemones



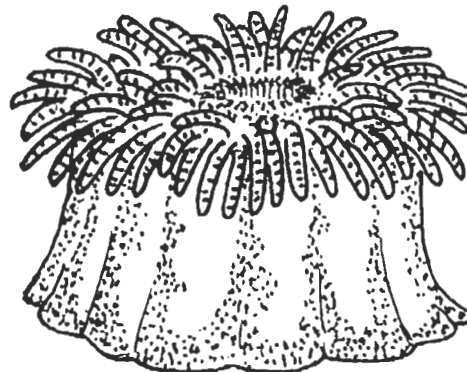
Frilled Anemone
(*Metridium senile*)

- column smooth and orange-brown
- up to one thousand fine tentacles
- commonly found on wharf pilings, in rock crevices, and in tide pools
- grows to four inches tall
- found from the Arctic south to Delaware Bay



Striped Sea Anemone
(*Haliplanella luciae*)

- column dark green with whitish or light vertical stripes
- up to fifty tentacles
- found on rocks and pilings intertidally and in estuaries
- grows to almost one inch tall
- found from Maine to Chesapeake Bay



Northern Red Anemone
(*Tealia felina*)

- column smooth and deep wine-red in color and often streaked with green
- short, thick, blunt tentacles that are usually banded with 1 or 2 dark rings
- height is 1/2 of its width which is two to three inches
- commonly found intertidally from sub-Arctic to Casco Bay

Sea Anemone Activities

1. Observations of a live sea anemone
 - a) Carefully place a live sea anemone in a container of water. Allow it to settle in for a few minutes.
 - b) Observe and describe its size, color, shape and protective adaptations.

2. Explorations
 - a) How does a sea anemone eat?
 - Using an eyedropper, place some brine shrimp near the tentacles of the anemone. Observe and describe how it catches its food.
 - Drop a small piece of clam into a sea anemone's tentacles. Observe and describe what happens.

 - b) How does a sea anemone protect itself?
 - Gently touch the anemone with a pencil. What happened? This action is a form of protection as it now appears to be a lifeless blob.

3. Model of a sea anemone
 - a) Wrap a layer of colored tissue paper around a toilet paper roll and tuck in the ends.
 - b) Cut three layers of colored tissue paper in a circle six inches in diameter.
 - c) Punch two holes in the center one inch apart and reinforce the holes of all of the sheets.
 - d) Cut 1 1/2 inch slits into the border of the circle like the spokes of a wheel.
 - e) Thread a twelve inch string through the holes and tie it off.
 - f) Insert the string through the roll and pull the string to withdraw the tentacles.

4. Studying nematocysts on a sea anemone's tentacle
 - a) Remove a tentacle from a live sea anemone using a pair of scissors. Place the tentacle on a microscope slide with a few drops of seawater and add a coverslip.
 - b) Examine the tentacle with a compound microscope. Did some of the nematocysts discharge? How do the undischarged nematocysts (inside of the football-shaped cnidoblasts) differ from the discharged ones?
 - c) Nematocysts will discharge in response to chemical and mechanical stimuli. Test the response to these solutions: 10% acetic acid, methyl blue stain, 30% NaCl, distilled water and clam extract. Use a separate slide when testing each solution. Place the solutions just to the left side of the coverslip and draw through by placing a paper towel on the right side.

5. Research
 - a) The sea anemone's symbiotic relationship with a hermit crab.
 - b) In the tropics, why is the clownfish not stung by the anemone with which it lives?
 - c) Compare the lifestyle of the sea anemone with that of its Maine relatives; jellyfish, comb jellies and hydroids.
 - d) Compare the lifestyle of the sea anemone with that of its tropical relatives; Portuguese Man-of-War and coral.

Bloodworm (*Glycera dibranchiata*)



Classification: Phylum: Annelida; Class: Polychaeta

Description: Bloodworms are pale creamy pink segmented worms with small fleshy projections called parapodia. Their pale skin allows their red body fluid to show through, hence, the name "bloodworm." Their anterior end has a small tapered head with four small antennae.

Habitat: These worms burrow into the sandy-mud or silty-clay of the intertidal and subtidal regions. They can tolerate low levels of oxygen in the substrate as well as minimum salinity.

Movement: Bloodworms are excellent burrowers utilizing their proboscis and short, stiff parapodia. During the winter months, they redistribute by swimming to another area, thus repopulating a flat.

Respiration: Each parapodia has two finger-like gills where gases are exchanged with their body fluid.

Ingestion: These worms have a large eversible proboscis armed with four hollow fangs which are connected to poison glands. These fangs impale and kill their prey and can inflict a painful bite to unwary humans.

Growth: Bloodworms can grow up to fifteen inches in length. Their rate of growth is affected by the availability of food, temperature and salinity.

Excretion: Liquid wastes are eliminated from each segment via tube-like structures called "nephridia." The nondigestible solids are packaged within fecal pellets and regurgitated.

Nervous System: The anterior brain is connected to a large ventral nerve cord. This cord runs from the anterior to the posterior end of the worm.

Circulation: These worms do not have a highly developed circulatory system. Coelomic fluid containing hemoglobin is circulated by peristaltic body movements.

Reproduction: During the middle of June, the water temperature and tidal stage initiate the spawning process of the sexually mature worms. They swim to the surface of the water where the males emit sperm and the females burst releasing their eggs. Both sexes of worms die soon after spawning.

Common Names: "beak thrower"

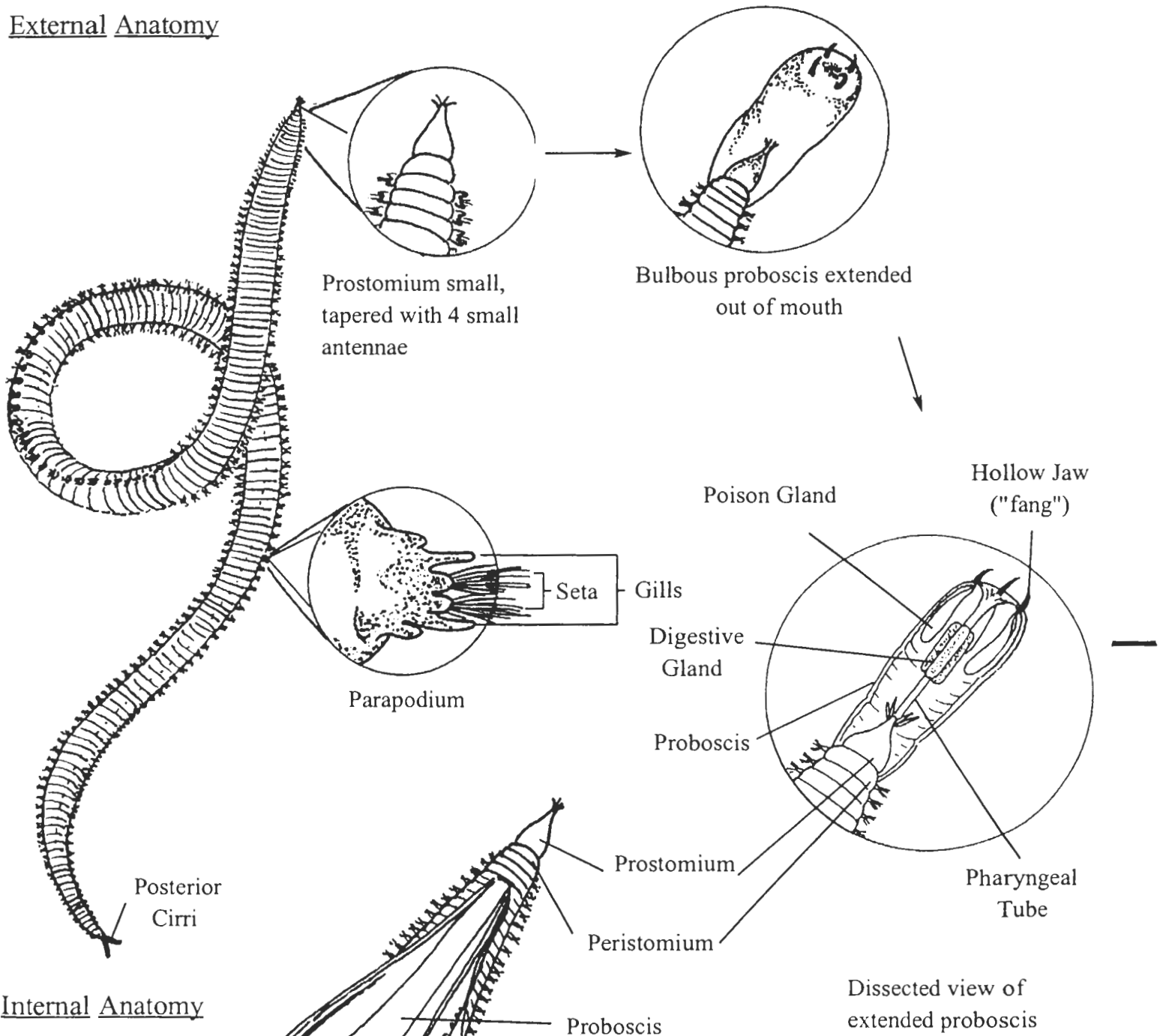
Predators: They are preyed upon by carnivorous worms, crustaceans and fish.

Commercial Value: Dollar per pound, bloodworms are one of Maine's most valuable marine resources. The 2002 landing was 682,994 pounds valued at \$5,759,384.

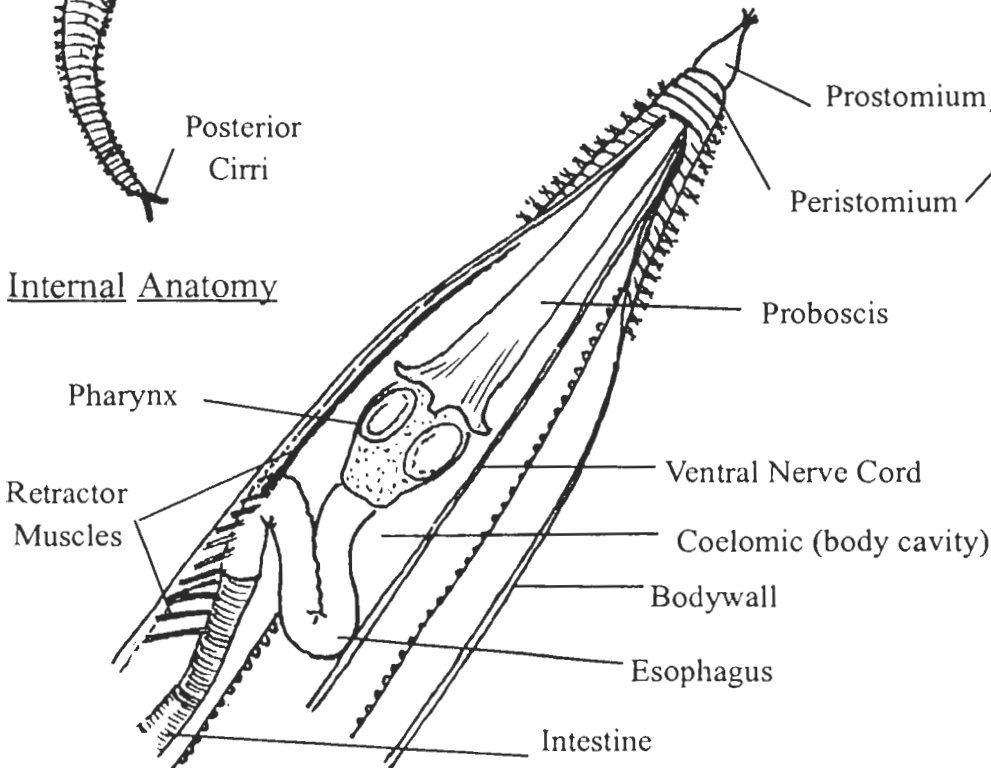
Other Gulf of Maine Species: Sand worm (*Nereis virens*), Lugworm (*Arenicola marina*), Terebellid worm (*Amphitrite johnstoni*), Scale worms (*Harmothoe* species) and Trumpet worm (*Pectinaria gouldii*)

BloodWorm

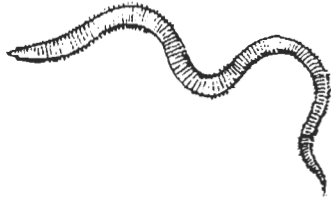
External Anatomy



Internal Anatomy

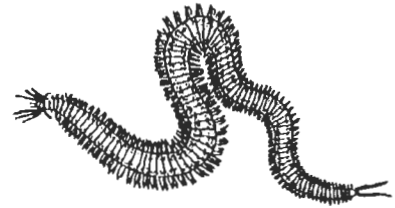


Gulf of Maine Species of Worms



Bloodworm
(*Glyceria species*)

- pale, translucent body with small parapodia
- small, tapered head with four tiny antennae
- large, eversible, bulbous proboscis with four small black fangs that give a painful bite
- fast burrower into the mud
- found mid to lower intertidal zone
- prized bait worm



Sandworm
(*Nereis species*)

- opalescent green and coppery-brown in color
- well developed parapodia
- head has four to five pair of tentacles
- eversible proboscis has a pair of large, sickle like jaws
- found upper intertidal zone
- used as a bait worm



Lugworm
(*Arenicola species*)

- large worm with three body regions; a small contractible head, a robust trunk and a long, thin tail
- head lacks appendages
- paired gills and minute parapodia on trunk region
- eversible proboscis with papillae
- intertidal making U-shaped burrows
- extrudes coiled castings near burrow opening

Trumpet Worm
(*Pectinaria gouldii*)

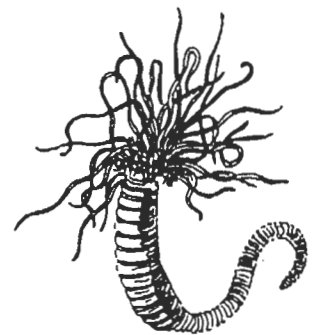


- flattened head possesses a fan of golden setae
- lives in a cone-shaped tube of cemented sand
- cone about two inches in length
- mostly buried with tip of cone exposed
- found intertidally to subtidally at shallow depths
- found in estuaries



Scale worm
(*Lepidonotus squamatus*)

- twelve to thirteen pairs of scales
- shades of brown, often mottled or spotted
- rolls up like a pill bug when disturbed
- lower intertidal and subtidal on all sorts of bottoms except mud
- also found in estuaries



Terebellid worm
(*Amphitrite johnstoni*)

- body tapered and divided into two regions
- head with numerous tentacles
- red, tree-like gills behind the tentacles
- form soft sand or mud tube
- lie buried in the substrate with the tentacles exposed for feeding

Bloodworm Activities

1. Observations of a live bloodworm.

- a) Place a live bloodworm in a container of seawater.
- b) Observe and describe its size, color, symmetry and protective adaptations.
- c) How does it move? Use a hand lens to study the sides of its body for specialized structures. These paddle-like appendages on each side of every segment categorizes it as a polychaete (*poly* means many and *chaete* means bristles).
- d) Notice that the body is divided into segments similar to its land cousin, the earthworm.

2. Digging worms

- a) A trip to the mud flats is an experience that will not be forgotten. Be sure to wear tight boots or a pair of old sneakers for your feet. A complete change of clothes is highly suggested, as well as a garbage bag to take home your muddy clothes.
- b) Locate small holes on the surface of the mud which may be the entrances to the worm's burrow. The presence of piles of mud balls called castings near the opening is a sure sign.
- c) Identify the worm's mucus-lined burrow as you dig. Why is the wall of the burrow a different color from that of the mud? (The burrow receives oxygen from the surface due to the worms activities)
- d) Screen the mud with a sieve or a window screen to observe the contents of the mud. Identify and describe each type of worm that is found in the mud flat.
- e) Make the following observations about each worm: (Be aware that some worms bite.)
 - swimming technique in a bucket of water
 - crawling technique on the surface of the mud, any tracks?
 - body plain or segmented, round or flat, color(s) on top and bottom of body
 - presence or absence of parapodia (side feet or paddles)
 - tentacles and eyes on the head
 - proboscis with teeth
- f) When you have completed your observations place the worms back on the surface of the mud and record their burrowing time. Or, you may now take your bait and go fishing.

3. Experiment on the effects of temperature on the metabolic activity of worms.

- a) Obtain a bloodworm or sandworm from a mud flat or a local bait dealer.
- b) Place the worm in an observation dish or test tube with seawater. Observe the expansion and contraction of the dorsal blood vessel using a dissecting microscope. The tail end of the worm provides a more obvious beat for determining the pulse rate.
- c) Prepare water baths of varying temperatures. Place the observation chamber with the worm into these baths. Allow time for the water in the observation chamber to assume that of the bath. Record the pulse rate.

4. Research

- a) The bloodworm industry in the State of Maine.
- b) The use of worms in recreational fishing.
- c) How bloodworms concentrate PCB's (polychlorinated biphenals) and how it effects the food chain.
- d) The effects of the nuclear power plant "Maine Yankee" or other waterfront industry on worms.

Red Chiton (*Ischonchiton ruber*)



Classification: Phylum: Mollusca; Class: Polyplacophora (Amphineura)

Description: Red chitons are small organisms that are flattened dorso-ventrally. Their bodies are protected by eight interlocking, rectangular or wing shaped, flexible plates.

Habitat: These organisms are found on rocky bottoms in both the lower intertidal and subtidal zones. These animals are negatively phototropic, i.e. move towards darkness, and are most commonly found in crevices and under rocks. Their range extends from the Arctic to Long Island Sound.

Movement: Chitons adhere to rocks and creep using a large, flat, ventral foot.

Respiration: Several pairs of ctenidium or gills are located in their lateral mantle cavities.

Ingestion: Chitons are browsers, feeding on the algal film that encrusts intertidal rocks. They use a rasping tongue called a radula to perform this task.

Growth: These animals grow slowly, reaching a length of up to 1 1/4 inches. The largest specimens are found in the northern part of their range.

Excretion: Digestive wastes exit the body through the anus. Liquid wastes are expelled via a pair of excretory pores located in the posterior mantle cavity.

Nervous System: Chitons have a ring of nerve tissue that encircles the mouth opening. A ladder-like system of nerve fibers runs from this ring to the posterior. Light sensitive cells are found along the edge of the girdle.

Circulation: Like most mollusks, the circulatory system is simple and open. The heart is located on the dorsal posterior side of the body beneath the seventh and eighth plates of their shell. Blood is pumped to the body's organs via an anterior aorta.

Reproduction: The sexes are separate but indistinguishable. Fertilization is external and the young develop into trochophore larvae before settling to the bottom.

Common Names: "sea cradle" and "chain of mail shell"

Predators: Carnivorous marine snails and sea stars prey on chitons.

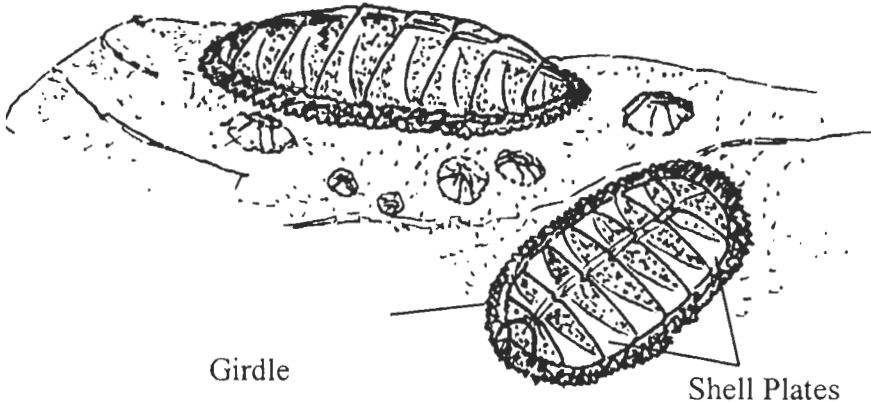
Commercial Value: None

Other Gulf of Maine Species: White Chiton (*Ischnochiton albus*), Bee Chiton (*Chaetopleura apiculata*) and Mottled Chiton (*Tonicella marmorea*)

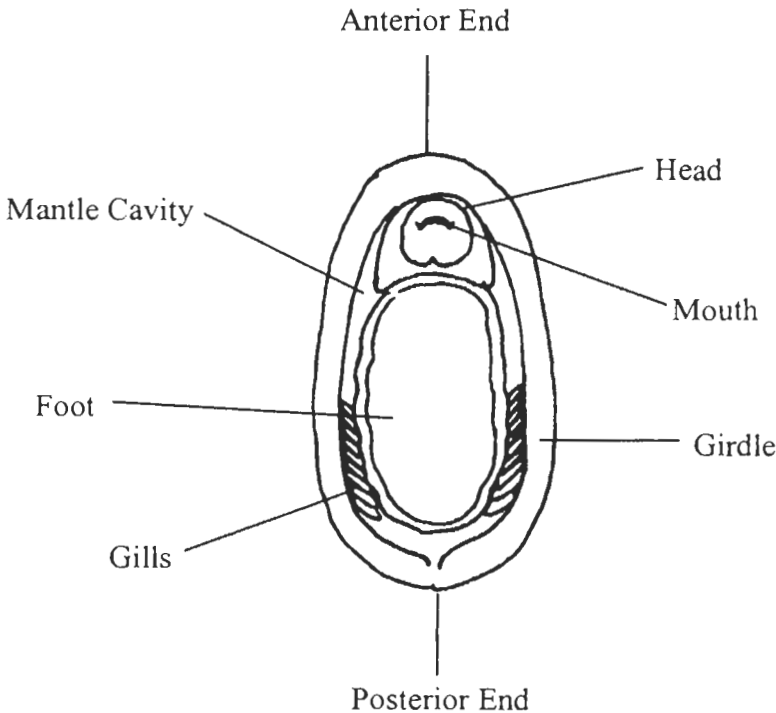
Red Chiton

External Anatomy

Dorsal View

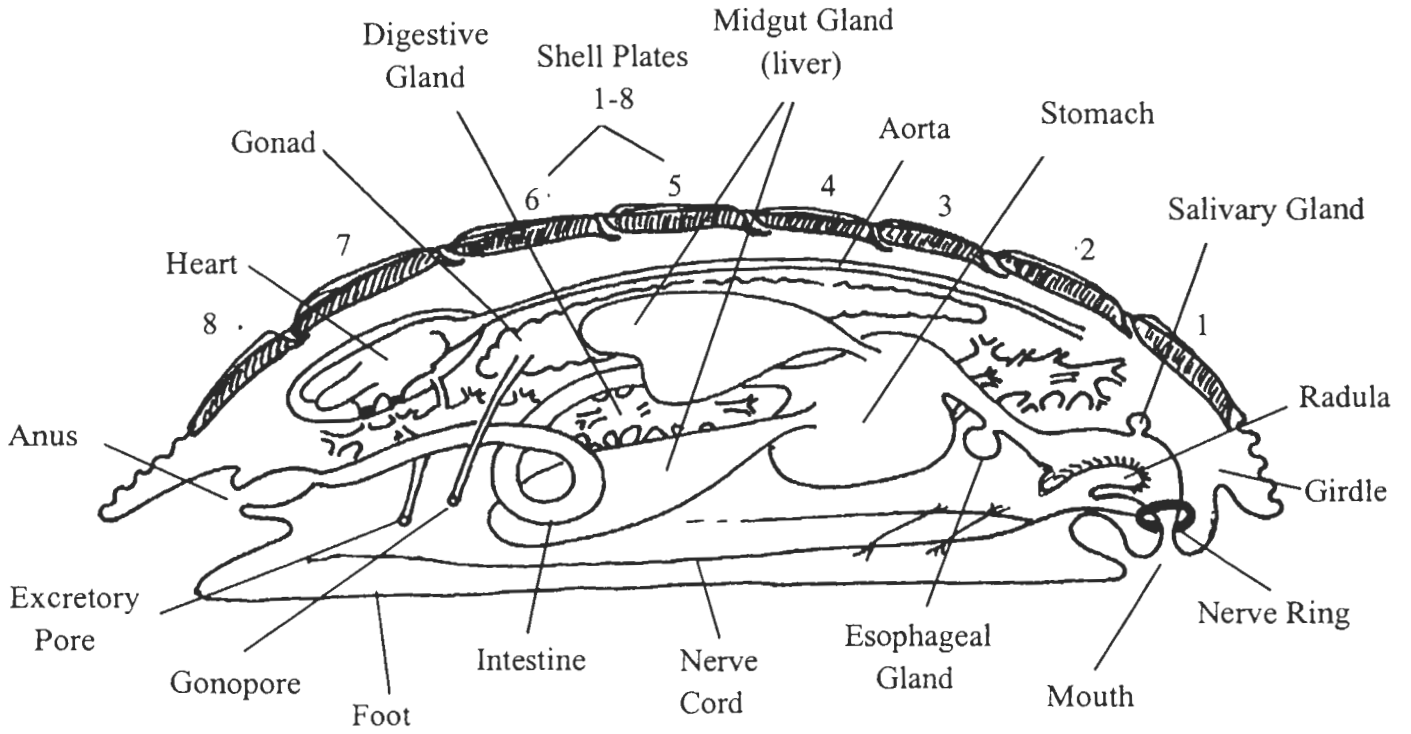


Ventral View



Chiton

Internal Anatomy



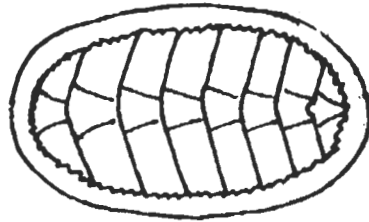
Chiton Activities

1. Observations of live chitons

- Place a live chiton in a clear container of seawater. Be sure that the water covers the chiton.
- Observe and describe its size, color, shape and protective adaptations.
- How does it move? Hold the container above your head and observe its actions.
- Can you see its mouth? What might it like to eat?
- Gently try to remove it from the bottom. What did it do? Use a knife to gently pry it off, if necessary.
- How many shell plates does it have? How would these overlapping plates help the chiton?

2. Chiton print

- Use a meat tray from the grocery store
- Using a pencil, firmly draw the outline of the chiton including its eight plates.
- Use an ink roller to apply a washable printers ink onto the surface.
- Lay a piece of paper on top and rub it with the back of your hand.



3. Tide pool diorama

- Paint a tide pool scene onto a piece of corrugated cardboard. This will serve as the base for a three dimensional diorama where poster board tags of plants and animals will be placed.
- Draw (or glue) pictures of intertidal plants and animals to the tags. On the back of each tag, give a description of each organism. Example: Chiton - I have eight overlapping plates which allows me to roll up like an armadillo.
- Place all of the tags into slots cut into the cardboard base.

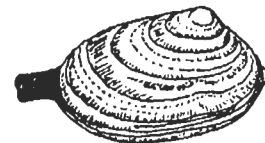
4. Stuffed chiton

- Draw and cut out two outlines of the chiton. These will become the top and bottom surfaces.
- Draw and color the details of its eight plates on the top piece.
- Staple the edges of the chiton leaving a space where you will be able to stuff it with newspaper.
- Finish off the remaining edges with staples.

5. Name connection

- Often times it is difficult to remember the names of certain marine organisms. Why not connect its name with that of your students?
- Examples: Kyla chiton, Linda limpet, Joey Jellyfish, etc.

Soft-shell Clam (*Mya arenaria*)



Classification: Phylum: Mollusca; Class: Bivalvia

Description: Soft-shell clams are elongated, thin-shelled bivalves. Their shells vary in color from white to dark grey according to their habitat. They have a long, extendable siphon or "neck."

Habitat: These clams are found intertidally and subtidally from subarctic areas to the Carolinas.

Movement: Soft-shell clams can burrow into the mud up to two and half times their shell length by using their muscular foot. This hatchet-shaped foot works best when the clam is small.

Respiration: These clams have two pairs of gills in their mantle cavity. These gills exchange gases and assist in the ingestion process.

Ingestion: Their "neck" is composed of two siphon tubes. The incurrent siphon tube allows water containing microscopic plankton to enter their mantle cavity. The gills trap and transport food toward the mouth using mucus and cilia. The labial palps sort and direct food to the mouth.

Growth: A fleshy membrane called the "mantle" secretes the limy shell. Thickened ridges on the shells indicate yearly growth. Thinner lines are interpreted as stress rings. Soft-shell clams can grow four to five inches in length.

Excretion: Digestive wastes exit their body by way of the anus into their excurrent siphon tube. Liquid wastes are removed by the excretory gland and eliminated through a pore into the mantle cavity and out the siphon.

Nervous System: The nervous system consists of three nerve centers connected by two pair of nerves. The margin of their mantle is the principal location of the clam's sensory cells.

Circulation: Their chambered heart pumps blood through a system of blood vessels that empty into sinuses surrounding the body organs.

Reproduction: The gonad can be found in the visceral mass. Reproduction takes place when male and female clams release sperm and eggs into the water. Fertilized eggs develop into free-swimming larvae before settling to the bottom.

Common Names: "steamer," "long-neck," "squirt clam," "belly clam," "nannynose" and "gaper"

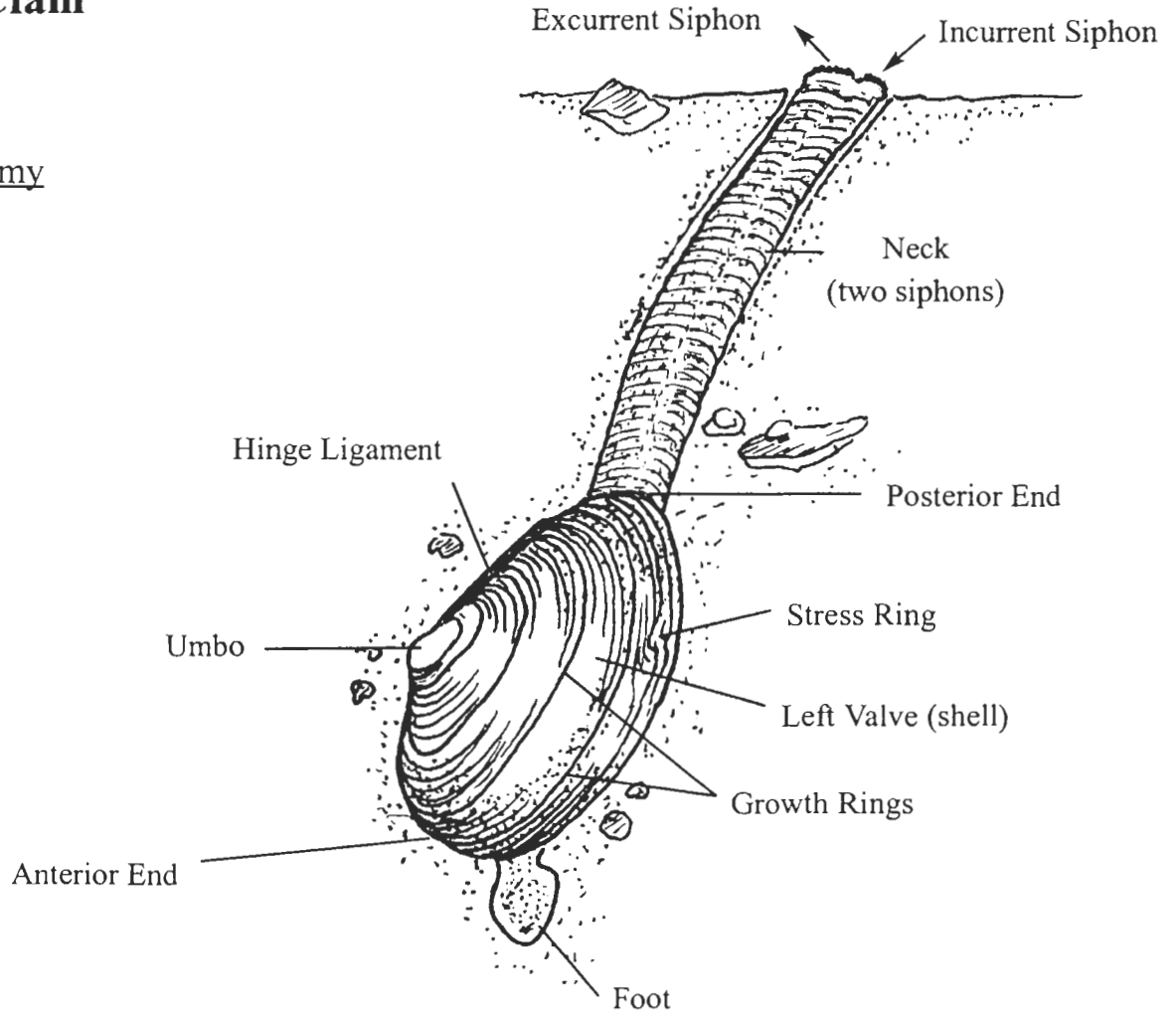
Predators: They are preyed upon by green crabs, sea stars, birds, fish, whelks, lobsters and humans.

Commercial Value: In 2002, 2,497,607 pounds of clams were harvested at a value of \$14,872,417.

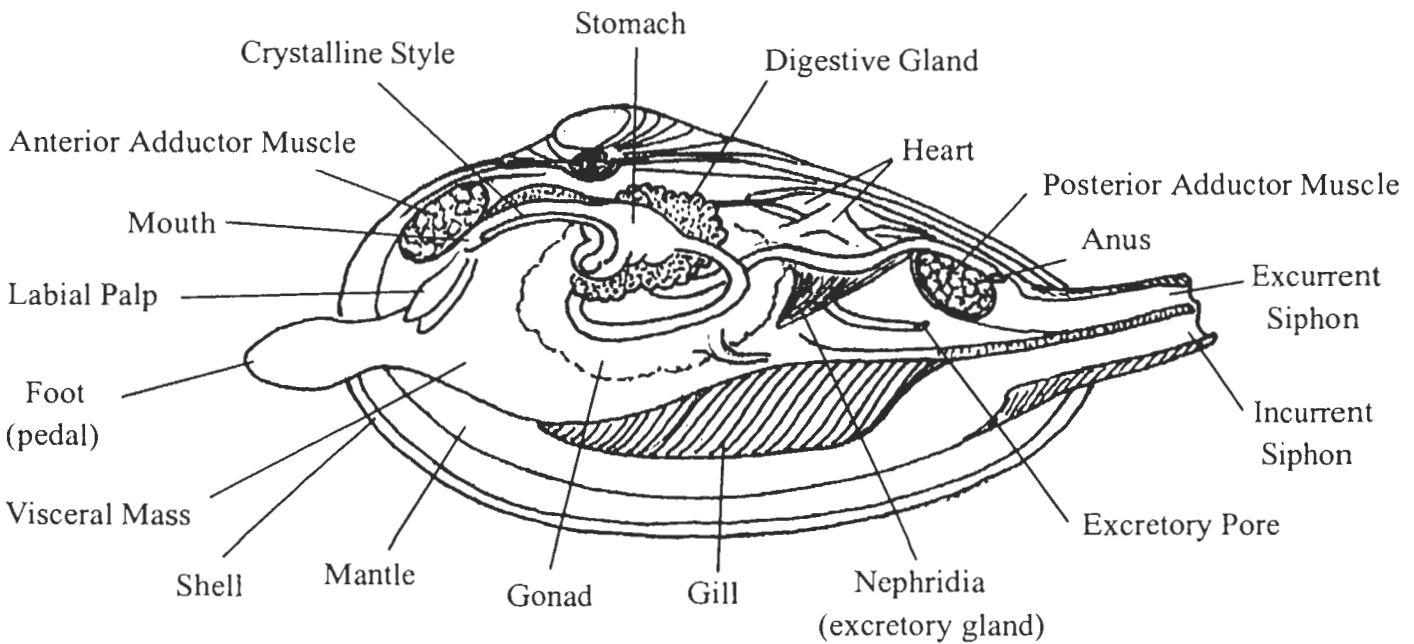
Other Gulf of Maine Species: Razor Clam (*Ensis directus*), Quahog (*Mercenaria mercenaria*), Ocean quahog (*Arctica islandica*) and Surf Clam (*Spisula solidissima*)

Soft-shell Clam

External Anatomy



Internal Anatomy

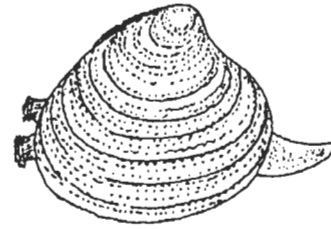


Gulf of Maine Species of Clams



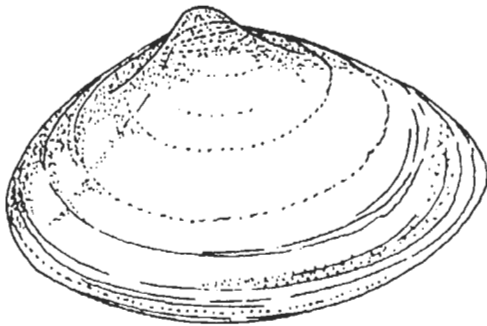
Soft-shelled Clam
(*Mya arenaria*)

- white, elongated, thin shell
- often called "steamers"
- found intertidally in mud flats
- harvested commercially



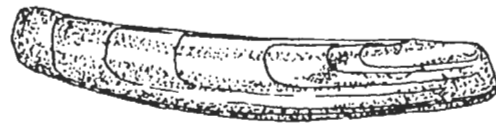
Hard-shelled Clam
(*Mercenaria mercenaria*)

- thick, white shell with a purple edge on the inside
- commonly called "Quahog" in New England
- found intertidally and subtidally in sand or muddy sand
- harvested commercially
- Indian's used this shell to make wampum.



Surf Clam
(*Spisula solidissima*)

- large clam that grows to eight inches
- white shell is somewhat triangular
- sometimes called a "hen" clam
- found in the very low intertidal zone or subtidally along beaches
- meat is canned or used in clam cakes



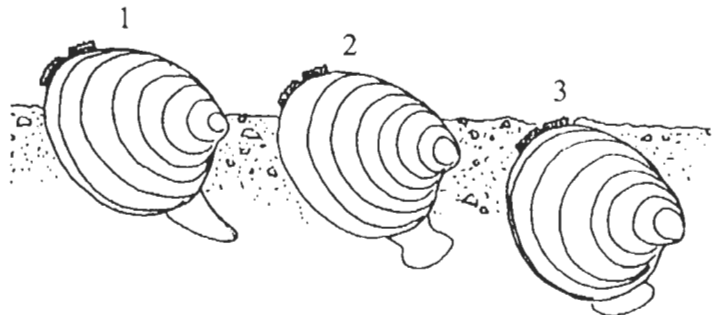
Razor Clam
(*Ensis directus*)

- fragile shell measuring up to ten inches in length
- sometimes called a "jackknife" clam
- found in the low intertidal zone and subtidally in sandy-mud bottoms
- burrow quickly and deeply into bottom substrate



Baltic Macoma Clam
(*Macoma balthica*)

- small, oval clam measuring up to 1 1/2 inches in length
- mud dwellers in shallow quiet bays



Clam's Method of Burrowing

The clam pushes its muscular foot into the sand or mud. Blood entering the foot causes it to swell and form a hatchet-shaped anchor. The foot muscles contract pulling the clam down into the substrate.

Clam Activities

1. Observations of live clams

- a) Obtain soft-shell clams ("steamers") from your local fish market or supermarket. (keep refrigerated)
- b) Place the clams in a container of seawater. Observe and describe their size, color, shape, shell etc.
- c) Pick up the clams and touch their black "neck" with your finger. What did they do?

2. Comparing different species of clams

- a) Pass out different kinds of clam shells such as: soft-shell, quahog, razor, hen and mahogany clams.
- b) Have the students trace around each shell on a piece of paper.
- c) Use a field guide to identify the different species of clams.
- d) Write the name and characteristics about each clam within its traced outline.

3. Explorations

- a) How do clams move?
 - Place sand in the bottom of a container and add seawater.
 - Observe a small clam as it attempts to burrow itself into the sand. How does it perform this task?
- b) How do clams eat?
 - Place a clam, siphon end up, in a container of sand. Add seawater to the container.
 - Add a drop of concentrated red food coloring near the siphon. Observe the movement of the dye.
 - Where was the water drawn into the clam? Where was it expelled from the clam?
- c) Raising soft-shell clams in the classroom
 - Juvenile clams are available from Beals Island Regional Shellfish Hatchery, Beals, ME 04611. (207) 497-5769. They will provide you with instructions on how to set up the proper apparatus for rearing them in the classroom.
 - Design and conduct your own growth studies on clams.

4. Reseed an area of a mud flat

- a) Submit your plan and site to the Department of Marine Resources for approval.
- b) Obtain juvenile clams from the Beals Island Regional Shellfish Hatchery.
- c) As the tide is coming in, gently toss the clams on the surface and they will burrow in to the correct depth. Be aware that sea gulls will feast on these clams if they are exposed for a long period of time.
- d) Use fixed reference points to identify your reseeded area, if you wish to return for further studies.

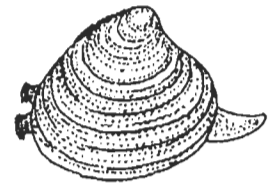
5. Art Activities

- a) Make a mobile with clam shells.
- b) Rubbings of clam shells will identify growth rings.
- c) Glue ocean treasures inside of a clam shell for use as a Christmas ornament.

6. Research

- a) Management plans practiced by the State of Maine and those of local municipalities.
- b) Paralytic Shellfish Poisoning (PSP) and how it is monitored in the State of Maine.
- c) Depuration plants which purify clams taken from polluted mudflats.
- d) What has been the commercial harvest & value of clams in Maine over the past 50 years?

Quahog (*Mercenaria mercenaria*)



Classification: Phylum: Mollusca; Class: Bivalvia

Description: These hard-shelled clams are characterized by thick rounded white shells. The inside of each shell has a rich purplish tinge to the posterior surface. These clams have a reduced siphon as compared to the soft-shell clam. "Quahog" is most commonly pronounced 'coe-hog'

Habitat: These clams inhabit sandy mud bottoms from the intertidal zone to subtidal depths of about sixty feet. They are found from the Gulf of St. Lawrence to the Gulf of Mexico.

Movement: These clams burrow just below the substrate's surface by use of their anterior foot.

Respiration: Gas exchange is accomplished by two pairs of gills located in their mantle cavity.

Ingestion: These clams are filter feeders trapping food on their mucus covered gills. This material is passed forward by cilia towards the mouth where a crystalline style draws the food into the stomach.

Growth: These clams can grow quickly in the rich organic environment of a mud bottom. Quahogs can live for several decades reaching a shell length of five inches.

Excretion: The kidney and anus excrete wastes into the mantle cavity. These wastes are then easily eliminated out the excurrent siphon into the surrounding waters.

Nervous System: There are three main nerve masses or ganglia connected by two pairs of nerve cords that coordinate the body's functions.

Circulation: Quahogs have an open system which is typical of bivalves. A dorsal heart circulates the blood to sinuses surrounding the various organs.

Reproduction: Quahogs have separate sexes. Fertilization is external as sperm and eggs are expelled into the water. Developing larvae pass through a trochophore and a veliger stage before settling to the bottom as miniature clams.

Common Names: "little neck," "hard shell," "round clam," "cherry stone," "chowder clam" and "money clam"

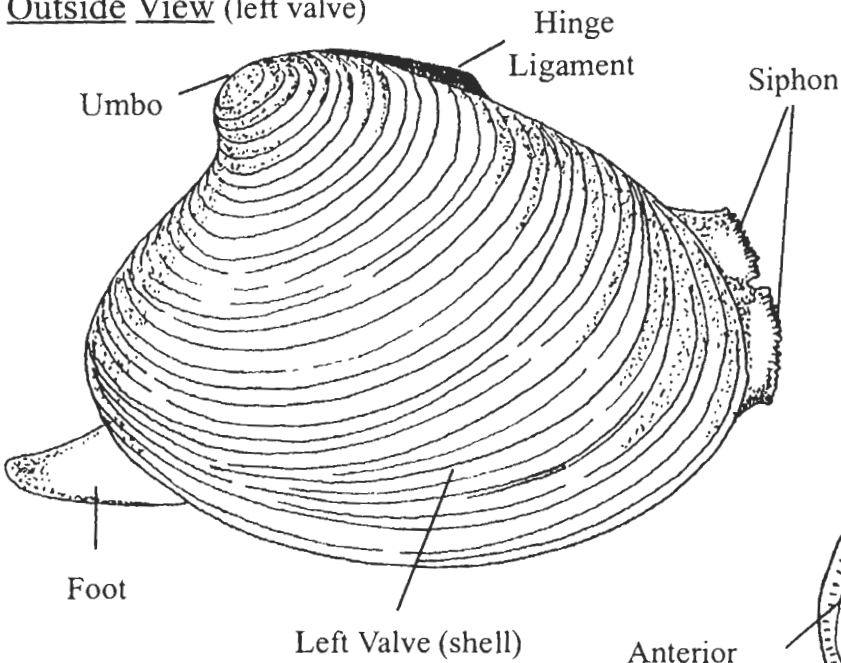
Predators: Carnivorous snails, lobsters and humans prey upon quahogs.

Commercial Value: In 2002, 6,795 pounds were landed at a value of \$47,970.00.

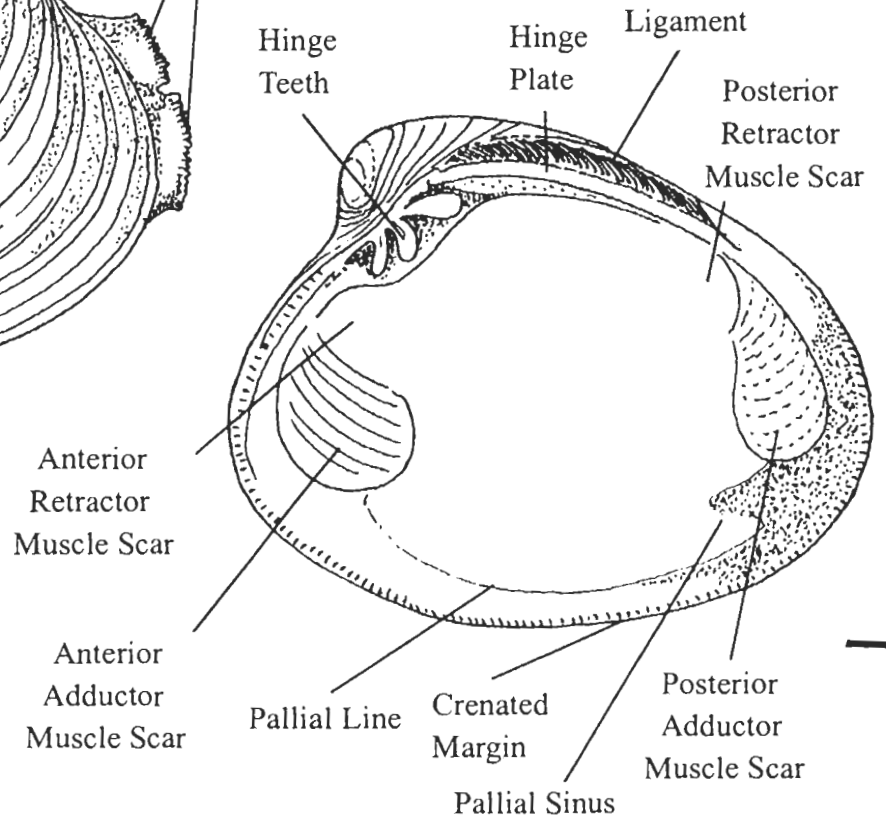
Other Gulf of Maine Species: Black or Mahogany Clam (*Arctica islandica*), False Quahog (*Pitar morrhuana*) and Surf Clam (*Spisula solidissima*)

Quahog

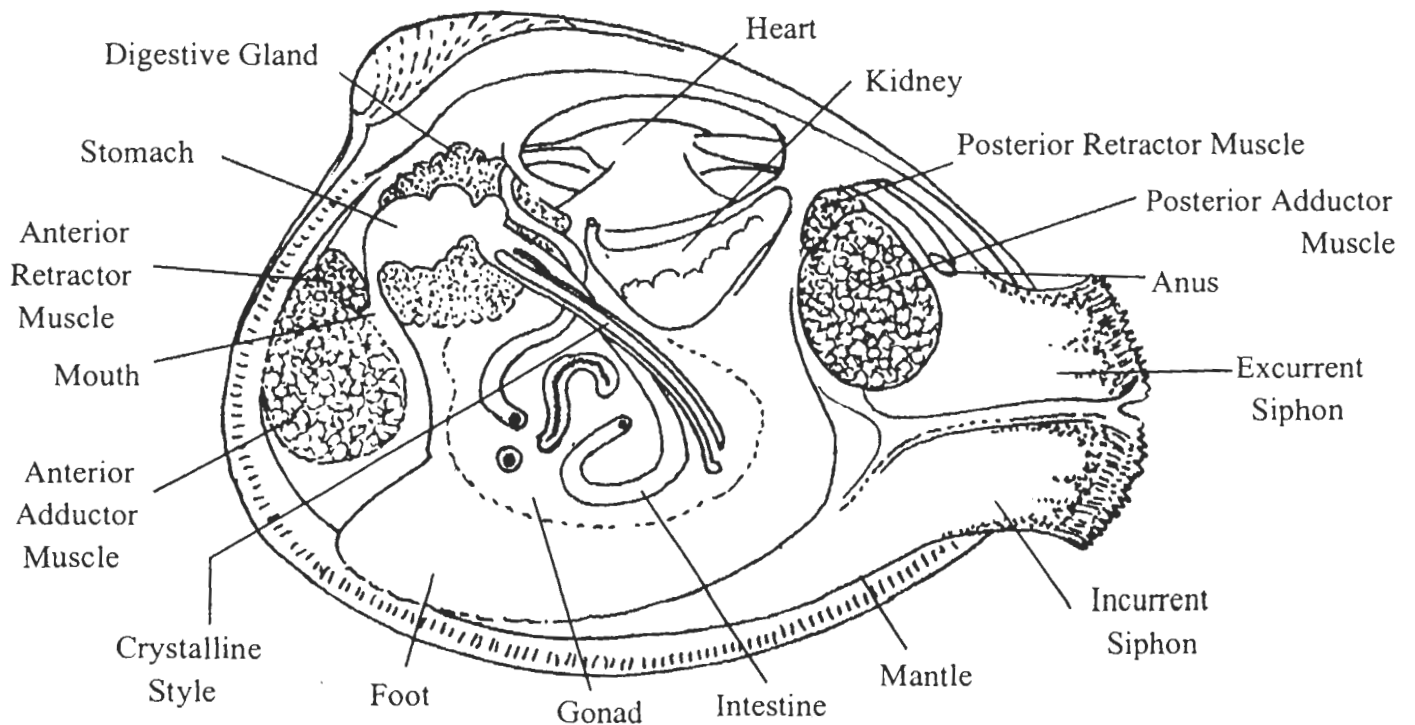
Outside View (left valve)



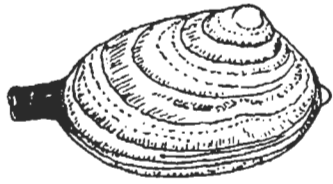
Inside View (right valve)



Internal Anatomy

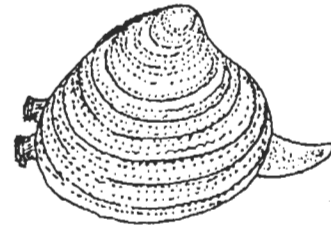


Gulf of Maine Species of Clams



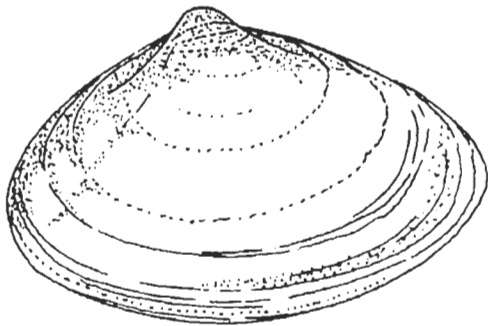
Soft-shelled Clam
(*Mya arenaria*)

- white, elongated, thin shell
- often called "steamers"
- found intertidally in mud flats
- harvested commercially



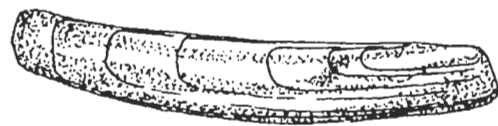
Hard-shelled Clam
(*Mercenaria mercenaria*)

- thick, white shell with a purple edge on the inside
- commonly called "Quahog" in New England
- found intertidally and subtidally in sand or muddy sand
- harvested commercially
- Indian's used this shell to make wampum.



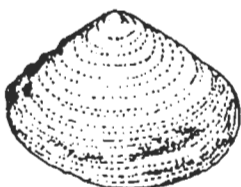
Surf Clam
(*Spisula solidissima*)

- large clam that grows to eight inches
- white shell is somewhat triangular
- sometimes called a "hen" clam
- found in the very low intertidal zone or subtidally along beaches
- meat is canned or used in clam cakes



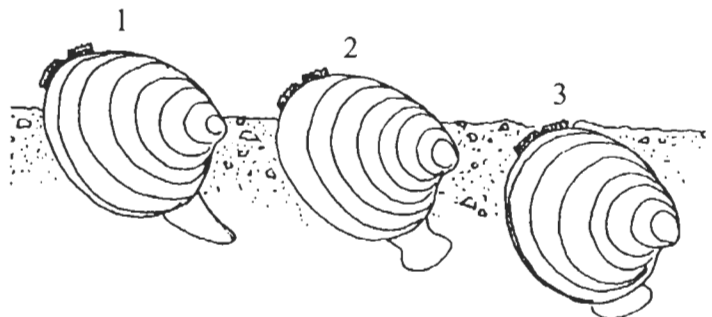
Razor Clam
(*Ensis directus*)

- fragile shell measuring up to ten inches in length
- sometimes called a "jackknife" clam
- found in the low intertidal zone and subtidally in sandy-mud bottoms
- burrow quickly and deeply into bottom substrate



Baltic Macoma Clam
(*Macoma balthica*)

- small, oval clam measuring up to 1 1/2 inches in length
- mud dwellers in shallow quiet bays



Clam's Method of Burrowing

The clam pushes its muscular foot into the sand or mud. Blood entering the foot causes it to swell and form a hatchet-shaped anchor. The foot muscles contract pulling the clam down into the substrate.

Quahog Activities

1. Observations of live quahogs

- Purchase live quahogs from a fish market or a supermarket. Be sure to keep them refrigerated.
- Place them in a clear container of seawater.
- Observe their short siphons in comparison to those of the soft-shell clam.

2. Comparison of quahogs

- Purchase various types of quahogs from the fish market or supermarket. Be sure to keep them refrigerated.
- Describe the shapes, sizes, similarities and differences of these clams.
- Commercial names for these clams are based on size: Littlenecks are to 1 1/2 inches, Cherrystones are to 2 inches and Chowders are to 3 inches. Where do your clams fit into these categories?

3. Experiment - Demonstrate the digestive action of the enzymes contained within the crystalline style.

- Remove the crystalline style (a clear, jelly-like rod) from the stomach region of the clam.
- Place the style in a mortar along with 1 ml of cool seawater. Grind it with a pestle to produce a style extract.
- Set up two series of 10 depression slides each. Add 2 drops of style extract to the each depression in the first series. Add two drops of cool seawater to the second series which will serve as the control.
- Add 1 ml of 1% starch solution to each of the twenty slides. Record the time.
- Add one drop of iodine indicator to the first slide in both series. Record the color in the chart. Repeat this process at five minute intervals with the remaining slides.

Time (min)	0	5	10	15	20	25	30	35	40	45
Style extract and starch										
Seawater and starch										

- A blue color indicates the presence of starch
 - A red-brown color indicates the presence of dextrin, the first step in the breakdown of starch.
 - No color indicates that the dextrin has been broken down into simpler sugars.
 - Record the appropriate colors in the above chart.

4. Research

- Several ways that the Native Americans used quahogs.
- The harvesting technique for these bivalves.

Blue Mussel (*Mytilus edulis*)



Classification: Phylum: Mollusca; Class: Bivalvia

Description: Blue mussels are bivalves that have two, smooth, tear-shaped, bluish-black shells. They attach themselves to almost any substrate by means of byssal fibers or threads.

Habitat: Mussels live in dense colonies or beds and are found intertidally and subtidally. Their range extends from subarctic areas to South Carolina.

Movement: Mussels are sedentary by nature. If they should become disturbed or if they develop a need to resettle, they can dissolve their byssal threads. These bivalves will use their muscular foot to relocate.

Respiration: The exchange of oxygen and carbon dioxide occurs through two pairs of gills located in the lateral mantle cavities.

Ingestion: Mussels are known to be very efficient filter feeders processing two liters of water per hour. Water containing phytoplankton enters through their incurrent siphon and is directed toward their gills. Food particles/phytoplankton are then trapped and transported by cilia to the labial palps which surround their mouth.

Growth: The mantle produces the annual rings on the shell which represent yearly growth. Mussels grow to an average shell length of two to four inches.

Excretion: Body wastes and processed water are expelled through their excurrent siphon.

Nervous System: The nervous system consists of three nerve centers connected by two pairs of nerves. The margin of the mantle is the principal location of the mussels sensory cells.

Circulation: Nutrients and oxygen absorbed into the blood are pumped by a heart through a system of vessels. These vessels transport the blood to the various sinuses throughout the body.

Reproduction: Mussels either expel sperm or eggs into the water. These gametes are released in large quantities to ensure fertilization. Development involves a planktonic stage before they settle onto the substrate.

Common Names: "edible mussel," "moules"

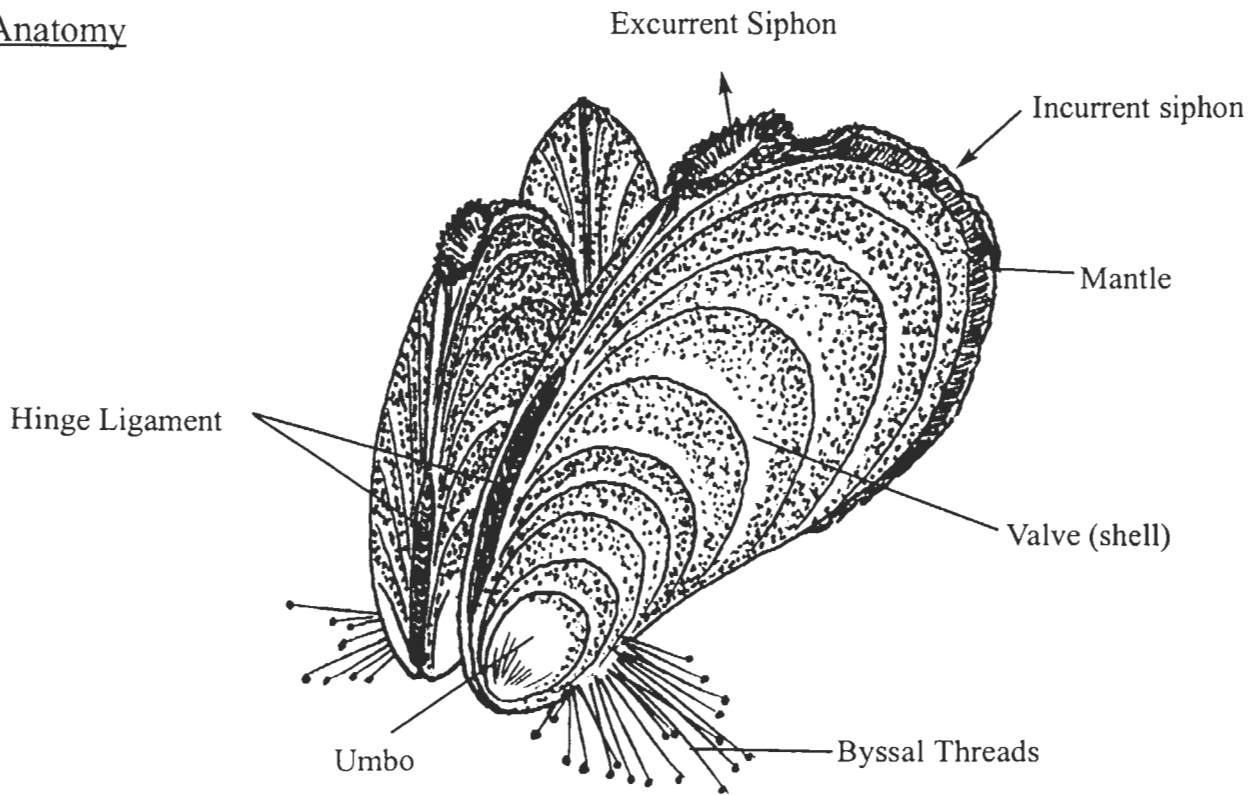
Predators: They are preyed upon by birds, fish, crabs, whelks, lobsters, sea stars and humans.

Commercial Value: The 2002 reported landings in Maine were 4,687,120 pounds having a commercial value of \$4,034,242. 10-15% were grown aquaculturally and the rest harvested from native populations.

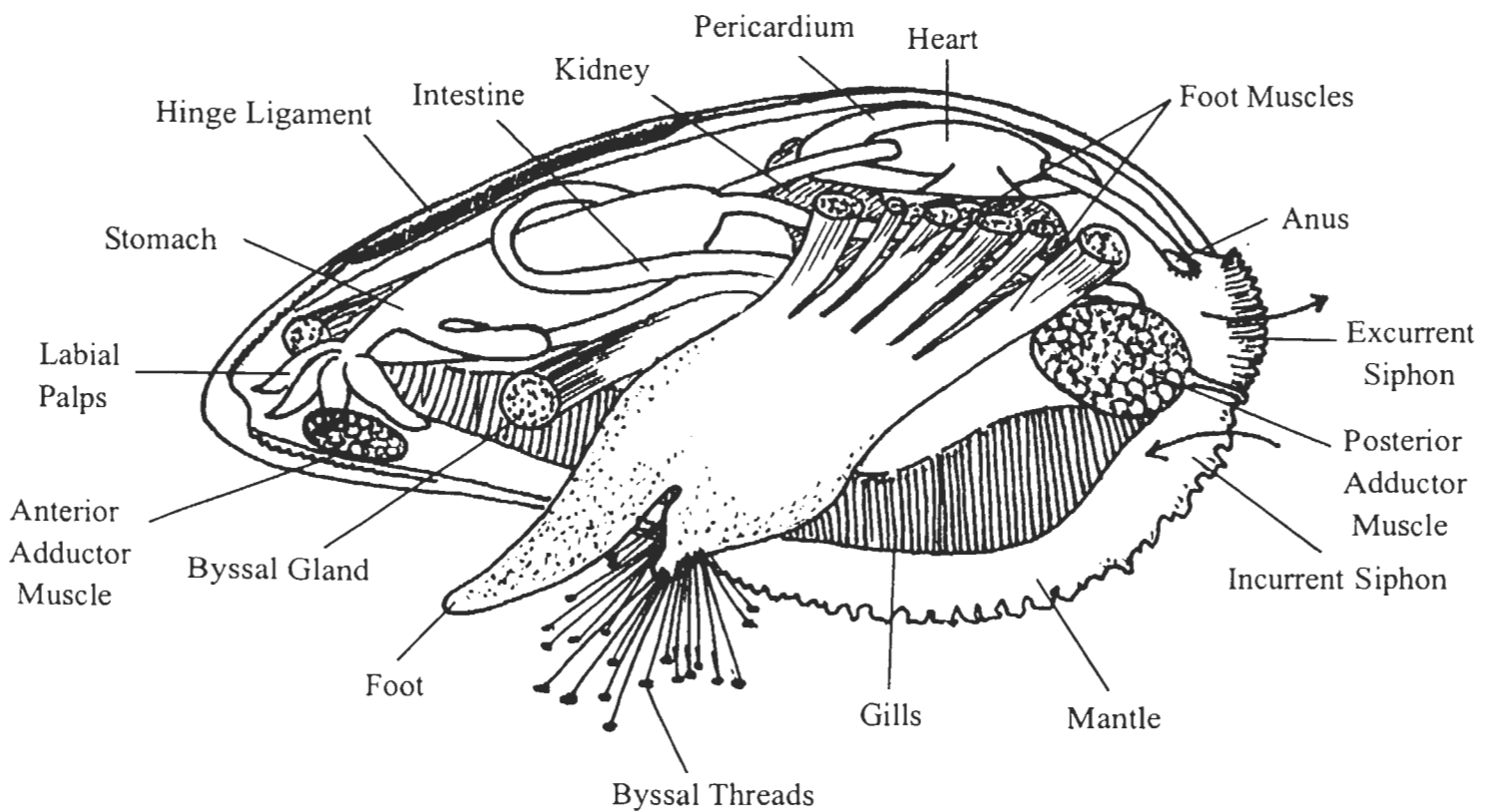
Other Gulf of Maine Species: Northern Horse Mussel (*Modiolus modiolus*), Atlantic Ribbed Mussel (*Geukensia demissa*), Pacific Mussel (*Mytilus trossulus*); small populations in Cobscook Bay

Blue Mussel

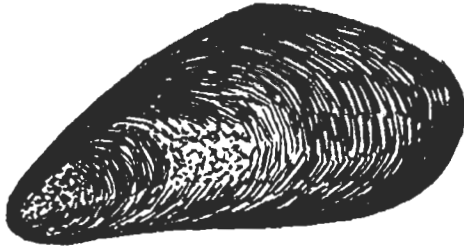
External Anatomy



Internal Anatomy

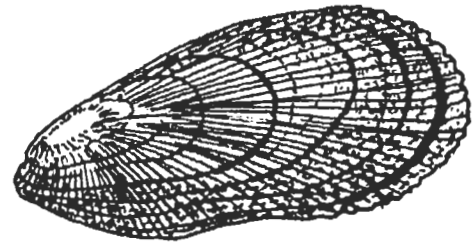


Gulf of Maine Species of Mussels



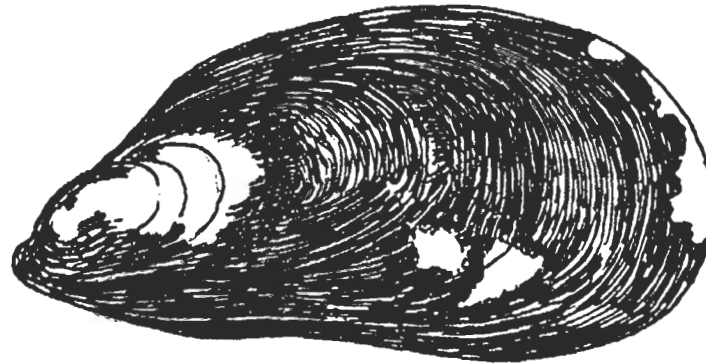
Blue Mussel
(*Mytilus edulis*)

- violet-blue shell with a bluish-black covering
- grows up to four inches in length
- umbo at the end of the shell
- often called the "common edible mussel"
- flesh tends to be cream colored
- competes with barnacles and seaweeds for intertidal space on the rocks
- raised by several aquaculturists in Maine



Ribbed Mussel
(*Modiolus demissus*)

- brittle, greenish or yellowish brown shell
- shell has numerous, rough, radial ribs
- grows up to four inches in length
- meat is less palatable as it is tough and bitter
- found living half-buried in the muddy banks of the salt marsh



Horse Mussel
(*Modiolus modiolus*)

- thick, brown shell four to six inches long
- a ragged fringe of brown outgrowths on the shell
- umbo at one side of the end of the shell
- edible but orange flesh is tough
- usually found subtidally along the rocky shore or washed ashore in the grip of kelp holdfasts

Mussel Activities

1. Observations of live mussels
 - a) Place a live mussel in a clear container of seawater. Be sure that the water covers the mussel.
 - b) Observe and describe its size, color, shape and protective adaptations.
 - c) Does it have any threads present or visible? What is the purpose of these threads?

2. Comparison of species
 - a) Obtain the shells of the three different types of mussels found in Maine; blue mussel, horse mussel and ribbed mussel.
 - b) Compare the color, size and shape of each. Use a ruler to measure the length of each.
 - c) Research the preferred habitat of each species.

3. Explorations
 - a) How does temperature effect the heart rate of a mussel?
 - Gently pry open the shells with a knife. Insert the knife between the mantle and the shell and sever the two adductor mussels. Remove one valve and place the mussel back into 15C seawater.
 - Use a dissecting microscope to observe the heart and determine its rate of contraction every two minutes.
 - Repeat the procedure with the temperature of the seawater being 10C and 20C.
 - b) Observing the microscopic cilia on the gills.
 - Using a pair of scissors, remove a small piece from the edge of a gill and mount it on a slide with a drop of seawater.
 - Observe it under a compound microscope and draw the cells of the gill edge. Describe the function of these cells.

4. Mussel mobile
 - a) Obtain whole mussel shells that are still attached at the hinge. These shells will be transformed into fish with the hinge end becoming the nose of the fish.
 - b) Cut out a dorsal fin, tail fin and pectoral fins from colored construction paper or felt cloth.
 - c) Glue these fins into their correct places as you glue the edges of the mussel shell together. Glue a piece of string between the shells as a way to suspend the fish. Wrap it with a rubber band while the glue dries.
 - d) Glue eyes in their appropriate places.
 - e) Attach the fish to a piece of wood or a coat hanger to create the mobile.

5. Christmas ornament
 - a) Using a low temperature glue gun, attach a colorful ribbon to the back of a mussel shell.
 - b) Glue a Christmas scene into the shell or a variety of ocean treasures.
 - c) Dip the shell into a can of varnish or spray it with polyurethane.

6. Mussel feast
 - a) Buy or collect about 2 pounds of blue mussels. Be sure to check for "red tide" if you are collecting.
 - b) Combine 1 cup of white wine (non-alcoholic if in school), 2 cups of water, 2 tablespoons of butter, 1 tablespoon of parsley and 1/2 teaspoon of garlic powder. Bring to a boil and cook mussels for 5 minutes. Shake and then steam for another 5 minutes until the shells are open.
 - c) Chew carefully because there may be some pearls present in the mussels.

American Oyster (*Crassostrea virginica*)



Classification: Phylum: Mollusca; Class: Bivalvia

Description: Oysters are mollusks that possess two asymmetrical shells. These elongated valves are light colored and have a rough surface.

Habitat: Oysters thrive best in estuarine conditions from the Gulf of St. Lawrence to the Gulf of Mexico. They are usually found below the mean low tide level on a bottom type that is firm and non-shifting. Oysters often live in colonies commonly referred to as "beds."

Movement: American Oysters permanently attach themselves to the bottom substrate by use of a cement which they are able to produce after completing their planktonic stage.

Respiration: Oysters have two pairs of gills in their mantle cavity.

Ingestion: Oysters are filter feeders that utilize their gills to trap microscopic food particles. Cilia, on the surface of the gills, transport these particles to the labial palps. These structures sort the food and direct it into the mouth.

Growth: Their two asymmetrical shells are produced by the mantle. Oysters can reach a shell length of ten inches. Pearls may form within oysters if an irritant, like a grain of sand, gets lodged in their mantle.

Excretion: Oysters excrete their wastes into a common canal created by the joining of the mantles and gills.

Nervous System: Sensory tentacles, that detect touch and chemicals, are located along the edge of their mantle. These tentacles are connected by nerve fibers to ganglia.

Circulation: A chambered heart pumps blood through simple branching vessels to sinuses which surround the body's organs.

Reproduction: Oysters reproduce by external fertilization when both sexes release their sperm and eggs into the water. Following several planktonic stages, the young or "spat" must settle onto the correct substrate. American Oysters possess the ability to vary their sex.

Common Names: "eastern oyster," "Atlantic oyster"

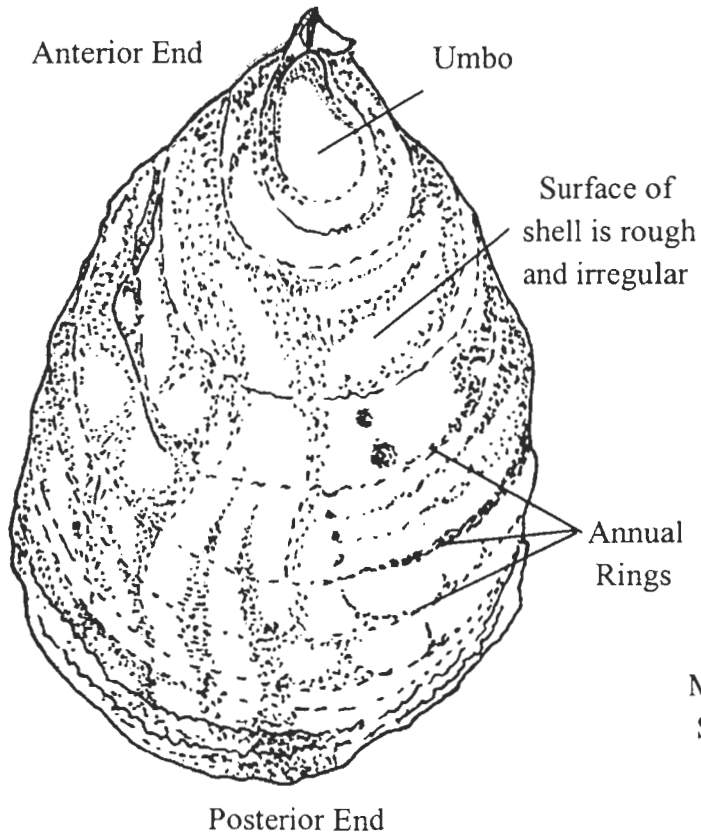
Predators: Sea stars, carnivorous snails, boring sponge, crabs and humans prey upon oysters.

Commercial Value: Landings for 2002 were 17,978 pounds valued at \$560,122. Most American Oysters harvested in Maine are cultivated.

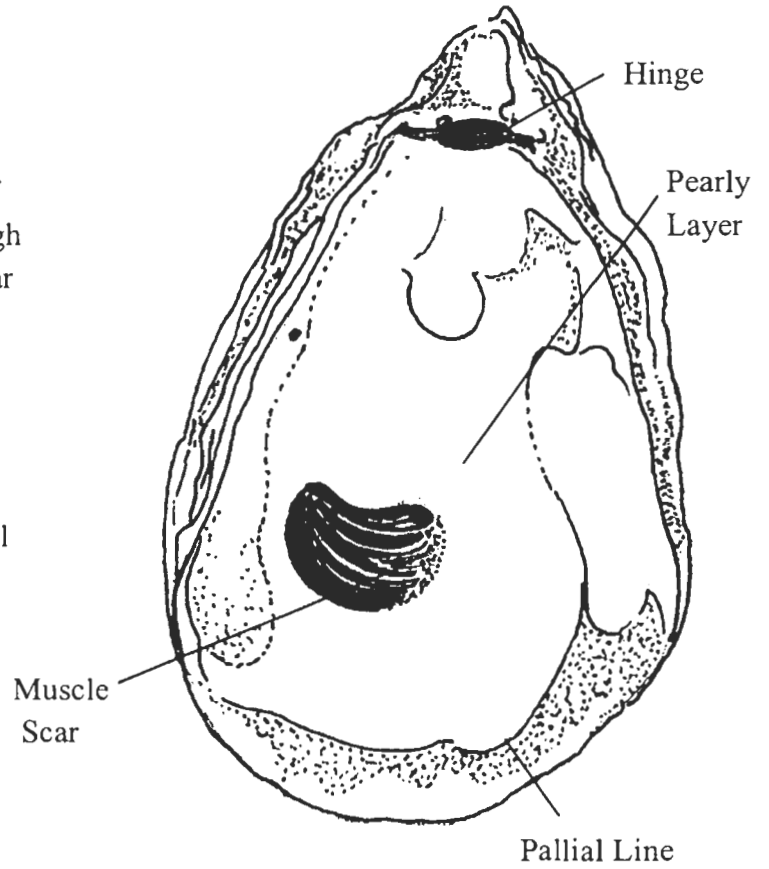
Other Gulf of Maine Species: European Oyster (*Ostrea edulis*)

Oyster

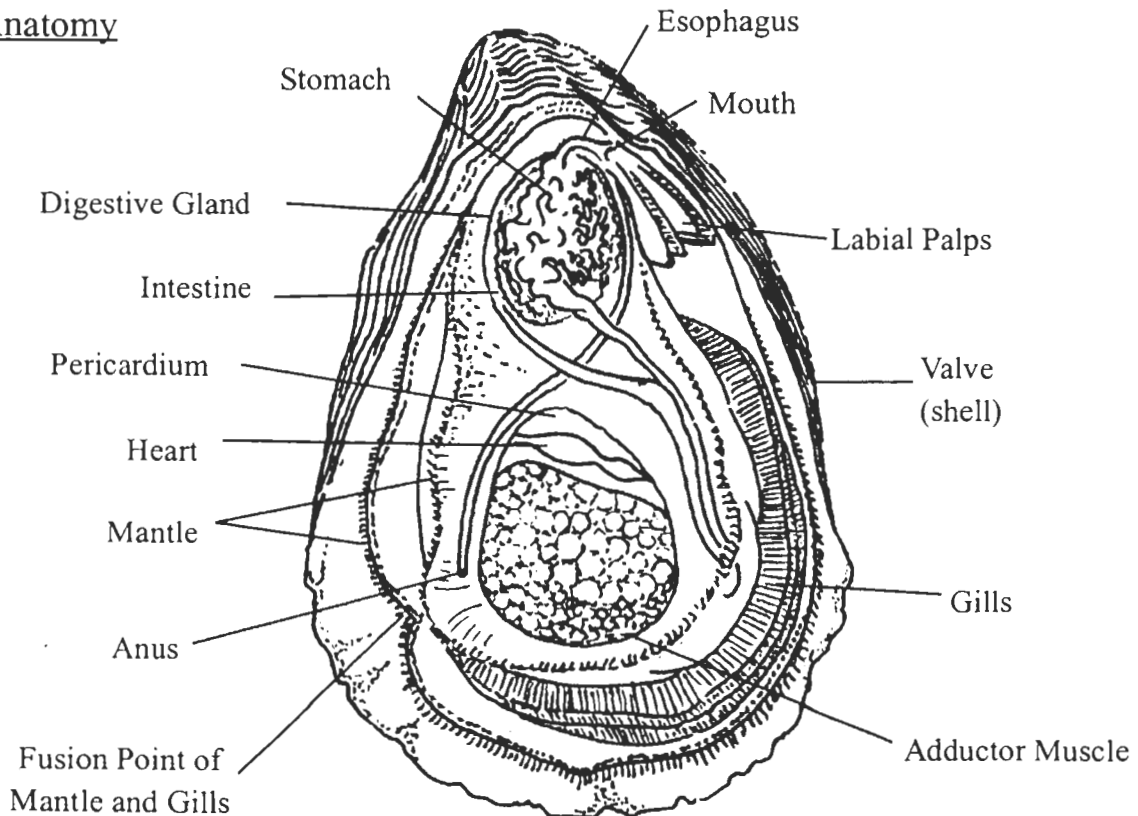
External View of Shell



Internal View of Shell



Internal Anatomy



Gulf of Maine Species of Oysters



American Oyster
(*Crassostrea virginica*)

- shells are thick, rough and variable in shape
- upper shell or right valve is smaller and flatter
- bottom shell or left valve attaches with a special glue to rocks or to other oysters in subtidal beds
- a purple muscle scar is visible on the inside of the shell
- large scale harvesting in states of NJ, MD & VA



European Oyster
(*Ostrea edulis*)

- shells shapes are less variable and more rounded
- upper valve is flat and lower shell is cup-shaped
- transplanted into Maine waters in 1940
- meat is darker with a distinct black edge
- specifically a cold water animal cultured in Maine and New Hampshire

Oyster Trivia

Have you ever heard the tale that you should never eat oysters during a month that does not have the letter "R" in it? Oysters are available year-round even though they are less marketable during these months which lack "R's." It is during this time period that oysters spawn. Their energy goes into reproduction making their meat soft and watery. Also, masses of developing larvae attach to the gills giving rise to the term "white sick" which make these oysters less desirable.



Oyster Midden

The Native Americans once harvested oysters in Maine's estuaries and discarded the shells into piles called "middens." One of these larger middens was discovered in Newcastle, Maine.

Oyster Activities

1. Observations of live oysters

- a) Obtain some live oysters (American and European) from your local fish market or supermarket. Keep them refrigerated.
- b) Place a live oyster in a clear container of seawater. Be sure that the water covers the animal.
- c) Observe and describe its size, color, shape and protective adaptations.
- d) Compare the American Oyster to the European Oyster in its size and shape.

2. Explorations

a) Observations

- Observe and describe the shells: color, shape, texture and the differences between dorsal and ventral shells.
- If it is an American Oyster, locate the scar on its shell which indicates where it was glued to the bottom.
- Carefully observe the shell for signs of spat (young oysters) or other organisms.

b) Shell measurements

- The height of the oyster is the distance from the pointed end or "beak" to the opposite end. If it is less than 3 inches it usually is a male and greater than 3 inches is a female. The oyster has the ability to change sexes which assures successful reproduction.
- The length of the oyster can be determined by measuring the widest part of the shell parallel to the beak.

c) Internal anatomy

- When opening an oyster, grasp the shell with a gloved hand. Place it on a firm surface with the wide edge of the shell protruding past the edge of the surface. Break off the edge of the shell with a hammer. Insert the knife between the broken edges and work the knife towards the umbo severing the adductor muscle.
- Using the diagram of the internal anatomy, locate the following parts: adductor muscle, heart, mantle, gills, labial palps, stomach and gonad.

3. Creating a fossil

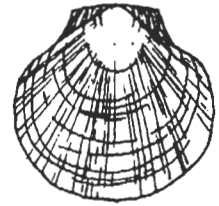
- a) Cut the sides of a milk carton so that it has a three inch rim. Press modeling clay into the bottom so that it is one inch deep.
- b) Obtain an oyster shell with an uneven surface. Press it into the clay and then carefully remove it.
- c) Mix plaster-of-Paris, according to the directions, and pour an inch of plaster over the impression.
- d) Let the plaster set for at least an hour. Peel away the milk container and separate.

4. Oyster Stew

- a) Ingredients: 3/4 stick of butter, 1 pint of shucked oysters, 1 pint of milk, salt and pepper
- b) Melt 3/4 stick of butter in a heavy saucepan.
- c) Rinse grit off oysters and simmer in hot butter for a few minutes. Add salt and pepper to taste.
- d) Add a pint of milk and bring it to a near boil. Serve at once with oyster crackers.

5. Read the story The Pearl written by John Steinbeck. This novel is appropriate for seventh grade reading. The Pearl is the tale of a fisherman named Kino, his wife Juana, and the pearl that they found.

Sea Scallop (*Placopecten magellanicus*)



Classification: Phylum: Mollusca; Class: Bivalvia

Description: Sea scallops are mollusks which possess two, fan-shaped shells. A set of distinctive "wings" or "ears" are located where their two shells are hinged together.

Habitat: Sea scallops are found from Labrador to New Jersey in depths ranging from twelve to nine hundred feet. These bottom dwellers prefer a substrate comprised of sand and gravel.

Movement: Scallops swim either forward or backward by contracting and relaxing their large adductor muscle in conjunction with working their mantle curtain. When swimming, scallops move in a zig-zag fashion.

Respiration: Gas exchange is accomplished by two pairs of large gills located in the mantle cavity.

Ingestion: Sea scallops are filter feeders that use their gills to trap minute food particles. Food is passed from the gills toward the mouth by use of cilia. The actual ingestion of food involves the labial palps and the crystalline style.

Growth: The scallop's mantle contains a fleshy layer of cells that is responsible for producing the shell. Sea scallops can grow to be over eight inches in diameter.

Excretion: Waste is expelled out of the anal opening into the mantle cavity where it is flushed out of the shell.

Nervous System: The scallop's nervous system consists of neural centers and their interconnecting nerve cords. Sensory tentacles and more than fifty blue eyes line the mantle edges giving them a general awareness of its surrounding.

Circulation: Nutrients and oxygen are absorbed into the blood. The blood is then pumped by a chambered heart through a system of vessels to the organs.

Reproduction: Sea scallops have separate sexes. They release sperm or eggs into the water during spawning which usually occurs during the late summer months. Following fertilization, the larval scallops pass through a trochophore and veliger stage before they briefly attach themselves to the bottom.

Common Names: "deep-sea scallop," "Atlantic sea scallop" and "giant scallop"

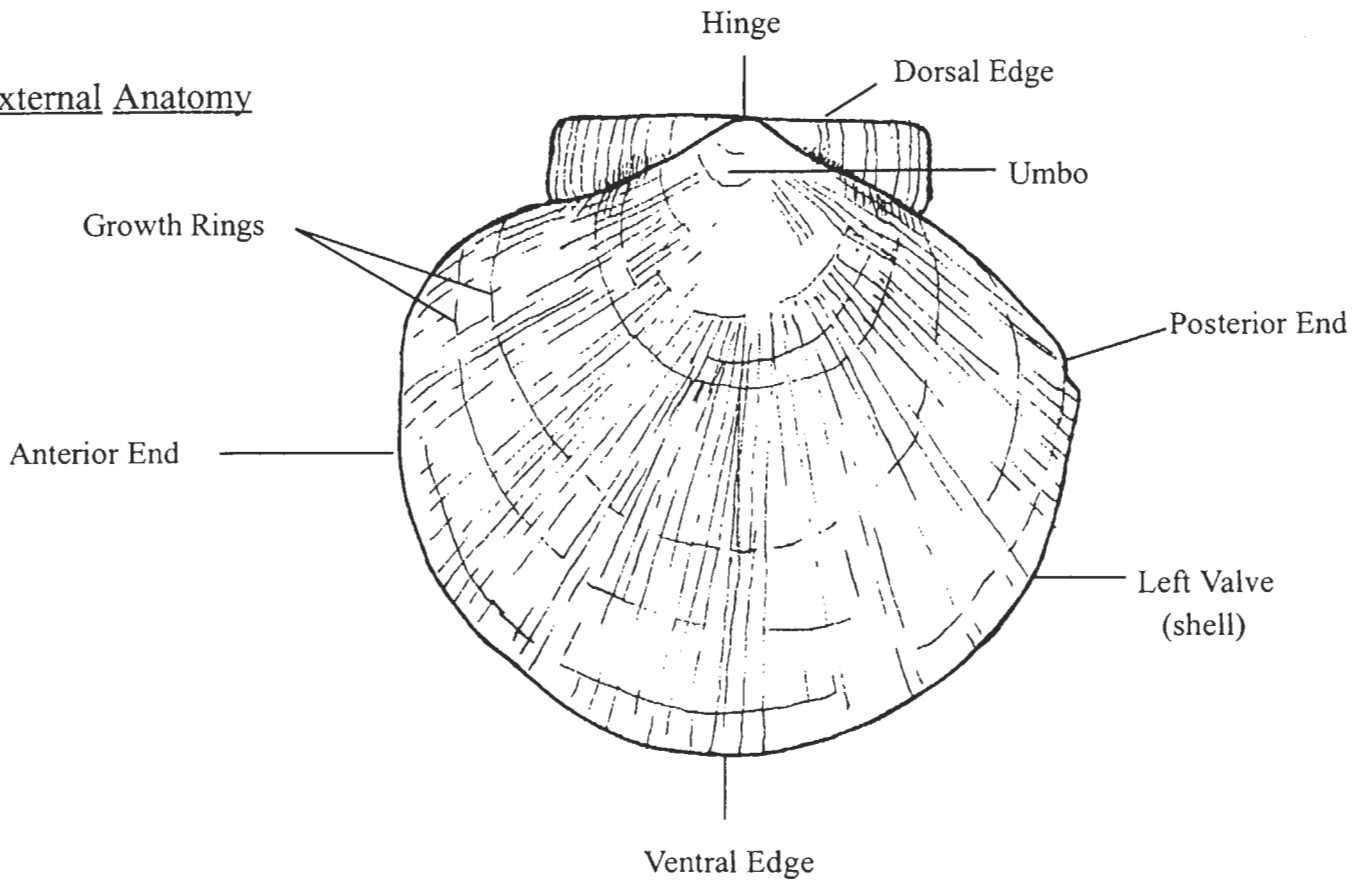
Predators: Sea stars, some species of fish and humans are the major predators of sea scallops.

Commercial Value: The 2002 reported landings were 358,370 pounds valued at \$1,998,780.00.

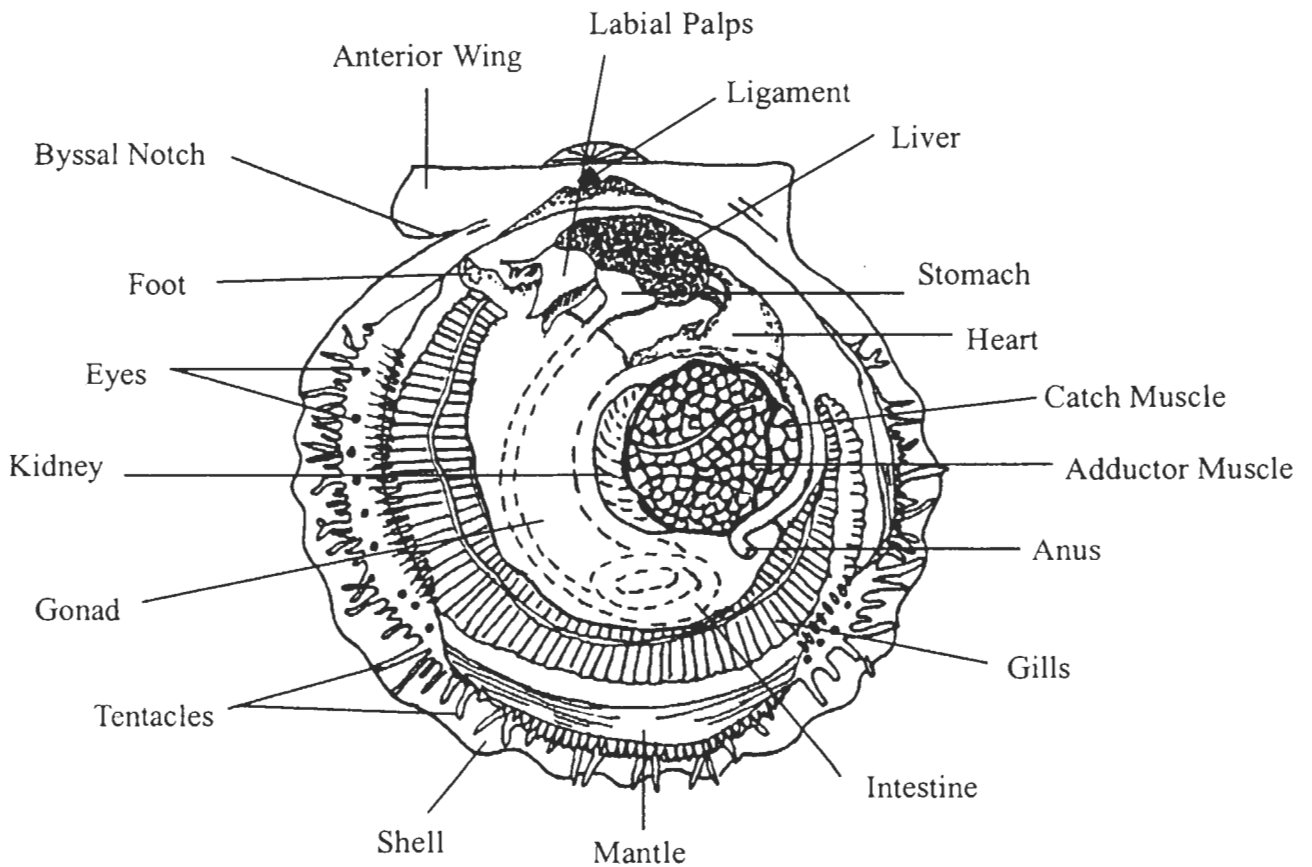
Other Gulf of Maine Species: Iceland Scallop (*Chlamys islandica*), Bay Scallop (*Aequipecten irradians*)

Scallop

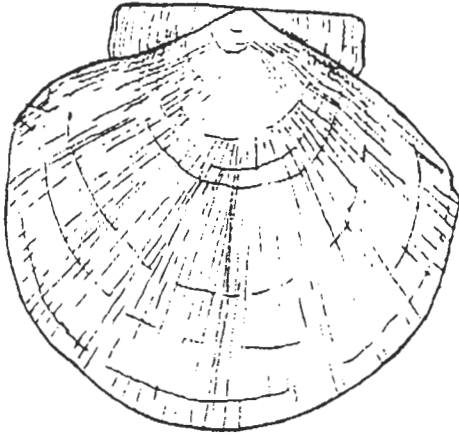
External Anatomy



Internal Anatomy



Gulf of Maine Species of Scallops



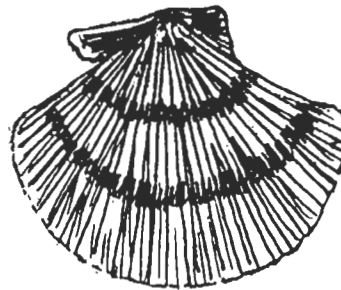
Deep Sea Scallop
(*Placopectin magellanicus*)

- large, smooth, flat, finely-ribbed valves
- wings at hinge line are about equal
- grows to eight inches in size
- harvested off the coast of Maine
- commonly found from Labrador to Cape Cod
- found in deep water south of Cape Cod to N. Carolina



Bay Scallop
(*Aequipecten irradians*)

- small, coarsely-ribbed valves
- coloration varies from drab grey to yellowish brown
- wings at hinge line nearly equal
- grows to three inches in size
- found from Cape Cod to Gulf of Mexico



Iceland Scallop
(*Chlamys islandica*)

- ovoid upper valve with fifty or more ribs
- variable in color
- unequal wings at the hinge line
- grows up to four inches in size
- found from the Arctic Ocean to Cape Cod

Scallop Activities

1. Observations of a live scallop

- a) In order to possess a live scallop, you must have a special permit from DMR.
- b) Place a small scallop in a container of seawater.
- c) Observe and describe its shape, color, movement, and protective adaptations.
- d) Place a live scallop in a tray for a short time. Make detailed observations of its structures and behaviors. (Be aware that the scallop may startle the students as it closes its shells.)
- e) How does this animal differ from the scallops purchased at a store? Attempt to locate its edible muscle when the scallop opens its shells.

2. Observations of scallop shells

- a) Large, flat scallop shells are from the sea scallops which are common to Maine. The smaller, coarsely-ribbed scallop shells are from Bay scallops that are found from Cape Cod south.
- b) Identify the differences between the top and bottom shells.
- c) Examine the inside and outside of the shells. Locate plants or animals, their remnants or scars that may be present on the shell. Common animals which attach or bore into shells are: slipper limpets, barnacles, spirorbis worms, bryozoans, jingle shells, boring worms and boring sponges.
- d) Examine the inside of the scallop shells for the hinge and the scar created by the adductor muscle.

3. Explorations

- a) How does a scallop sense changes in the environment?
 - Locate the small bluish-black dots on the edge of the scallops mantle. Approximately how many are present and what are their function?
 - Use a pencil to gently touch the small tentacles found on the edge of the mantle. What was the scallop's reaction?
- b) How does a scallop move?
 - Place a small scallop in a large container of seawater. Probe it gently with a pencil as a stimulant.
 - How does a scallop move? How do the hinge, adductor muscle and mantle curtain work together to allow this type of locomotion?

4. Art Activity

- a) Scrimshaw
 - Use a sharp nail to scratch a design on the inside of a scallop shell.
 - Generously coat the scratched surface with India ink and allow it to set for a few minutes.
 - Wipe off the excess ink using a paper towel.
- b) Rubbing of a scallop
 - Draw the shape of a scallop and its growth rings on a piece of cardboard. Apply a heavy bead of Elmer's glue to the pattern on this template.
 - Place a piece of white paper over the template and rub it with a crayon.

5. Research Topic: Maine's scallop fishery; including fishing gear, regulations and fishing season.

Periwinkle (*Littorina littorea*)



Classification: Phylum: Mollusca; Class: Gastropoda

Description: Periwinkles are spiral-shaped univalves that grow to be about one inch in height and width. Their shell colors can be a combination of shades varying from black to gray or olive to brown.

Habitat: Periwinkles are often found living in colonies in the intertidal zone. Their range extends from Nova Scotia, where they were first introduced from Europe, to Delaware Bay. They inhabit the rocky shore and mud flat environments. It is our most common intertidal snail.

Movement: They move slowly using their large muscular foot that projects out of their shell. To prevent desiccation during low tide, this foot can be retracted into the shell and sealed off by the operculum.

Respiration: Periwinkles respire through the use of a gill located in their mantle cavity.

Ingestion: Periwinkles graze on plant matter especially the algal film that covers objects located in the intertidal zone. They collect this food by use of their rough elongated tongue called the "radula."

Growth: Periwinkles grow by enlarging their shell. The fleshy mantle secretes calcium carbonate or limy materials at their pallial line. The largest periwinkles are found in the northern part of their range.

Excretion: Wastes exit the anal opening, located in the mantle cavity behind the head.

Nervous System: Their simple eyes, which detect light, are located at the base of their tentacles. Their tentacles are sensitive to touch and smell.

Circulation: Nutrients and gases absorbed into the blood are circulated by an open system. Blood moves through vessels into sinuses which are located around the body's organs.

Reproduction: Periwinkles have separate sexes and practice internal fertilization. The eggs are deposited in jelly-like masses on the intertidal substrate.

Common Names: "winkles," "common periwinkle"

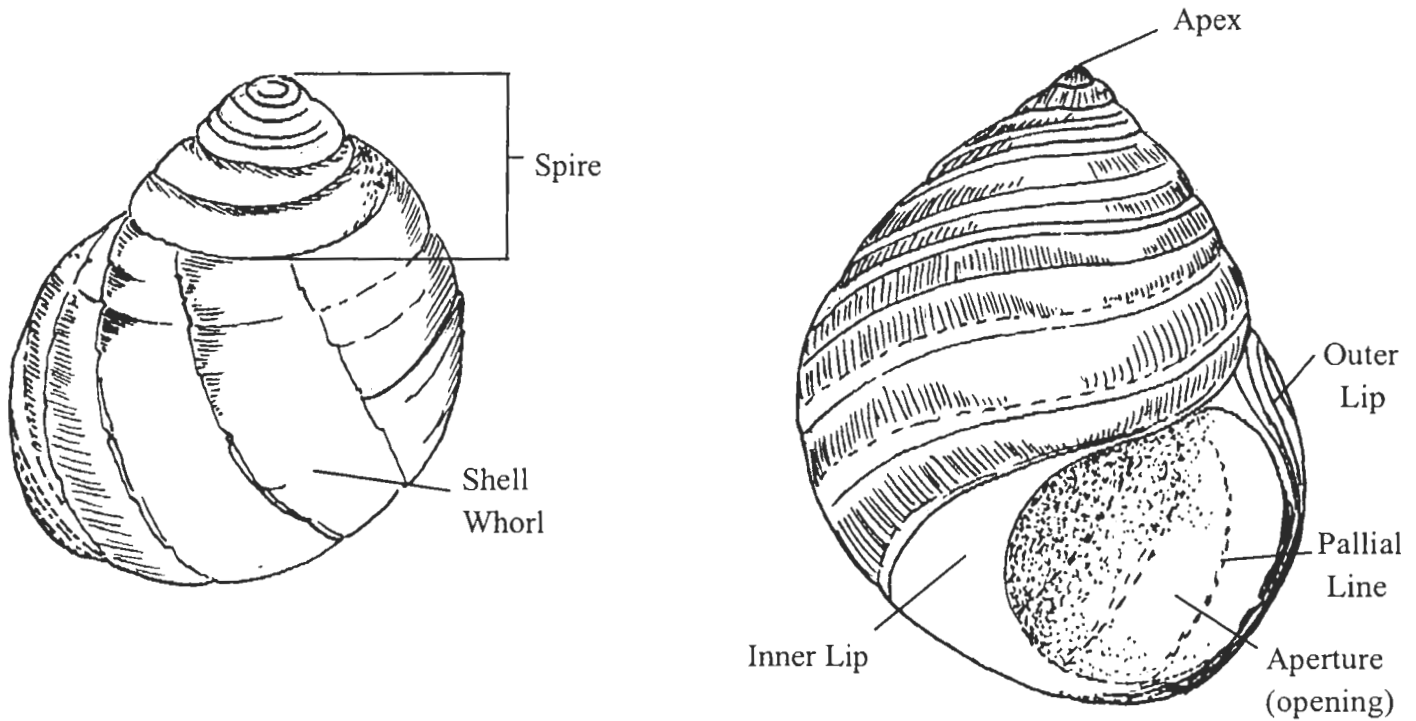
Predators: Birds, fish, carnivorous snails, and humans prey upon periwinkles.

Commercial Value: Maine's 2002 catch was 136,171 pounds valued at \$349,665.00.

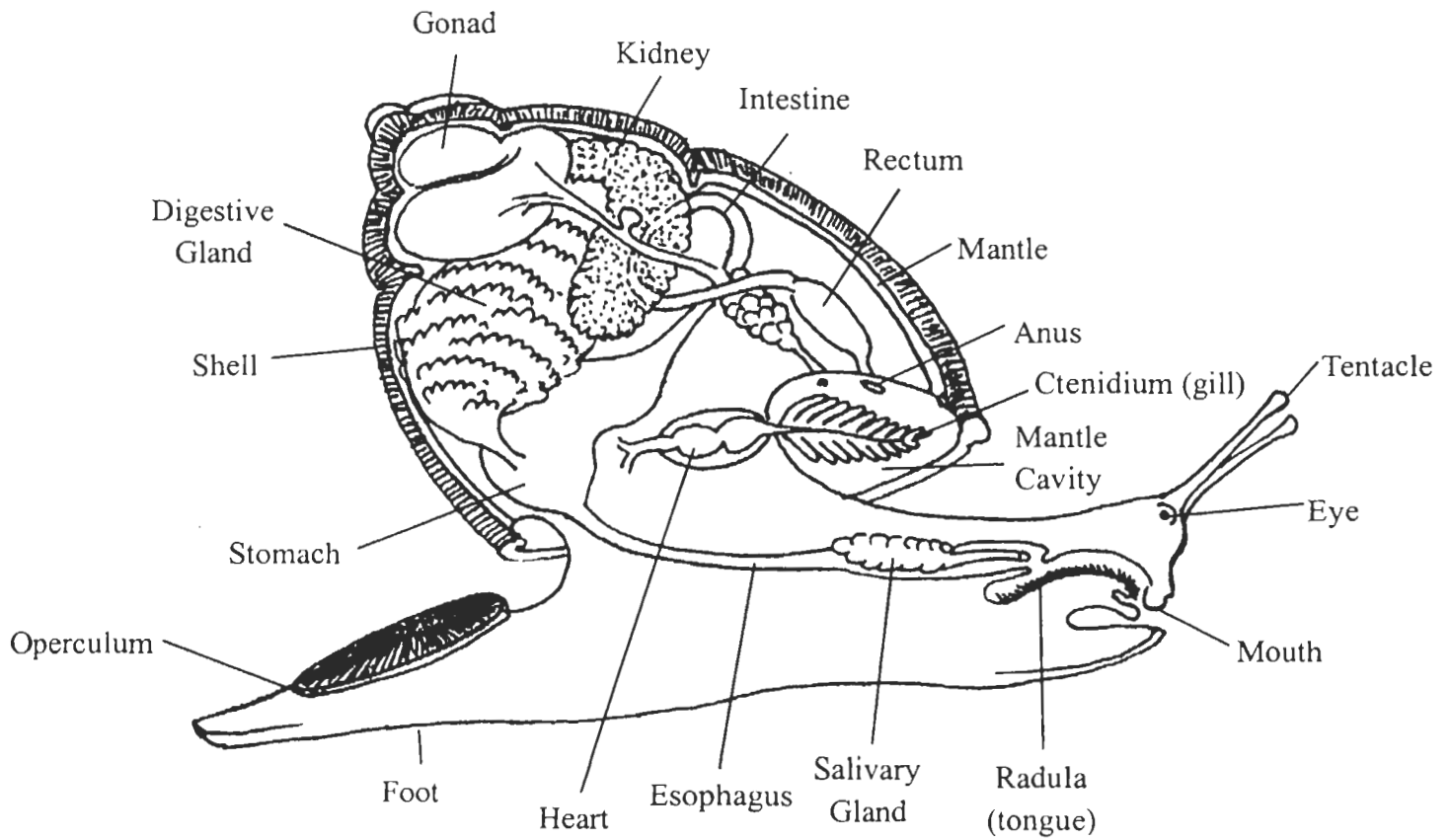
Other Gulf of Maine Species: Rough Periwinkle (*Littorina saxatilis*) and Smooth Periwinkle (*Littorina obtusata*)

Periwinkle

External Anatomy



Internal Anatomy

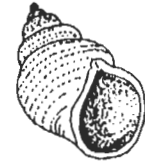


Gulf of Maine Species of Gastropods



Common Periwinkle
(*Littorina littorea*)

- most common intertidal snail
- grows to 1 1/4 inches
- feeds on algae
- withstands long periods without water
- brought from Europe more than a century ago



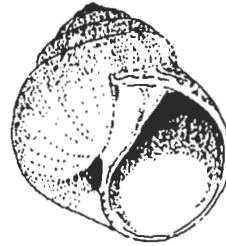
Rough Periwinkle
(*Littorina saxatilis*)

- shell has deeper sutures than the common periwinkle
- shell is smaller (less than 1/2 inch) than the common
- lives higher up in the intertidal zone
- ovoviviparous - eggs internally hatching out as miniature adults



Smooth Periwinkle
(*Littorina obtusata*)

- small round periwinkle resembling a small moon snail in shape
- whorls of the shell are smooth and the spire is low
- varies in color from orange, yellow, to brown and are sometimes banded
- commonly found amongst rockweed



Northern Moon Shell
(*Lunatia heros*)

- gray to tan in color and often called a "moon snail"
- large shell growing to 4 inches
- indentation near opening called its umbilicus
- an enormous foot can be completely retracted
- preys on bivalves by drilling a hole through the shell
- found along beaches
- "sand collars" containing eggs often found washed ashore



Sand Collar

Other Gastropods - The Limpets



Tortoiseshell Limpet
(*Acmaea testudinalis*)

- small, flattened cone-like shell
- round to oval in shape
- often called "chinaman's hat"
- found intertidally clinging tightly to rocks, kelp stipes or eelgrass.



Common Slipper Shell
(*Crepidula fornicata*)

- grows to about 1 1/2 inches long
- platform or deck on the inside of the shell
- often called a "boat shell"
- usually found in stacks with the larger bottom ones being females and the smaller top ones being males
- attached to hard objects intertidally and commonly found attached to scallop shells subtidally

Periwinkle Activities

1. Observations of a live periwinkle

- a) Place a periwinkle in a clear container of seawater. Describe its size, shape, shell, foot, etc.
- b) Pick up the periwinkle and gently touch its foot. What happens?
- c) What might the snail do to survive when the tide goes out?

2. Comparing different species

- a) Obtain a wide variety of live snails (or their shells) such as: common periwinkle, rough periwinkle, smooth periwinkle, dogwinkle, waved whelk, moon snail and mud snail.
- b) Observe the similarities and differences and group them (size, color, shell shape and aperture shape).

3. Explorations

a) Measuring a snail's pace

- Place a live snail in the bottom of a petri dish containing a small amount of seawater.
- Circle the dish on a piece of white paper. Draw a line from one side of the dish to the other and divide this line into the proper metric or English scale.
- Place the dish on top of the scale and position the snail at its starting point.
- Determine the time that it takes for the snail to cross the dish. (several tries might be necessary)
- Calculate the speed by dividing the distance traveled by time.

b) What type of habitat does a snail prefer?

- Identify individual snails with a mark from a permanent magic marker.
- Place the snails in a small aquarium with seawater and an airstone. Leave some airspace at the top.
- Vary its habitat by; placing different objects in the tank, creating various bottom types and darkening a section of the tank by taping black construction paper to the glass.

c) Can you record the grazing pattern of a snail?

- Apply a thin even coat of India ink on a piece of glass and allow it to dry overnight.
- Place the glass, ink side up, in the bottom of a pan with some snails. Place the pan in a cool, dark place for several hours. (Snail's prefer to move in the dark.)
- Remove the glass and observe the surface for rasping marks. Use a hand lens or dissecting scope.

4. Population Study

Tag-recapture technique is a method used in estimating the size of marine animal populations. Find out how many common periwinkles inhabit an average area of shoreline or estimate the total number present in a large tidepool.

a) Select and mark the boundaries of your study area.

b) Collect a fairly large number (500) and tag them with a spot of nail polish. Clean the area of the shell with acetone before applying the nail polish. Return them randomly to the study site.

c) Allow some time to pass before returning for a random sample of the study site. Count the sample number and determine how many are tagged. Record these numbers.

d) Use the Lincoln-Peterson index to estimate the population

M1 = number of animals previously marked and released

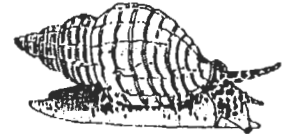
M2 = total number of marked animals recaptured

T = total number of animals captured (marked and unmarked)

$$P = \frac{M1 \times T}{M2}$$

e) Repeat the procedure for increased accuracy and find the average.

Waved Whelk (*Buccinum undatum*)



Classification: Phylum: Mollusca; Class: Gastropoda

Description: Waved whelks are medium sized, univalves with both axial and spiral ridges on their shell. When their soft body is exposed, it is white with black splotches. Two distinctive features of a whelk shell are an oval aperture and a siphonal notch.

Habitat: Waved whelks can be found along the Atlantic seaboard from the Arctic to New Jersey. They live subtidally to depths of about six hundred feet.

Movement: Whelks have a powerful muscular foot that glides on a film of mucus, that they produce.

Respiration: Respiration is accomplished through the use of a gill located in the animal's mantle cavity.

Ingestion: Waved whelks are primarily scavengers feeding on dead or dying marine organisms. They use their radula or tongue to scrape flesh from their prey. This file-like tongue is replaced as it is worn off.

Growth: These snails grow rapidly to their adult size of two to four inches in length. These mollusks grow larger in the northern part of their range.

Excretion: Wastes are passed from the kidneys and intestines into the mantle cavity where they are washed out of the body.

Nervous System: These snails have well-developed simple eyes and sensory tentacles that respond to light and other stimuli. Nerve masses are concentrated in the head region.

Circulation: Like most mollusks, whelks have an open circulatory system involving a two-chambered heart, vessels, and several blood sinuses.

Reproduction: Following breeding, females release masses of whitish eggs in large rounded capsules. These egg masses are attached to objects such as kelp stalks. Miniature whelks hatch out of these capsules. These egg cases are often called "fisherman's soap" because they produce a lathery secretion when rubbed with water.

Common Names: "northern whelk," "edible whelk" and "European whelk"

Predators: Lobsters, cod, wolffish, sea stars and humans prey upon waved whelks.

Commercial Value: A "by-catch" of the lobster industry, the 2002 landings were 653 lbs valued at \$614.

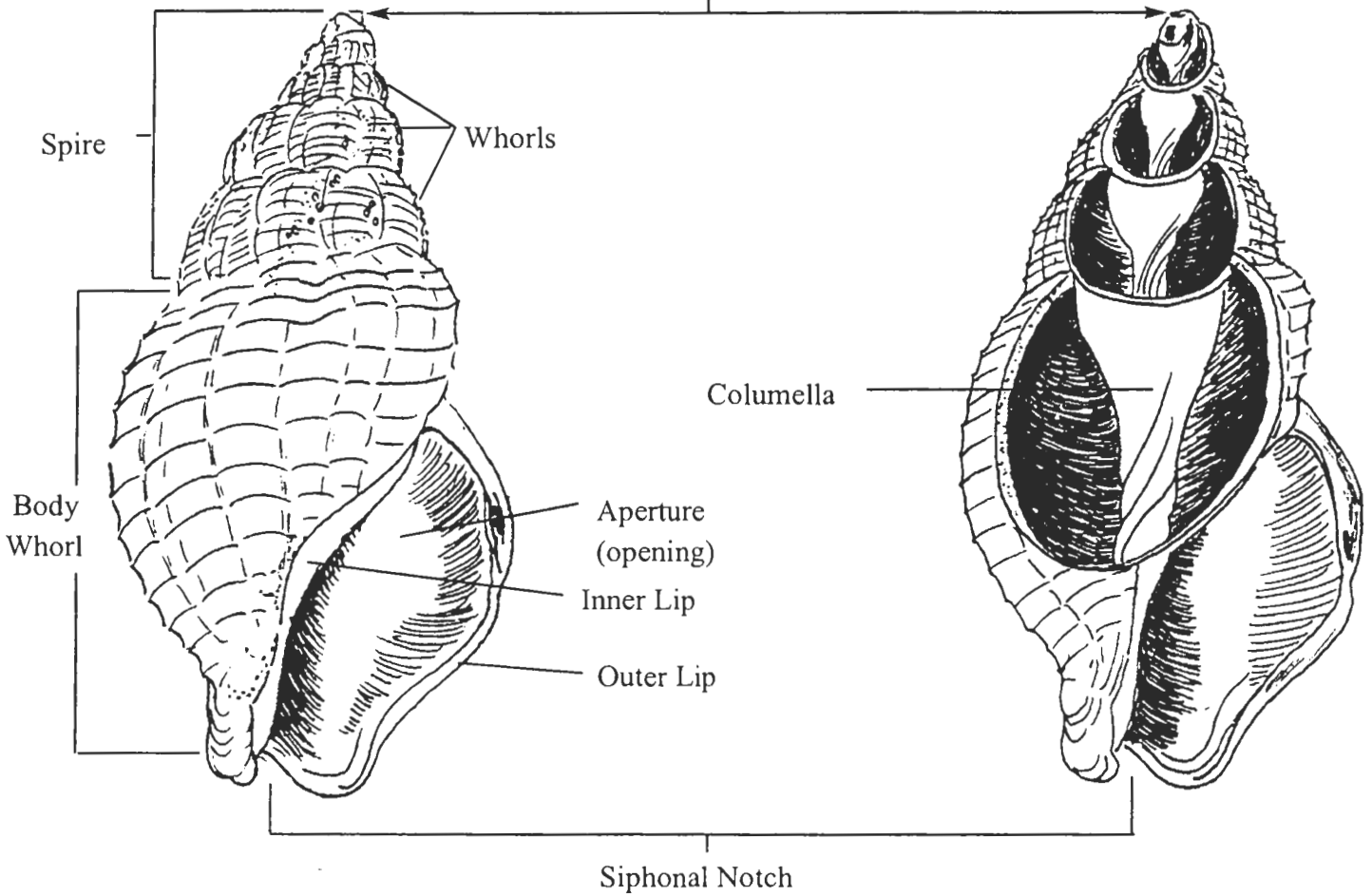
Other Gulf of Maine Species: Dog Winkle (*Thais lapillus*), Ten Ridged Whelk (*Neptunea decemcostata*), Stimpson's Whelk (*Colus stimpsoni*) and Channeled Whelk (*Busycon canaliculatum*)

Waved Whelk

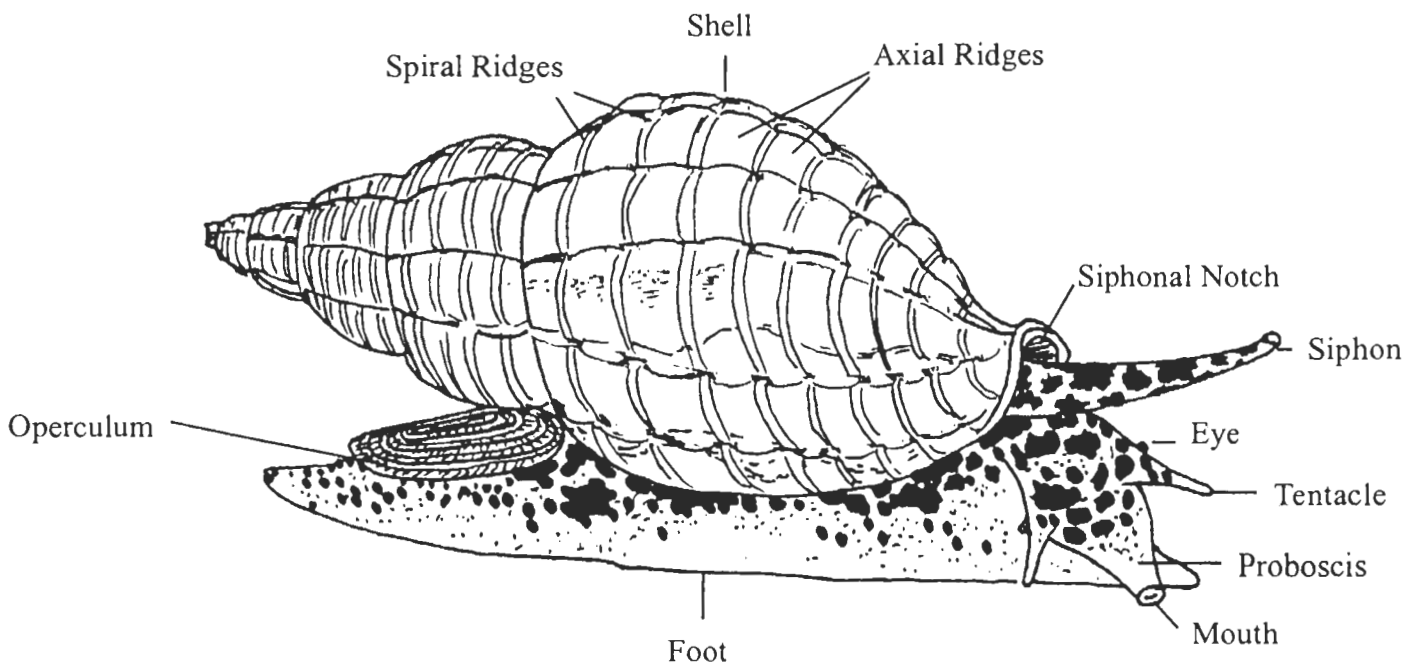
External Shell Complete

Apex

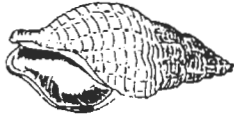
Dissected shell



External Anatomy



Gulf of Maine Species of Whelks



Waved Whelk
(*Buccinum undatum*)

- shell has axial ribs and spiral ridges
- foot is white with black flecks
- young found in tide pools but adults are mainly subtidal
- scavenge on dead material
- masses of egg capsules called "fisherman's soap" are often found on beaches



Stimpson's Whelk
(*Colus stimpsoni*)

- spindle-shaped shell with dark coating
- seven to eight flattish whorls
- extended spire and siphon canal
- found subtidally from below low tide line to deep water



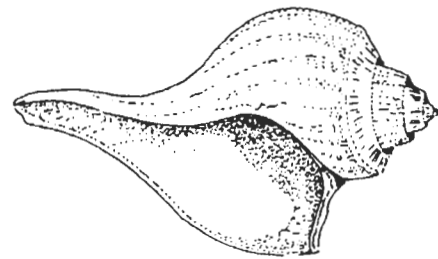
Mud Dog Whelk
(*Nassarius obsoletus*)

- dark, weakly sculptured shell
- shell usually has an eroded apex
- often called a "mud snail"
- found intertidally to subtidally on muddy bottoms



Ten-Ridged Whelk
(*Neptunea decemcostata*)

- thick, spindle-shaped shell
- seven to ten strong reddish-brown spiral ridges
- head and foot are pale grey
- found subtidally
- scavenge on dead material



Channeled Whelk
(*Busycon canaliculatum*)

- largest sea snails on Maine's coast
- rarely found North of Casco Bay, Maine
- short spire, large body whorl, and long siphon canal
- mostly subtidal along bay and ocean beaches
- feeds on bivalves using its own strong shell to chip and pry their prey open
- lay their eggs in strings of egg capsules



Dogwinkle
(*Thais lapillus*)

- shell varies in color (orange, yellow, brown, or banded with white) and texture
- often called a "dog whelk"
- chiefly intertidal
- feeds by drilling holes through mussels, snails and barnacles
- eggs resemble rice grains attached to rocks

Whelk Activities

1. Observations of live whelks
 - a) Place a live whelk in a clear container of seawater. Be sure that the water covers the whelk.
 - b) Observe and describe its size, color, shape and protective adaptations.
 - c) Is it right-handed or left-handed? Hold the whelk with the point up and the aperture facing you. Is the opening on the right or left?
2. Comparing the shells of different whelk species.
 - a) Obtain the following shells: Waved, Ten-ridged, Stimpson's, Channeled, Mud Dog and Dog Winkle.
 - b) Compare the similarities and differences of each whelk.
3. Explorations
 - a) How does a whelk move?
 - Place a whelk on a moist, smooth surface. Observe it as it glides along the surface.
 - Slowly remove it from the surface. What do you notice? The slime production aids it in gliding along the surface.
 - b) How does a dogwinkle eat?
 - Place a dogwinkle into a container of sea water with a mussel. Describe its reaction.
 - Examine empty mollusk shells which have a small, round hole drilled through them. The dogwinkle is a meat eater that feeds by drilling a hole with its radula and then it sucks up the soft body. It can take a dogwinkle up to 3 days to drill a hole through a shell.
 - c) What does the radula look like?
 - Place a whelk in boiling water for a few minutes. Remove the snail from the shell.
 - Using a scalpel, carefully cut the head between the tentacles. Locate a coiled thread-like structure and remove it with forceps.
 - Mount the radula on a microscope slide, stain it with methyl blue, and observe it under the microscope. Describe what it looks like and how it enables the whelk to eat.
 - Mount the radula of a periwinkle and compare it to that of the whelk.
 - d) Can a whelk recognize the presence of its predator the sea star?
 - Using forceps, remove several tube feet from a sea star. Place the tube feet in a mortar with 2-3 ml of seawater. Mash the tube feet to release the chemical ingredients.
 - Place the whelk in the center of the container of seawater. Pour the tube feet solution in the corner of the container and observe the whelk's reaction to the diffusing solution.
4. Shell collection
 - a) Paint a cardboard egg carton with tempera paint.
 - b) Glue a cotton ball into each egg cup. Arrange collected shells or treasures on top of each cotton ball.
 - c) Glue a small label next to each item.
5. Shadowbox
 - a) Paint an ocean scene on the bottom of a shoe box using tempera paints.
 - b) Glue pebbles, sand and mussel shells on the side of the box which will serve as the base of the scene.
 - c) Glue a whelk shell to the surface of the mussel shell, representing the feeding process.
 - d) Suspend fish from the top to complete the scene.
 - e) Attach blue cellophane over the face of the box to represent the water.

Short-Finned Squid (*Illex illecebrosus*)



Classification: Phylum: Mollusca; Class: Cephalopoda

Description: Squid are sleek, fast-swimming, torpedo-shaped mollusks which lack an external shell. They have two distinct tentacles and eight arms that are used for catching and holding prey.

Habitat: This pelagic species of squid ranges from the Arctic Ocean south to Cape Cod. During their spawning season, they are often found in the deeper waters off Cape Hatteras, North Carolina south to Cape Canaveral, Florida.

Movement: Squid use their fins to propel themselves forward. When swimming, squid draw water into their mantle cavity and forcefully expel it out a ventral siphon. This process creates a jet propelled reaction.

Respiration: Squid respire by means of two lateral gills located in their mantle cavity.

Ingestion: Two long tentacles and eight arms are used to grab, hold and transfer food to their beak-like jaws. These appendages are equipped with toothed or hooked suction cups. Squid commonly feed on small fish and krill.

Growth: The mantle surrounding the body cavity of short-finned squid usually grows to a length of 9-13 inches. Support is provided by a flexible internal shell-like "pen" that runs down their dorsal surface.

Excretion: Digestive wastes exit through the anus and are flushed out through the ventral siphon.

Nervous System: Squid have a well developed brain and nervous system. Their highly evolved eyes have the ability to focus, allowing them to visualize objects. Their tentacles are sensitive to touch. They also possess the ability to taste.

Circulation: Cephalopods are the only mollusks to have a closed circulatory system. Circulation is provided by three hearts; a systemic heart pumps blood to the body, while the two branchial hearts pump blood to the gills.

Reproduction: Prior to reproduction, one of the male's arms becomes modified to transfer sperm to the female's mantle cavity. After fertilization occurs, the egg masses produced by the female are spawned into the water in a gelatinous mass and remain pelagic until hatching.

Common Names: "Boreal Squid," "Northern Squid," "calamari,"

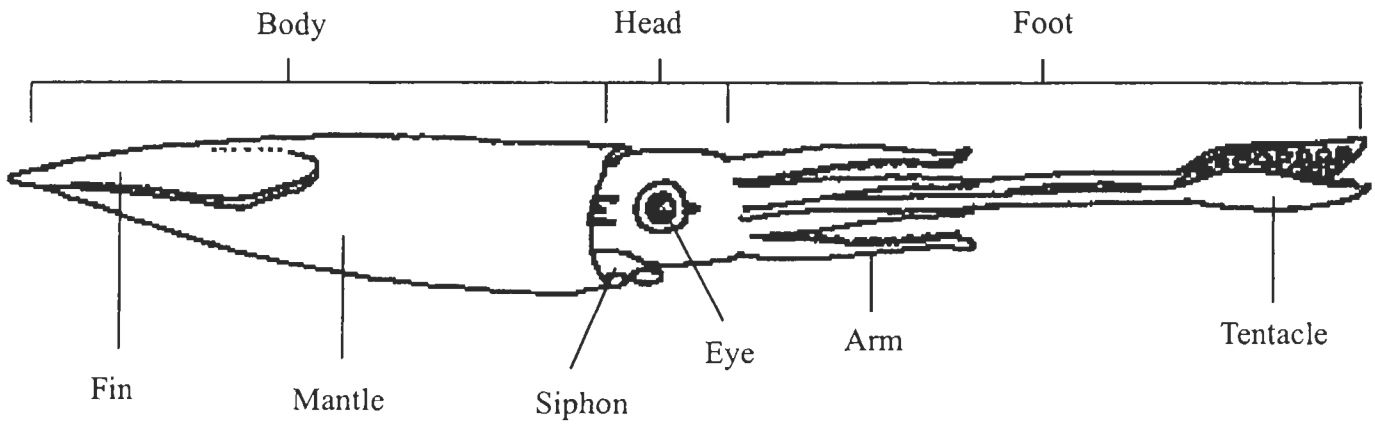
Predators: Many types of fish, marine mammals and humans eat squid.

Commercial Value: In Maine, squid are an under-exploited species used for food or bait. The 2002 landing was 687 pounds valued at \$446.

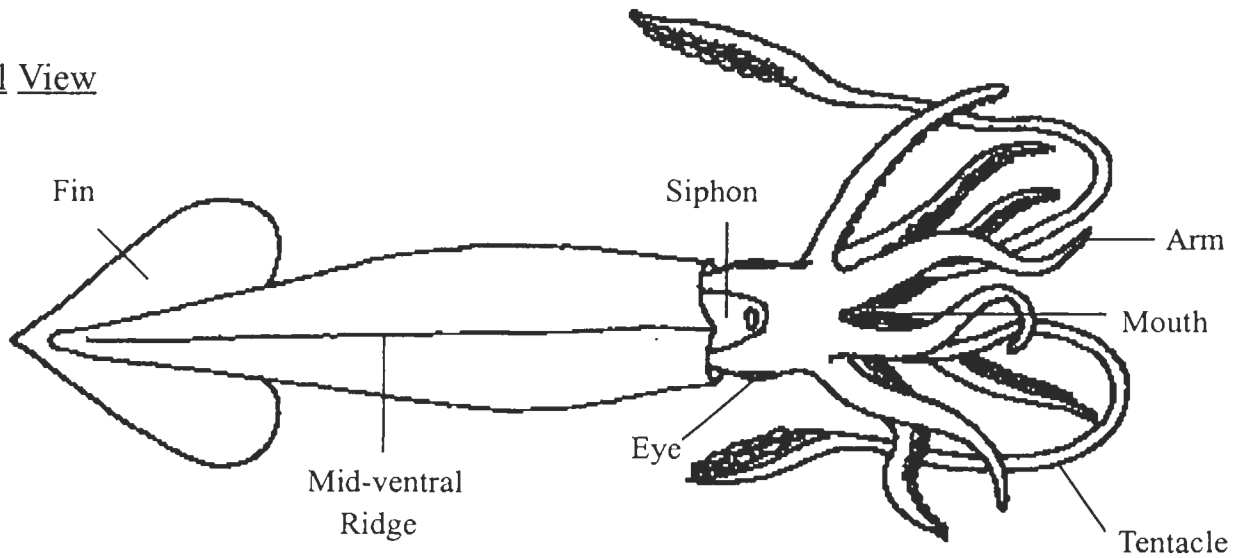
Other Gulf of Maine Species: Long-finned Squid (*Loligo pealei*)

Short-Finned Squid

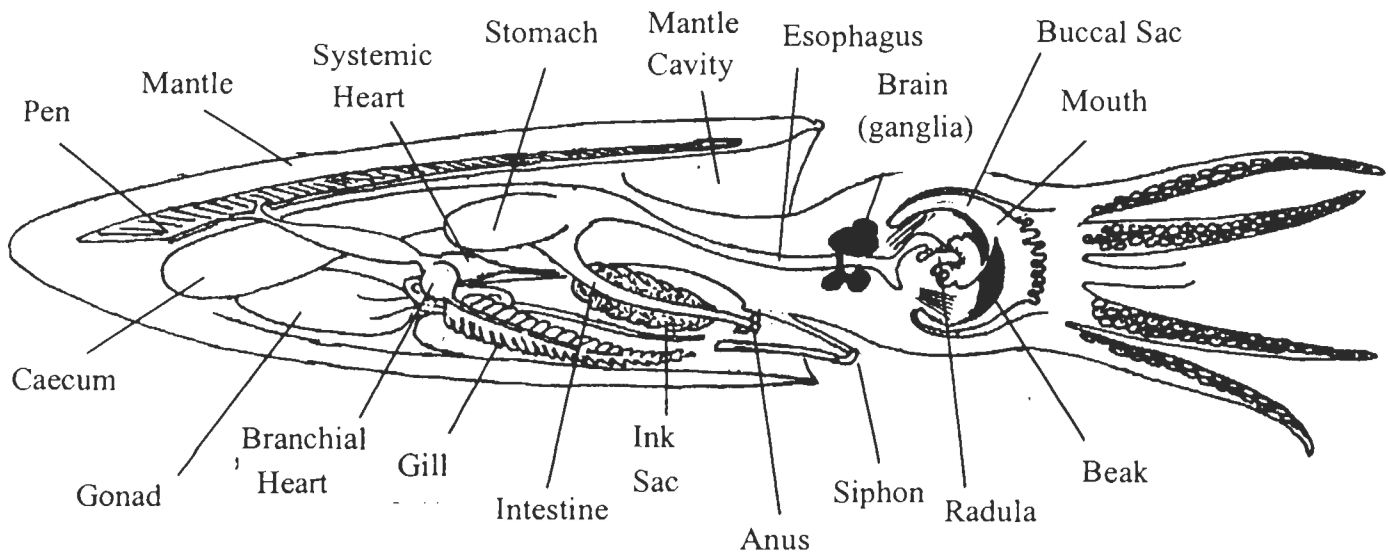
Lateral View



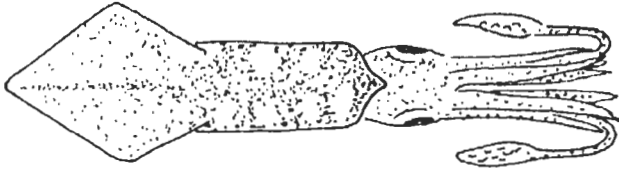
Ventral View



Internal Anatomy

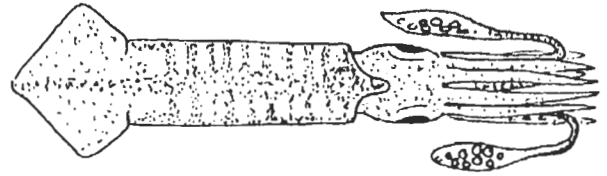


Gulf of Maine Species of Cephalopods



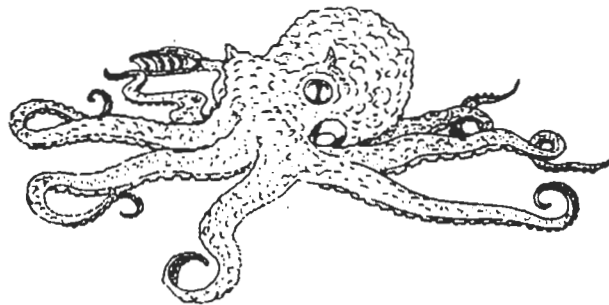
Long-finned Squid
(*Loligo pealei*)

- fins are long (1/2 of the mantle length)
- mantle up to seventeen inches in length
- commonly found between Cape Cod and Cape Hatteras



Boreal or Short-finned Squid
(*Illex illecebrosus*)

- fins are short (1/3 of mantle length)
- mantle up to nine inches in length
- found in the Arctic Ocean south to Cape Cod
- commonly seen inshore during the summer



Octopus
(*Bathypolypus arcticus*)

- a rough and warty species
- body can grow to two feet in length
- a horn-like structure is found over each eye
- the third right arm of males is spooned
- found at trawling depths, north of Cape Cod

Squid Activities

1. Observations of the squid

- a) Whole squid are available in the fish department at your supermarket or fish market. A three pound box of frozen squid can be ordered from Maine Shellfish Co. in Ellsworth. They will drop it off at your local fish market during their deliveries. This box contains at least twenty whole squid.
- b) Place a squid on a paper plate for observations and provide paper towels for clean up.
- c) Describe its size, shape, color and protective adaptations.

2. Comparing different cephalopods

- a) Obtain pictures of the squid's relatives; octopus, cuttlefish and nautilus.
- b) Have the students compare the similarities and differences of these mollusks.

3. Dissection of the squid

The squid is a mollusk which lacks a hard external shell. They are called cephalopods which means "head-footed" because their appendages are attached to their head.

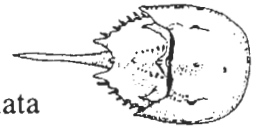
- a) Mantle - A thick, muscular covering called the mantle protects the internal organs.
- b) Skin - A thin, mottled layer of skin covers the mantle and allows the squid to camouflage itself. Remove a small piece of skin and examine it with a hand lens or a dissecting microscope. Look for contracted and expanded pigment cells called chromatophores. Is the dorsal side lighter or darker than the ventral?
- c) Movement - Locate the external siphon, often called the "funnel", on the ventral side of the squid. They are rapid swimmers by forcefully expelling a jet of water through this siphon tube. Locate the pair of posterior fins which act as swimming stabilizers.
- d) Appendages - How many short arms and long tentacles does it have? Examine them with a hand lens and describe the differences.
- e) Mouth - Make a cut between the two ventral arms to remove a muscular structure called the "buccal bulb." This bulb contains a beak, salivary glands (one contains venom) and a tongue-like radula.
- f) Eyes - The eyes are highly developed as they have the ability to accurately detect visual images. Their eyes are similar to vertebrates as they have a lens, iris, cornea and retina. Cut open an eye to locate a lens.
- g) Pen - Locate the tip of the pen on the dorsal edge of the mantle. Carefully pull this transparent support structure out. This pen is the remnant of a shell.
- h) Ink sac - Use scissors to cut down the ventral side of the squid's mantle. Locate a silver sac and snip it open to release the ink. When the squid is disturbed, ink is ejected out creating a cloud to screen its escape. Use the squid's pen to dip into the ink and write your initials.
- i) Internal anatomy - Use the diagram to locate its internal organs. A female squid will have two, oval, white glands which produce the egg sac.

4. Book or Video - "20,000 Leagues Under the Sea" by Jules Verne.

5. Research

- a) The giant squid

Horseshoe Crab (*Limulus polyphemus*)



Classification: Phylum: Arthropoda; Subphylum: Chelicerata; Class: Merostomata

Description: The anatomy of the horseshoe crab has remained virtually unchanged for over three hundred million years. Despite their common name, these horseshoe-shaped, spiked tail animals are more closely related to spiders than crabs. Contrary to popular belief, their tail or telson is not used for defense.

Habitat: Horseshoe crabs are found along the Atlantic coast from Nova Scotia to the Gulf of Mexico. They prefer the shelter of shallow waters in summer and move offshore to deeper waters during the winter months. There are no other Gulf of Maine species of horseshoe crabs.

Movement: Five pairs of walking legs are used to lift and push the animal forward. The last pair of legs are modified for pushing and digging. Their tail or telson is used for maneuvering and righting themselves.

Respiration: Gas exchange is accomplished by a book gill which is composed of five pairs of lamellae containing numerous blood-filled plates. This organ is located on the ventral side of the abdomen.

Ingestion: Primarily scavengers, they use their first pair of appendages called "chelicera" to transfer food to their gnathobase. The gnathobase, located at the base of their legs, grinds the food and passes it to the mouth.

Growth: Similar to all Arthropods, growth is accomplished by molting their exoskeleton. This outer shield splits along its anterior seam and the animal exits forward. Including their telson, adult females can grow up to two feet in length, while males are usually smaller in size.

Excretion: Wastes are excreted out the anus, located on the ventral side of the abdomen near the telson.

Nervous System: A brain which surrounds the mouth controls three pairs of eyes and numerous photoreceptors. Two lateral, compound eyes provide form vision, two median eyes provide ultraviolet (UV) vision, and ventral photoreceptors function in their larval stage.

Circulation: The heart pumps blood through an open system of vessels and sinuses. Their blood is bluish in color due to a copper-based respiratory pigment. This blood is used in medical research.

Reproduction: During late spring, the female comes ashore with a male in tow and digs several small nests in the sand. She deposits thousands of eggs into the nests. These eggs are then fertilized by the accompanying male. The young hatch out several weeks later and make their way to the open water.

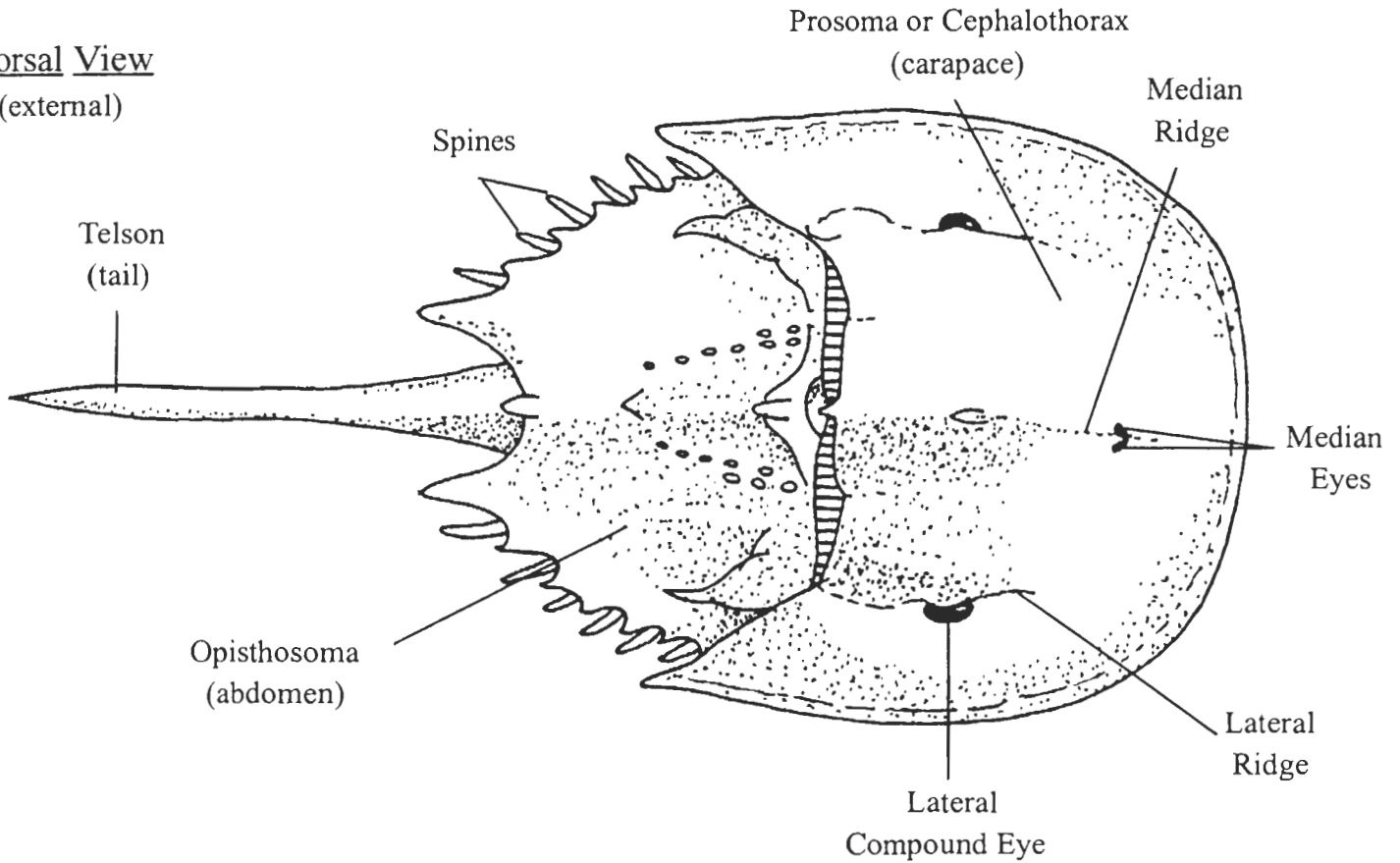
Common Names: "king crab," "living fossil"

Predators: The eggs and juveniles are eaten by fish and numerous types of shore birds. Adults are preyed on by sea gulls and humans.

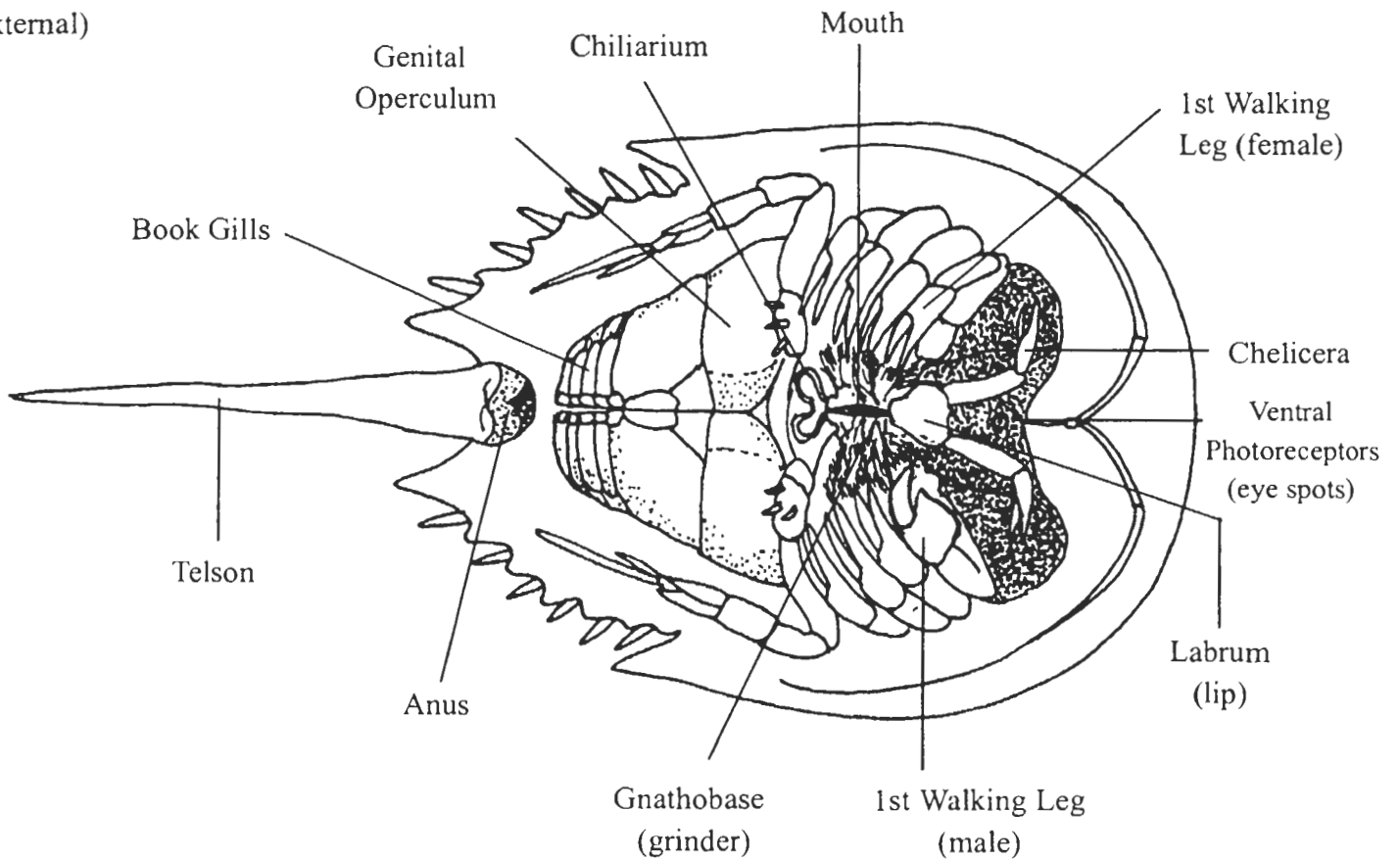
Commercial Value: They have no commercial food value to humans but are used for eel bait and fertilizer. They are also used by the medical community in research and for the detection of specific bacteria.

Horseshoe Crab

Dorsal View (external)

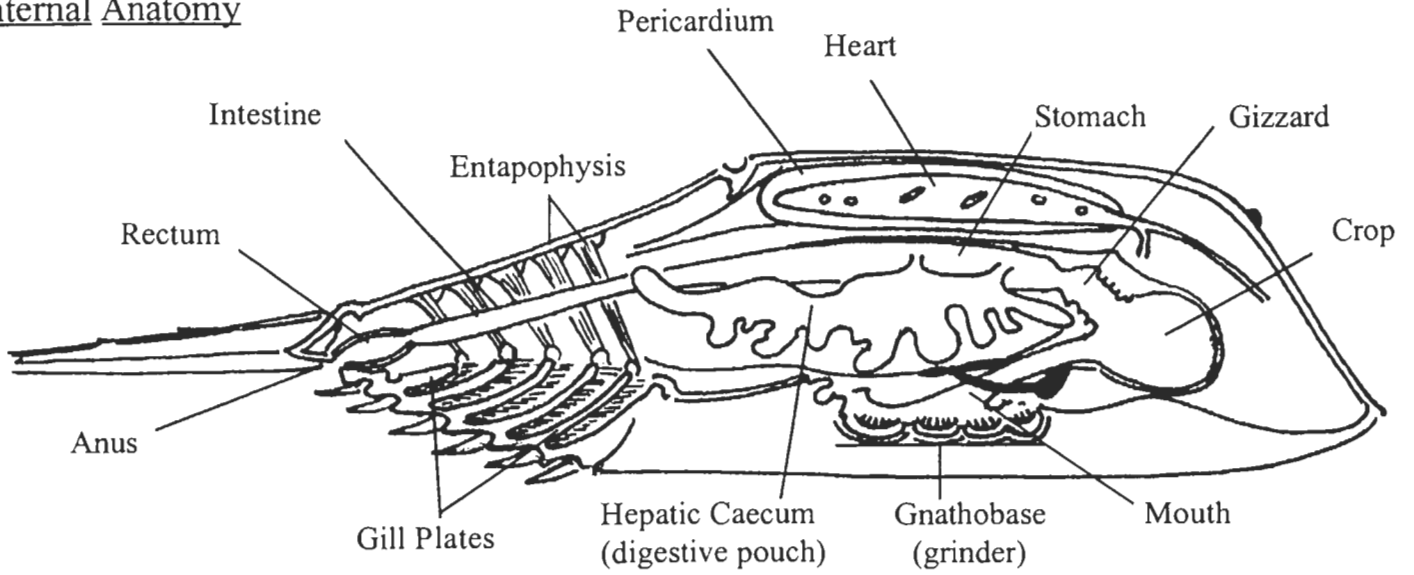


Ventral View (external)



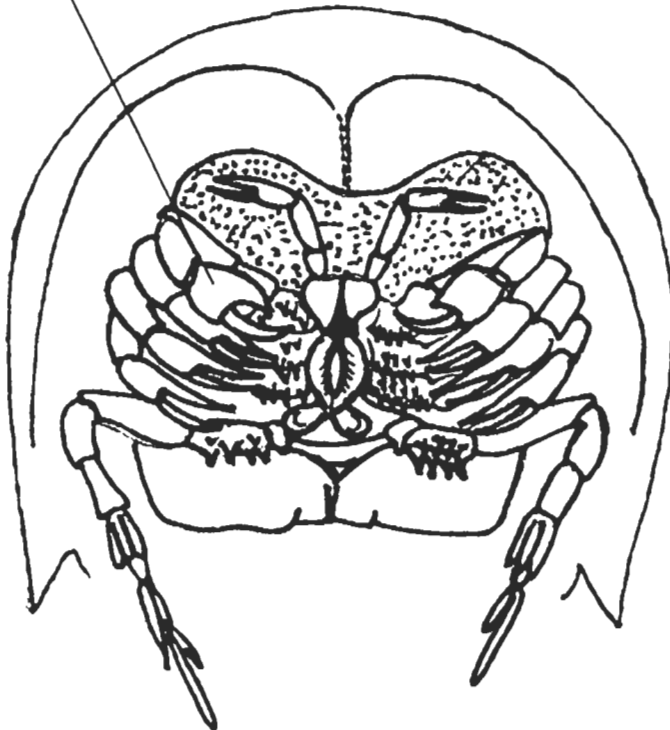
Horseshoe Crab

Internal Anatomy



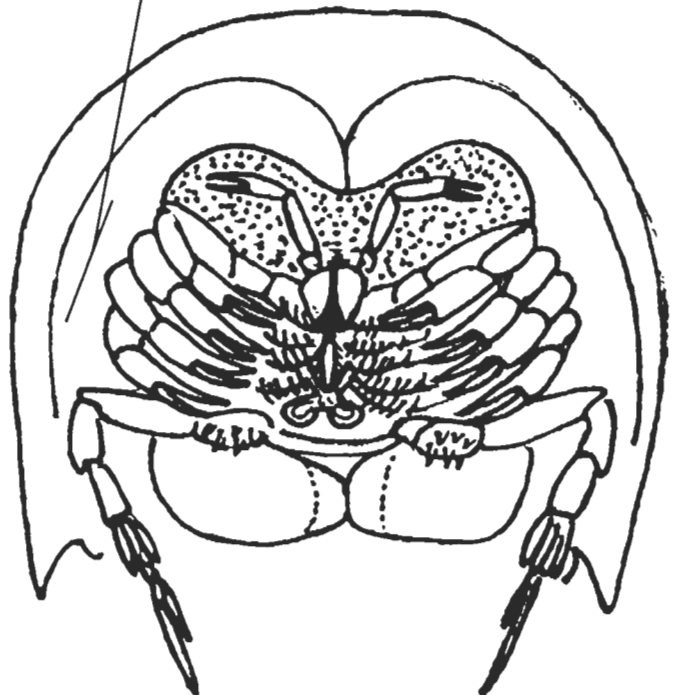
Male Ventral View

First pair of walking legs have enlarged hook-like tips that are used during mating.



Female Ventral View

First four pairs of scissor-like walking legs are all similar



Horseshoe Crab Activities

1. Observations of a live horseshoe crab

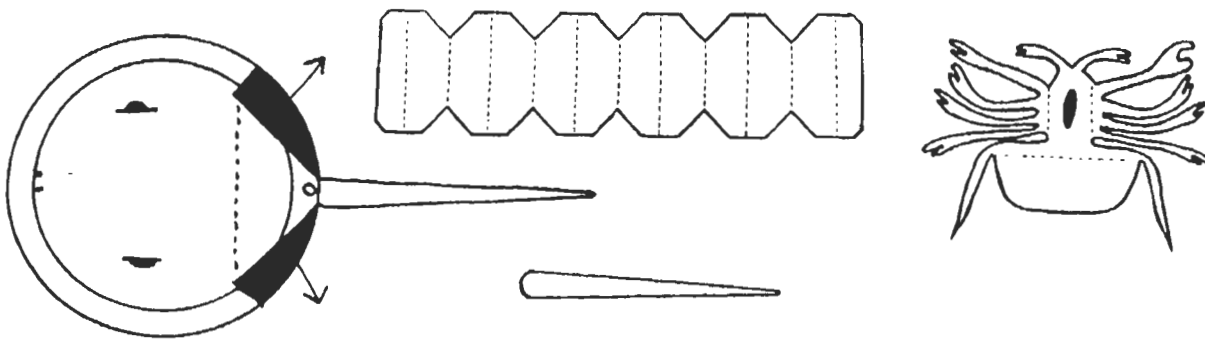
- a) Obtain a live horseshoe crab and place it in a large tray with some seawater. The gills must remain moist.
- b) Small horseshoe crabs can be purchased through a Biological Supply Co. for classroom study.
- c) Observe and describe its size, color, shape and protective adaptations.
- d) Locate the following parts: cephalothorax, abdomen, tail, eyes, mouth, book gills and walking legs.

2. Explorations

- a) How does the horseshoe crab move?
 - Observe all of their legs as it moves forward. Which pair of legs seems to provide the forward thrust? Describe the shape of these legs in comparison with the others.
 - Small horseshoe crabs are capable of swimming. How might they do this?
 - Turn over the horseshoe crab. How does it right itself? The tail spine is not used as a weapon.
- b) How does the horseshoe crab sense its environment?
 - Locate its four visible eyes. The two large ones are compound eyes. The two small ones are eyespots which detect light. Many microscopic photoreceptors are also present on its tail.
- c) Is your horseshoe crab a male or female?
 - Look at the first pair of walking legs to determine the sex of the horseshoe crab. If the first pair resemble scissors like the majority of the walking legs, then it is a female. If the first pair resemble boxing gloves, then it is a male. Males use these clasper-like claws to attach to the female's shell during spawning.
 - A size comparison of adult horseshoe crabs can also indicate their sex. Females tend to be considerably larger than males.

3. Horseshoe crab model

- a) Paint a 6" paper bowl brown inside and out. Cut out the two triangles as indicated below.
- b) Make some accordian style gills and a section of walking legs out of brown paper.
- c) Tape the gills and legs to the underside.
- d) Cut out a tail and attach it to the abdomen with a paper fastener.



4. Research

- a) Why is the horseshoe crab considered a "living fossil?"
- b) Why is the horseshoe crab not really a crab?
- c) Why is the horseshoe crab important to biomedical research?

Northern Rock Barnacle (*Balanus balanoides*)



Classification: Phylum: Arthropoda; Class: Crustacea

Description: Northern Rock Barnacles are crustaceans which resemble small white volcanoes. Their limy shell consists of a fixed cone and a moveable cap or trapdoor. The cone is made up of six fixed plates, while the trapdoor is composed of four movable plates.

Habitat: These common intertidal creatures are found from the Canadian Maritimes to as far south as Delaware. Colonies of barnacles make up the recognizable white band within Maine's intertidal zone.

Movement: After completing their planktonic developmental stage, rock barnacles sink to the bottom and seek a suitable site for permanent attachment. The glue that they produce is secreted by a pair of cement glands located in their antennae.

Respiration: Rock barnacles do not have any gills. Gas exchange is accomplished directly through the skin of their mantle cavity and their thoracic appendages.

Ingestion: In order to trap small food particles in the water, rock barnacles utilize their six pairs of jointed appendages. These legs or "cirri" rise out of their shell and rhythmically pull food back into the body cavity.

Growth: The plates of their protective shell grow by the addition of new material to the edges of these plates. The living animals found within these shells grow by molting their skin-like exoskeletons.

Excretion: Digestive wastes are excreted from the anus into the mantle cavity and flushed to the outside.

Nervous System: Their most important sensory organs are the sensory hairs found on their appendages. The reduced brain and attached ventral ganglia control the animal's activities.

Circulation: A simplified blood pump called the "rostral sinus" circulates blood through the mantle.

Reproduction: Barnacles are hermaphrodites. Fertilization occurs when the penis is extended into a neighboring barnacle and sperm cells are released. Eggs develop in a protective chamber within the mantle cavity and hatch out as free-swimming microscopic larvae.

Common Names: "acorn barnacle," "rock barnacle"

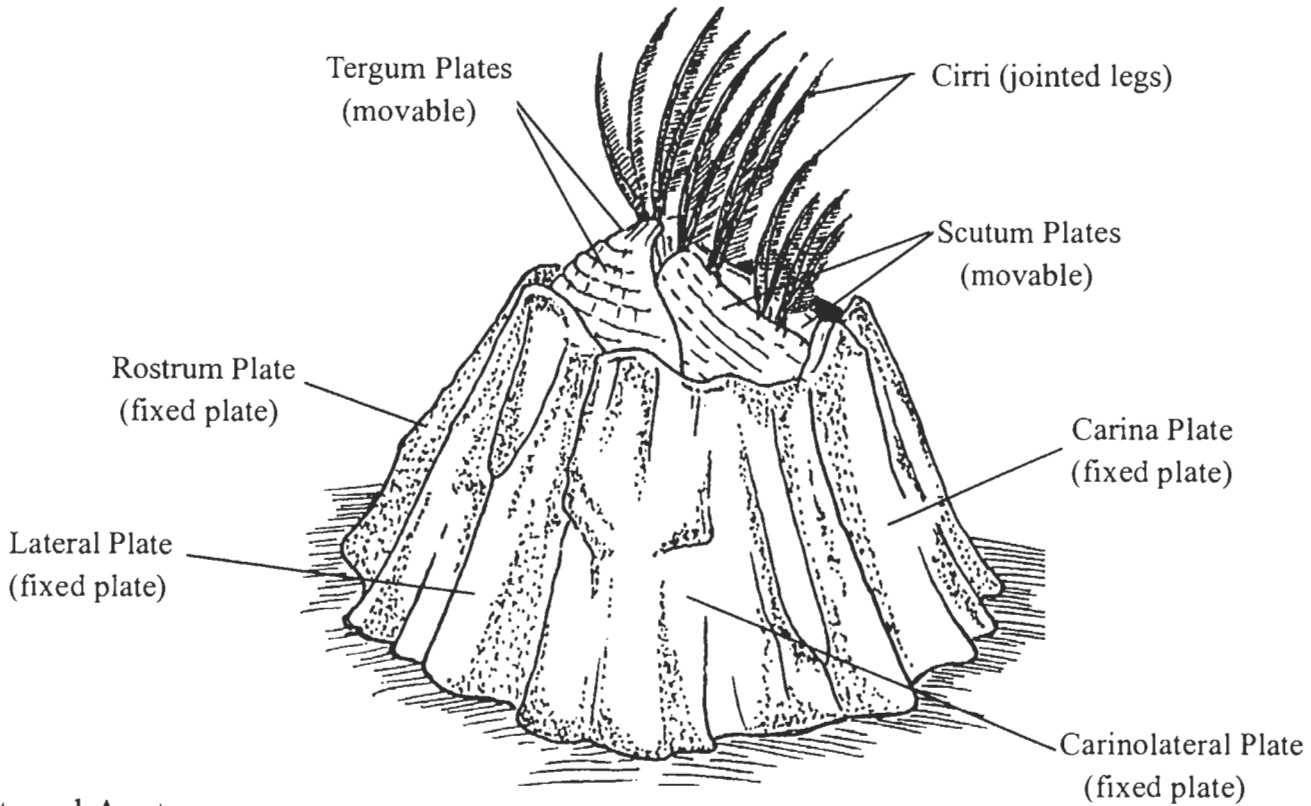
Predators: Dog whelks, sea stars, and bottom-feeding fish like cunners prey on barnacles.

Commercial Value: Barnacles have no commercial value. However, major industries have developed for the prevention and removal of these marine pests from boat hulls.

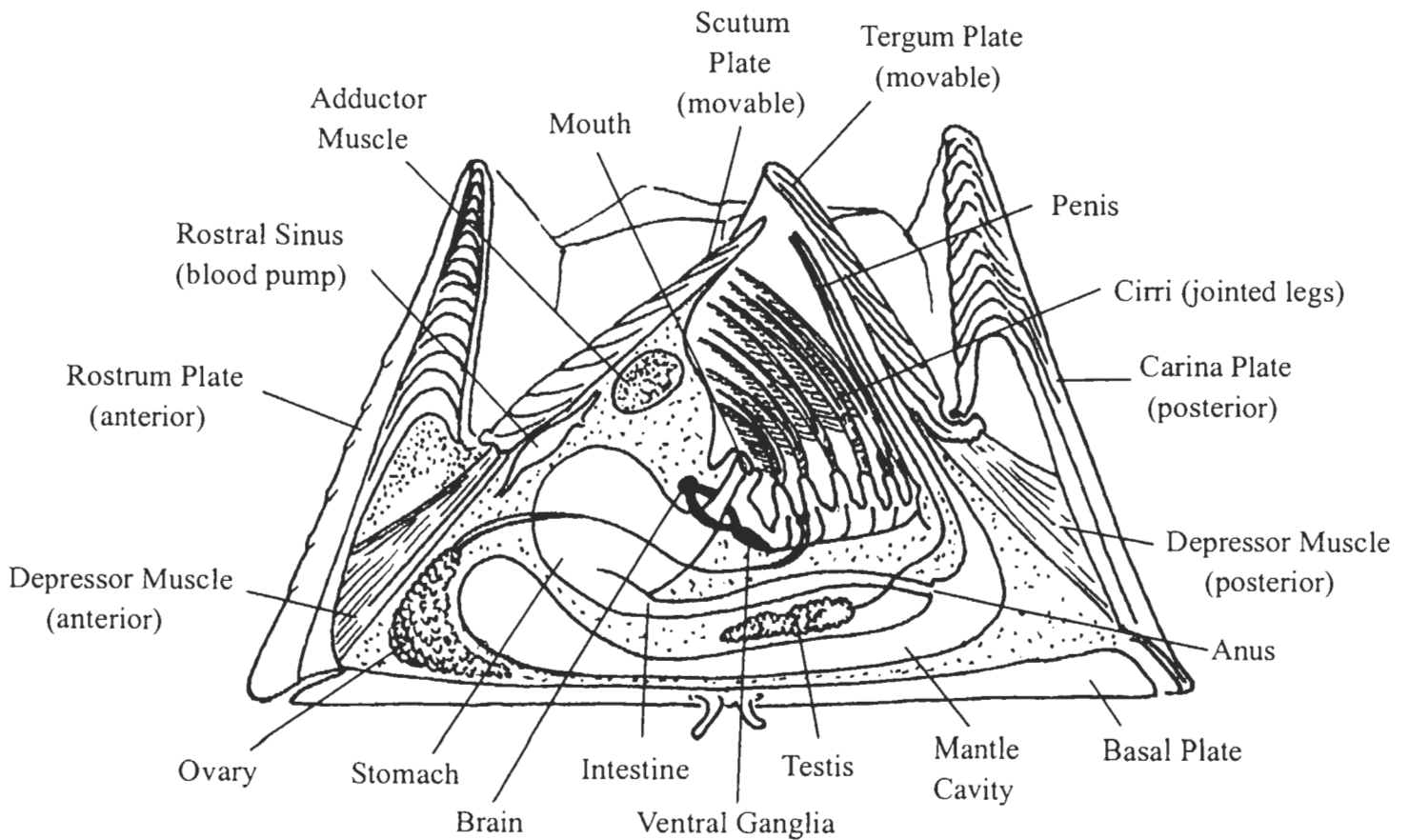
Other Gulf of Maine Species: Ivory Barnacle (*Balanus eburneus*), Crenate Barnacle (*Balanus crenatus*) and Goose Barnacle (*Lepas anatifera*)

Northern Rock Barnacle

External Anatomy



Internal Anatomy

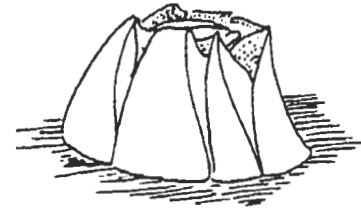


Gulf of Maine Species of Barnacles



Northern Rock Barnacle
(*Balanus balanoides*)

- rough, folded, white shell that varies in shape
- base of the shell is not enclosed or calcified
- grows up to one inch in size
- commonly found attached to rocks in the intertidal zone



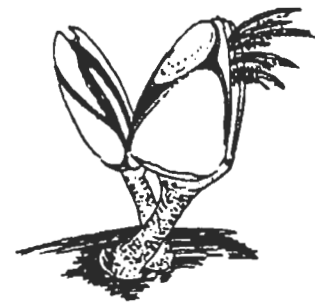
Ivory Barnacle
(*Balanus eburneus*)

- shell plates are smooth and ivory white
- base of the shell is enclosed or calcified
- may grow up to one inch in size
- can be found in the estuaries where the water is nearly fresh
- also found subtidally in shallow waters
- a common fouling species on boat bottoms



Crenate Barnacle
(*Balanus crenatus*)

- base is calcified but its side plates are hollow-chambered
- may grow to two inches in size
- boreal species found primarily from the Arctic to Cape Cod
- subtidal species found in deep water



Goose Barnacle
(*Lepas species*)

- body is compressed into five limy plates
- mounted on a rubbery stalk
- will grow to 1 3/4 inches tall
- mainly pelagic as a fouling organism in open ocean waters
- often found washed ashore after a major storm attached to drift wood or buoys

Barnacle Activities

1. Observations of live barnacles

- a) Submerge the live barnacles in a clear container of seawater.
- b) Observe them with a hand lens. Count the number of plates that make up its cone and trapdoor.
- c) Describe its size, color, shape, exoskeleton and behaviors.

2. Barnacles Feeding

- a) Use a hand lens to observe the barnacles feeding.
- b) Six pair of jointed legs or cirri exit the cone and attempt to grab food. Describe this process.
- c) Turn off the air/filtration systems before introducing food. Use an eyedropper to add about 25 brine shrimp to the water.

3. Explorations

- a) How does water temperature affect the feeding rate?
 - Count how many times per minute the cirri exit for each recorded temperature.
 - Repeat the process four times and then determine the average rate for each temperature.
- b) How does salinity affect the feeding rate?

Salinity is measured in parts per thousand (o/oo) and the average concentration in the open ocean is 35 o/oo. This means that there are about 35 grams of dissolved solids per 1000 grams of water.

 - Buy synthetic sea salt (pet store). Mix up different salinity solutions and mark each container.
 - Count how many times per minute that the cirri exit for each concentration.
 - Repeat the process four times and then determine the average rate for each.
- c) How does light affect the feeding rate?
 - Shine a flashlight upon the barnacles. Does this affect their feeding rate?
 - Cast a shadow upon the barnacle. Does this affect their feeding rate?
- d) Do barnacles have a preference to their substrate?
 - Design a number of settling plates for planktonic barnacles to out settle on. Vary the shape, material and position of the settling plates in the water. Be sure that water is able to freely pass over them and that they are easy to remove from a frame for future study.

4. What is a barnacle's house made of?

- a) Discover what barnacles are made of by using an eyedropper to place a few drops of acetic acid (vinegar) on the plates of a dead barnacle. Observe with a hand lens. (Vinegar and other acids will form carbon dioxide in the presence of calcium compounds, thus the vigorous bubbling.)

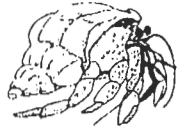
5. Role-playing Activity

- a) Have the students imitate barnacles by pretending to cement their head and back to the floor.
- b) Read the following description and have the students role-play. You are a shrimp-like animal sitting upside down in a volcano-shaped house. The tide comes in and the trap door to your shell house opens. Your feathery legs sweep the water for plankton which you kick down to your mouth. The tide goes out and you close up tightly.

6. Research

- a) The effects of these marine hitchhikers on ship hulls and whales.

Hermit Crab (*Pagurus acadianus*)



Classification: Phylum: Arthropoda; Class: Crustacea

Description: Hermit crabs are easily recognized by their unique behavior of occupying an abandoned gastropod shell. These animals do this in order to protect their soft abdomen. Their anterior body is protected by a hard reddish brown exoskeleton.

Habitat: These creatures are rarely found in tide pools preferring the safety of deeper subtidal conditions. They are commonly found in shallow (wading depth) water at low tide on sandy bottoms. This northern species of crab ranges from Canada to as far south as Chesapeake Bay.

Movement: Hermit crabs have five pairs of legs which are used for several functions. The first set have large claws used for feeding and protection. The next two pairs are used for walking. The last two pairs function in holding their body in their acquired shell.

Respiration: Gills, used for gas exchange, are protected under the carapace of their cephalothorax.

Ingestion: They are primarily scavengers feeding on dead flesh that they may encounter, including meat from their own kind.

Growth: In order to grow, hermit crabs must molt. They may have to find a new snail shell to inhabit after they increase in size. Acadian hermit crabs can reach a carapace size of 1 1/4 inches in length.

Excretion: Antennal, or green glands, are utilized by these crabs for excretion of liquid waste. Digestive wastes are passed out the posterior anus.

Nervous System: Nerves carry impulses from their eyes, antennules and antennae to the brain. A ventral nerve cord runs the length of the body.

Circulation: Hermit crabs have an open circulatory system. The blood flows through vessels into sinuses which surround the body organs.

Reproduction: The male hermit crab fertilizes the female just after she molts. The resulting fertilized eggs are carried and protected within her acquired shell until they hatch.

Common Names: " Acadian Hermit Crab"

Predators: Crabs, lobsters and fish prey upon hermit crabs.

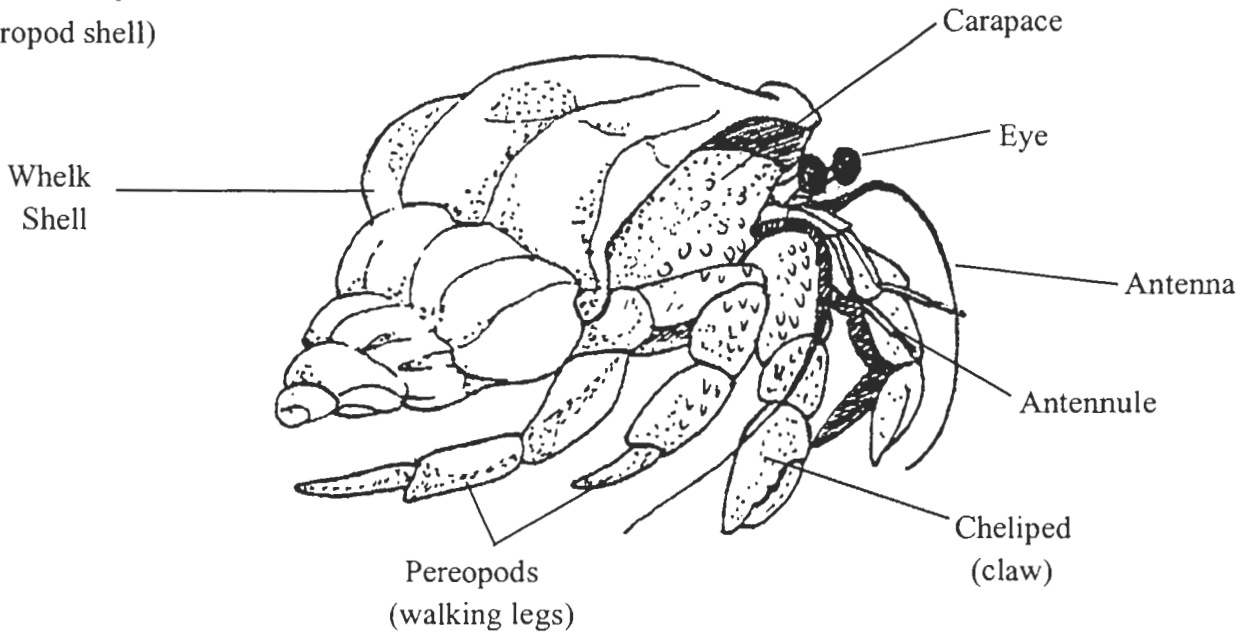
Commercial Value: None

Other Gulf of Maine Species: Flat-clawed Hermit (*Pagurus pollicaris*), and Hairy Hermit (*Pagurus arcuatus*)

Hermit Crab

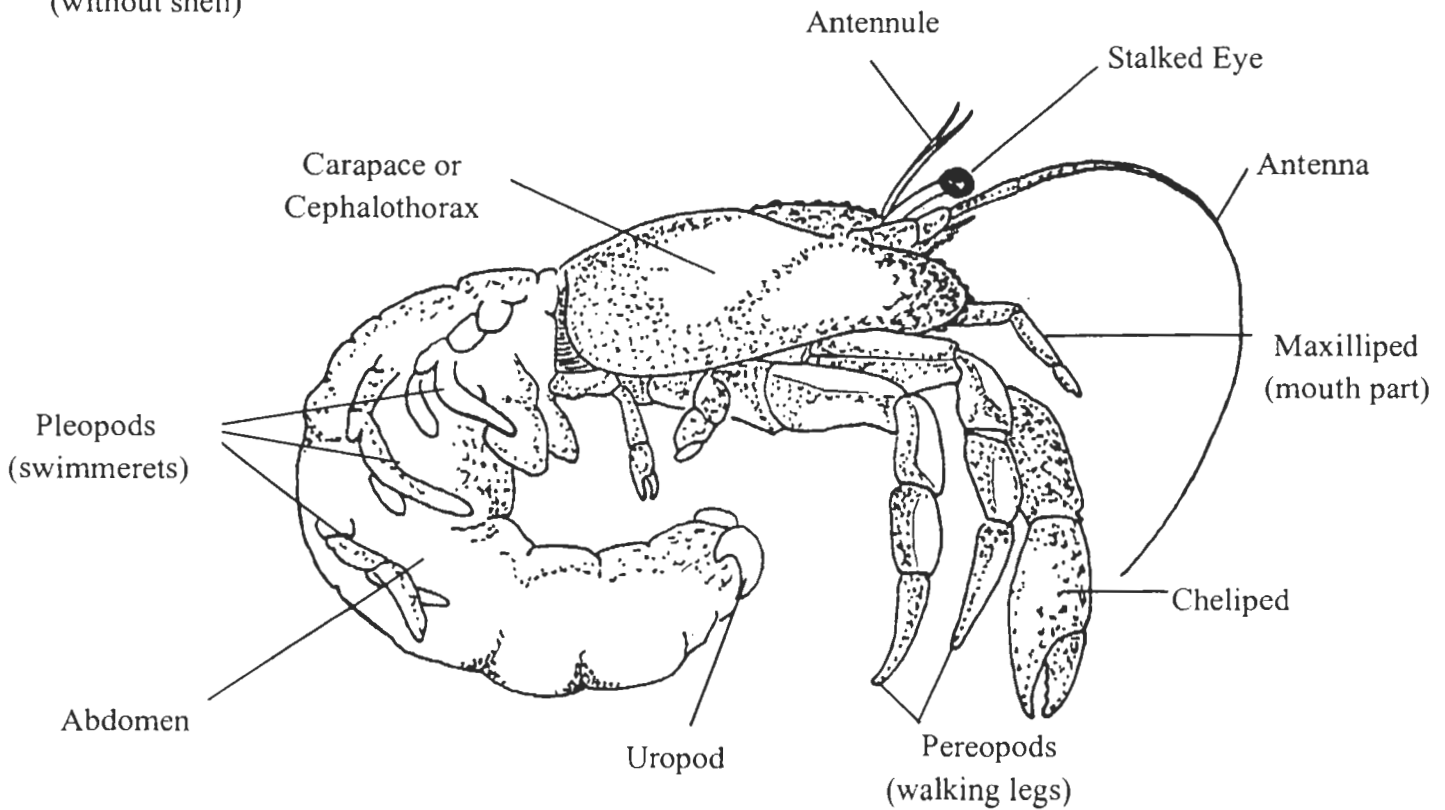
External Anatomy

(in gastropod shell)

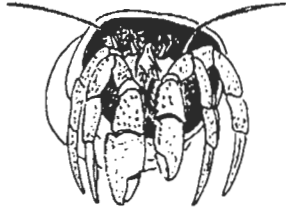


External Anatomy

(without shell)



Gulf of Maine Species of Hermit Crabs



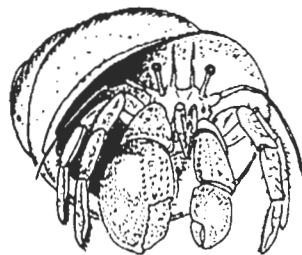
Acadian Hermit Crab
(*Pagurus acadianus*)

- major claw moderately wide with a bold orange stripe
- claw covered with tubercles
- boreal or northern species
- sometimes found in tide pools



Hairy Hermit Crab
(*Pagurus arcuatus*)

- major claw is wide
- claw heavily ridged with tubercles
- very hairy looking with long bristles
- found from the Arctic south to Long Island
- chiefly a subtidal species



Flat-Clawed Hermit Crab
(*Pagurus pollicaris*)

- major claw is broad and flat
- claw covered with tubercles
- largest hermit crab
- occupies whelk and moon snail shells
- chiefly a subtidal species

Hermit Crab Activities

1. Observations of live hermit crabs

- a) Place a live hermit crab in a clear container of seawater.
- b) Observe and describe its size, color, shape, sensory devices, protective adaptations, movement and behaviors.
- c) How is it different from other crabs? How many legs are used as walking legs? How do the first pair of legs differ from the rest? How do these claws differ from one another?
- d) Notice the long antennae. How might they help the hermit crab?
- e) Notice their eyes located at the ends of stalks. Why are they situated like this?

2. Observations of land hermit crabs

- a) If you would like a hermit crab in your classroom but not the fuss of a saltwater aquarium, purchase a land hermit crab from your local pet store.
- b) How does this land crab compare to its marine cousin?
- c) Research how is it capable of surviving out of water?

3. Explorations

a) Studying shell selection

- Remove a hermit crab from its adopted shell by placing it in a pan of seawater and heating it to 34C. Remove the crab by gently grabbing it with a pair of forceps.
- Place the shell-less crab in a pan of seawater and observe its behavior.
- Place shells of different sizes and shapes in with the crab. Observe its behavior and preference.
- Why do hermit crabs seek a snail's shell as a home?

b) Examining snail fur

- Colonies of hydroids sometimes encrust snail shells containing hermit crabs.
- Use a hand lens to examine the fur-like coating on the shell. Describe its appearance.
- Other animals such as sea anemones also attach themselves to a hermit crab's shell. How would the presence of the anemone help the crab? How would the anemone be helped by being located on the crab's shell? Research this form of symbiosis called "mutualism."

4. Bulletin Board - A Hermit crab's body.

- a) Enlarge the drawing of the hermit crab's body and shell onto a poster board.
- b) Cut the body into parts such as head, abdomen, claws, legs and antennae. Laminate for durability.
- c) Place the body parts, labels for the parts and push pins into a container near the bulletin board.
- d) Allow the children time to assemble the hermit crab.

5. Read the story Pagoo by Holling Clancy Holling. An intricate study of tide pool life is presented through the story of Pagoo, a hermit crab.

6. Creative Writing: Write a story about "The adventurous travels of a hermit crab" in search of a new home.
Write a story about "Why the hermit crab lives in a shell."

Rock Crab (*Cancer irroratus*)



Classification: Phylum: Arthropoda; Class: Crustacea

Description: Rock crabs have smooth, reddish colored shells which are sometimes speckled with purple dots. These decapods have five pairs of jointed legs with the chelipeds being identical in shape.

Habitat: Rock crabs are commonly found in the intertidal and subtidal waters from Labrador to South Carolina. They prefer rocky areas which provide crevices for protection.

Movement: They walk in a sideward manner by use of their four pairs of pointed walking legs. While moving, the four leading legs pull, and the four trailing legs push. The chelipeds are not used in locomotion.

Respiration: Stiff closely-branched gills are adapted for gas exchange. They are found under the carapace attached to their walking legs.

Ingestion: Rock crabs are primarily scavengers that feed on dead animals. Whenever the opportunity exists, they will prey upon animals that they can capture. Food is passed from the claws to the maxillipeds and then to the mouth.

Growth: An adult crab can grow up to four to five inches in width and weigh eight to ten ounces. In order to grow, crabs must molt their exoskeleton. Regeneration of missing or damaged appendages can occur.

Excretion: Green glands act like kidneys as they filter wastes from the blood. These glands also maintain an internal balance eliminating excess water or salts. Digestive wastes exit through their anal opening.

Nervous System: Nerves carry impulses from the eyes, antennules, and antennae to the brain. There is a ventral nerve cord with segmental ganglia that runs the length of the body.

Circulation: They possess an open circulatory system where the blood is not contained in vessels but pools around their major organs in sinuses. Their bluish-colored blood contains a copper-based pigment.

Reproduction: After mating, the females carry their eggs under their wide abdomen or tail. The larvae hatch out of the eggs, become planktonic and then settle to the bottom as miniature adults.

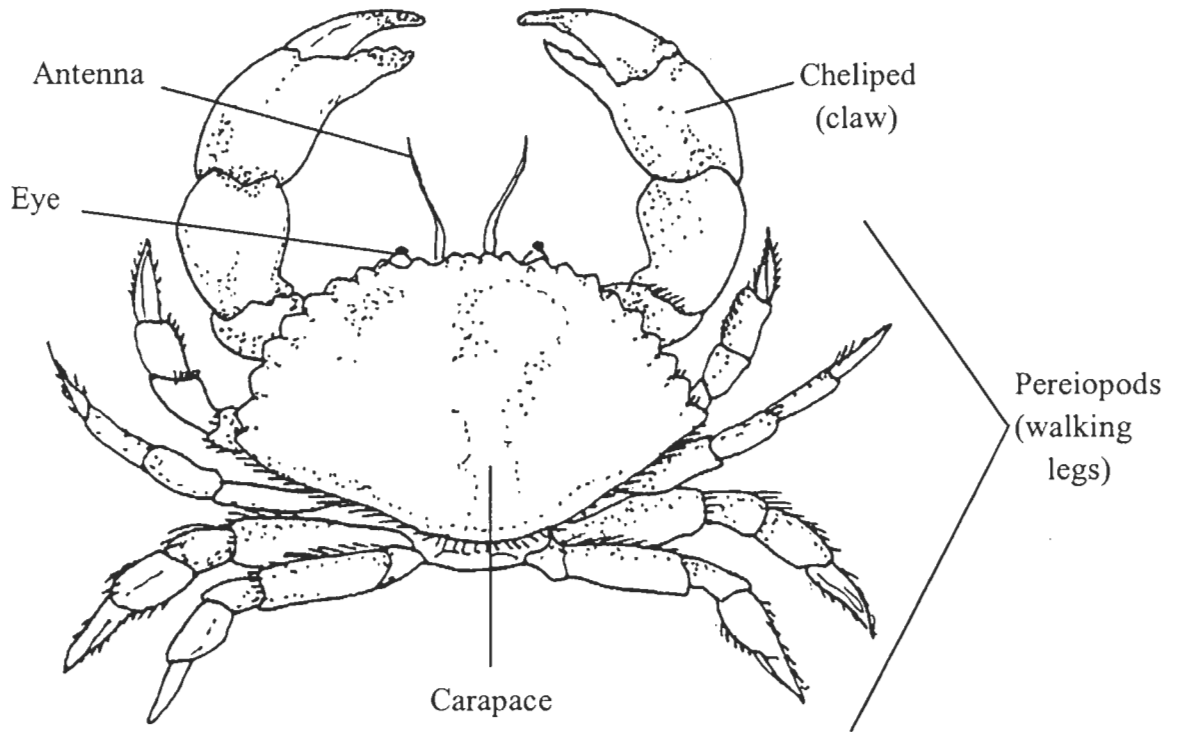
Common Names: "Cancer crab," "eelgrass crab," "mud crab" and "sand crab"

Predators: They are preyed on by cod fish, lobsters, sea gulls, herons and humans.

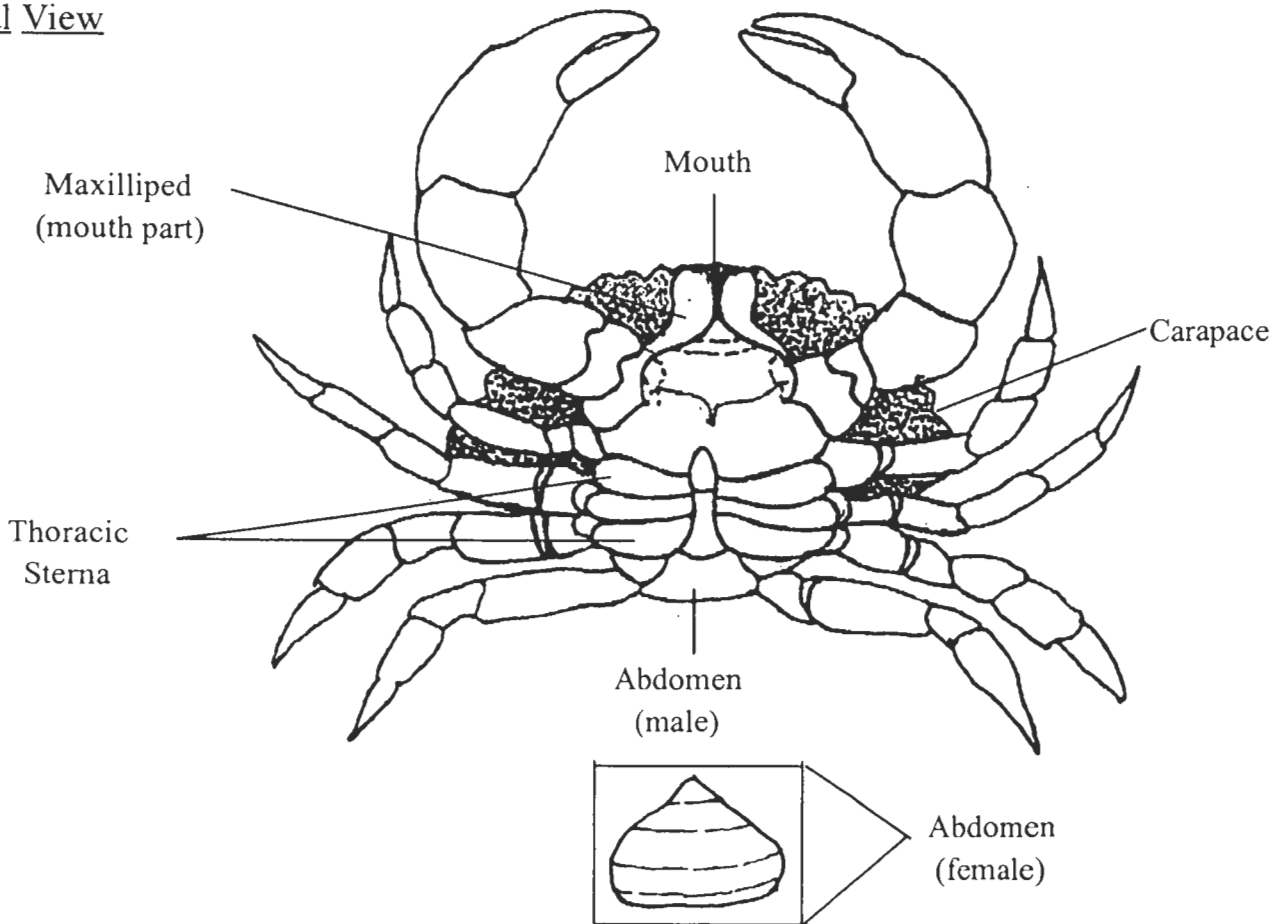
Commercial Value: Maine's 2002 catch was 997,769 pounds valued at \$423,097.00. Most of Maine's crab industry is a "by-catch" of the lobster fishery.

Other Gulf of Maine Species: Jonah Crab (*Cancer borealis*), Green Crab (*Carcinus maenas*), Toad Crab (*Hyas araneus*), Northern Stone Crab (*Lithodes maia*), and Deep-sea Red Crab (*Geryon quinqueiensis*)

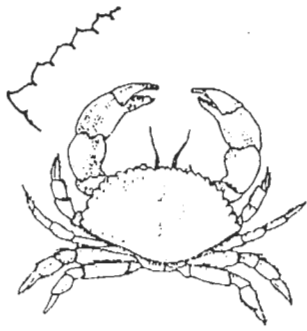
Dorsal View



Ventral View

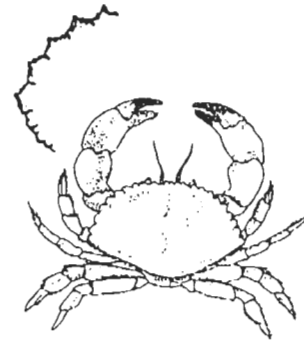


Gulf of Maine Species of Crabs



Rock Crab
(*Cancer irroratus*)

- yellowish, freckled with reddish or purplish brown spots
- shell is oval with nine smooth marginal teeth
- carapace is smooth
- grows to 5 1/4 inches in size
- intertidal but more commonly subtidal in shallow water



Jonah Crab
(*Cancer borealis*)

- easily confused with the rock crab
- has jagged marginal teeth
- carapace has rough texture
- grows to 6 1/4 inches in size
- mild tempered
- usually found in deeper water than the rock crab



Green Crab
(*Carcinus maenas*)

- males and juveniles are greenish above and yellowish below
- females are greenish above and red-orange below
- small in size growing to three inches
- last pair of legs flattened but not paddle-shaped
- most common New England shore crab
- found intertidally under rocks, seaweed and in tide pools



Toad Crab
(*Hyas araneus*)

- shell is narrow, triangular and reddish to olive in color
- grows to 3 3/4 inches in size
- legs are long and spindly resembling a spider
- tubercles or bumps are present on the sides and top of the body
- shell often decorated or camouflaged with plants and animals
- found subtidally on mud or pebbly bottoms

Crab Activities

1. Observations of a live green crab.

- a) Place a live crab in a container of seawater.
- b) Observe and describe its size, color, shape, and protective adaptations.
- c) How does the crab move? Describe all of its legs. How many segments in each leg? Gently work the joints of the leg to see how they allow the crab to move.
- d) Look at the shape of the tail to see if your crab is a male or female. Gently lift up the tail with your finger to observe the swimmerets. How would these structures help a female crab?

2. Collecting green crabs at the shore

- a) Locate green crabs under seaweed or rocks in the intertidal zone. Be sure to turn the rocks back over as the life on and around them are depending upon it.
- b) Place them in an observation tray and locate their external body parts.
- c) Place two crabs in a tray and observe how they interact.

3. Live Crab Race

- a) Draw a circle in the sand or make a circle using a piece of yarn.
- b) Place several crabs in the center and release them at the same time. The winner is the first crab to walk out of the marked circle.
- c) Now conduct a student crab race. Have students sit down and place their hands behind them. Now using their hands and feet, have them race between established boundaries. Remember that crabs run sideways.

4. Crab feast

- a) Purchase some live rock crabs from a grocery store or a lobsterman.
- b) Boil a few inches of water in a pot and steam them. (12 - 15 min.)
- c) Remove all of the leg appendages. Most of their meat is located in the claws, legs and leg sockets. Use a solid table knife as the tool to crack open the leg segments. Strike the top side of each segment with the handle of the knife to cleanly crack open the shell. A nut cracker may be necessary to crack open the claws. Use a pick to remove the meat from the leg sockets.
- d) If you remove the carapace, you will be able to locate the internal organs. Beware, this tends to be messy.

5. Crab vocabulary

- a) Cut out and color a large pattern of a rock crab on a piece of poster board.
- b) Cut two slits two inches wide and two inches apart in the middle of the carapace.
- c) Cut out a strip of paper twelve inches long and divide it with lines into six two inch segments.
- d) Write a vocabulary word about the crab and its meaning in each square. Examples may include: crustacean, carapace, abdomen, antenna, cheliped, molting, exoskeleton and scavenger.

6. Creative Writing

- a) A Strange Beginnings Story - Why did the crab start walking sideways?
- b) Describe the world of a tide pool from a crab's point of view.

Green Crab (*Carcinus maenas*)



Classification: Phylum: Arthropoda; Class: Crustacea

Description: Green crabs are characterized by a broad carapace with five marginal and three frontal teeth. Adults are usually greenish black in color. The coloration of the ventral surface varies; mature males are yellow, and females are reddish orange.

Habitat: Presently, they are found from Nova Scotia to New Jersey. Green crabs are our most common shore crab. They have migrated northward from the mid-Atlantic region during the last century.

Movement: Green crabs use their four pairs of walking legs to quickly move in a sideward manner over the ocean bottom. They can also dig into the bottom sediment in search of food or to escape from predators.

Respiration: Specialized gill chambers are located under the carapace on both sides of the body. The gills are attached to the thoracic appendages. A structure called the "dorsal flabellum" keeps the gills clean.

Ingestion: Green crabs are major predators of soft-shell clams. They use their two large claws to capture and tear apart their food. This food is then passed to the mouth parts for shredding before being swallowed.

Growth: Growth is accomplished by periodic molting of their exoskeleton. The adult's carapace can grow to a width of approximately three inches.

Excretion: Green glands filter liquid wastes from the blood. These glands also maintain an internal salt-and-water balance by eliminating excess water. Digestive wastes exit through the anal opening.

Nervous System: A cephalic ganglia or brain has nerve fibers that pass to the eyes and antennae. A ventral nerve cord runs the length of their body.

Circulation: A dorsal heart pumps blood to the gills and then to the various body organs where the blood collects in sinuses before being returned to the heart.

Reproduction: Mating occurs after the female has molted. Later the fertilized eggs, which are orange in color, are carried, cupped under the female's abdomen until they are ready to hatch.

Common Names: "clam crab"

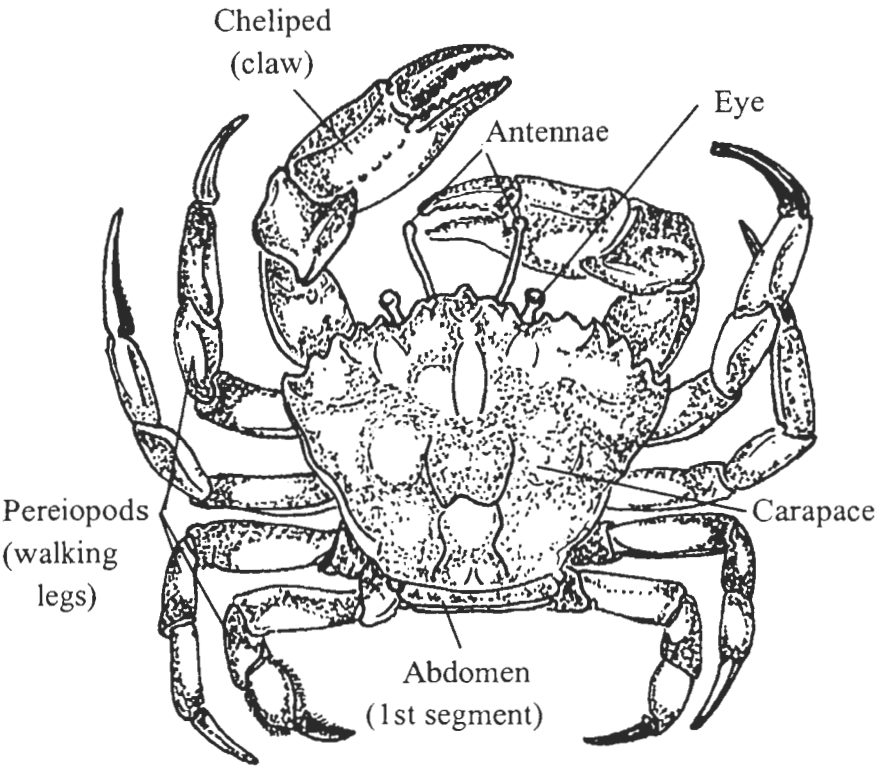
Predators: Sea gulls, bottom feeding fish, lobsters, and humans prey upon green crabs.

Commercial Value: They are of limited commercial value as they are purchased for bait by fishermen.

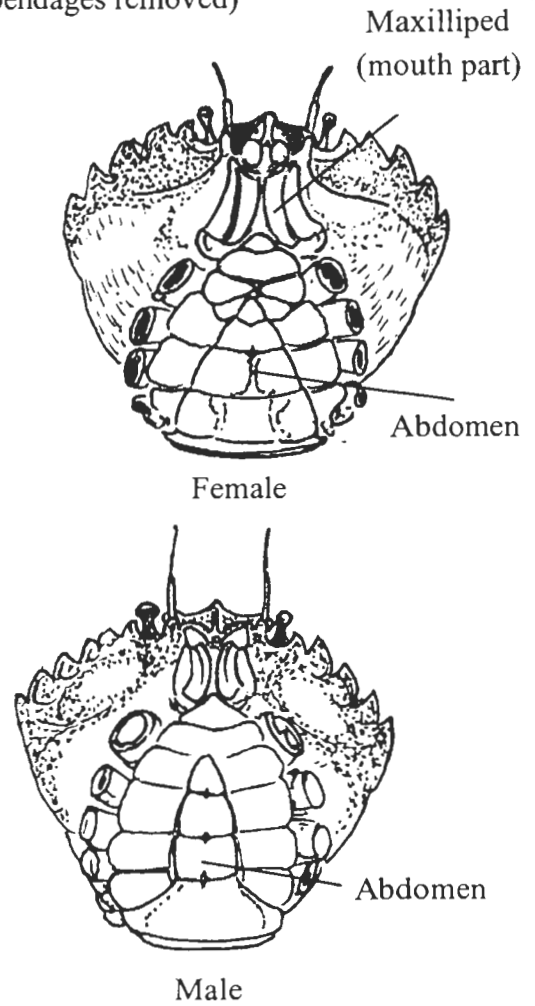
Other Gulf of Maine Species: Toad Crab (*Hyas araneus*), Jonah Crab (*Cancer borealis*) and Rock Crab (*Cancer irroratus*), Asian shore crab, an invasive species (*Hemigrapsus sanguineus*)

Green Crab

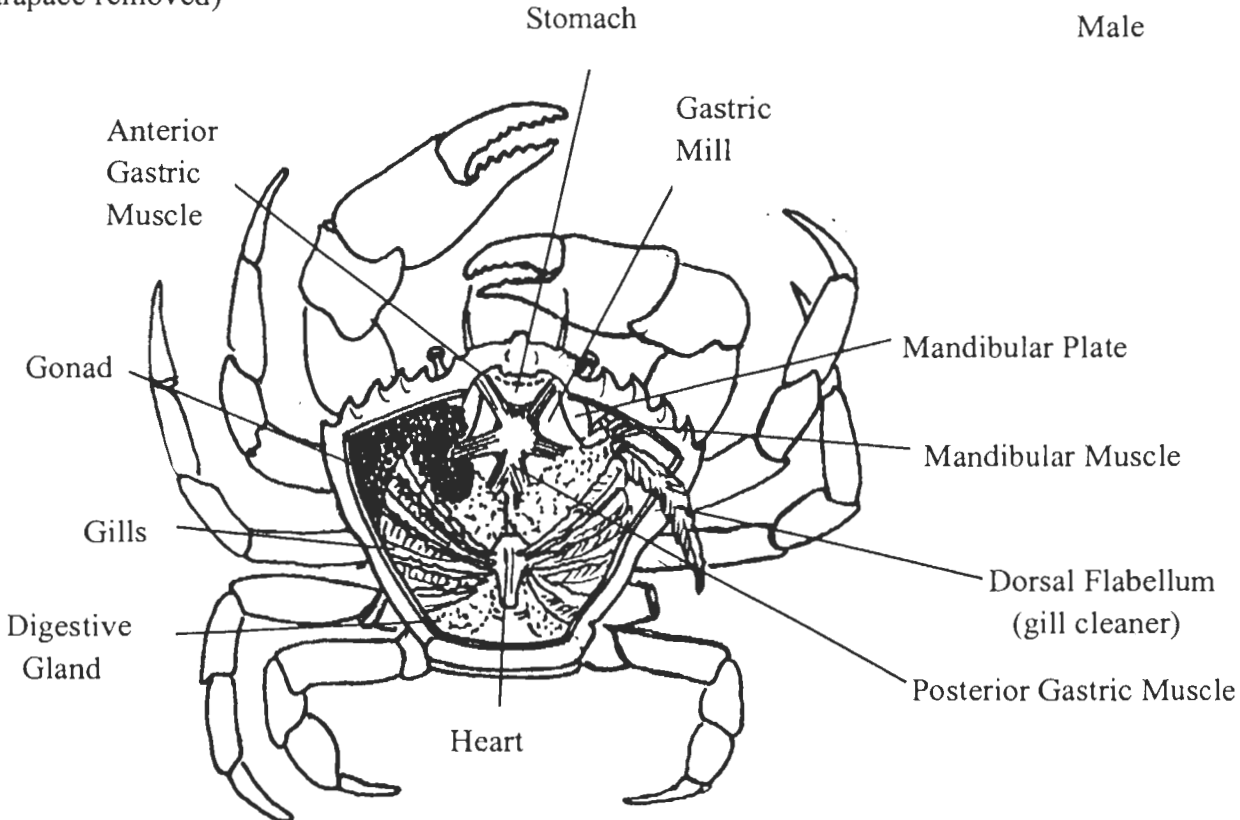
Dorsal View



Ventral View (Appendages removed)



Internal Anatomy (carapace removed)



Beach Flea (*Orchestia* species)



Classification: Phylum: Arthropoda; Class: Crustacea

Description: Beach fleas are crustaceans that are usually less than one inch in length. Their laterally compressed bodies are divided into seven thoracic and six abdominal segments. These amphipods vary in color from reddish-brown to olive-green with some species being pale and appearing colorless.

Habitat: These animals burrow under seaweed and other debris that is washed up along beaches and salt marshes. The presence of these animals is revealed when one disturbs this shore material.

Movement: Their thoracic appendages are used for swimming and digging. In an effort to escape from predators, these legs are used to propel these animals in surprisingly high jumps.

Respiration: Gills are attached to the appendages of the thoracic and first abdominal segments.

Ingestion: These animals are scavengers which feed on decaying plants and animals associated with the strand line. They use their gnathopods to transfer food to their mouths.

Growth: Similar to other Arthropods, these crustaceans grow by molting their exoskeleton. These animals can grow to be approximately one inch in length.

Excretion: Solid wastes from their digestive system are passed out their anal opening. Liquid wastes are eliminated through antennal glands in their heads.

Nervous System: Amphipods have two large compound eyes and sensory antennae on their heads. A cephalic ganglia acts as a brain by processing and transferring information to a ventral nerve cord.

Circulation: Beach fleas have an open circulatory system which means that blood is not always contained within vessels. A dorsal heart pumps blood to various body cavities called "sinuses."

Reproduction: Amphipods have separate sexes. The female carries her fertilized eggs in a specialized external brood pouch. These eggs hatch out as miniature adults.

Common Names: "beach flea," "beach hopper," "sand flea," "sand hopper"

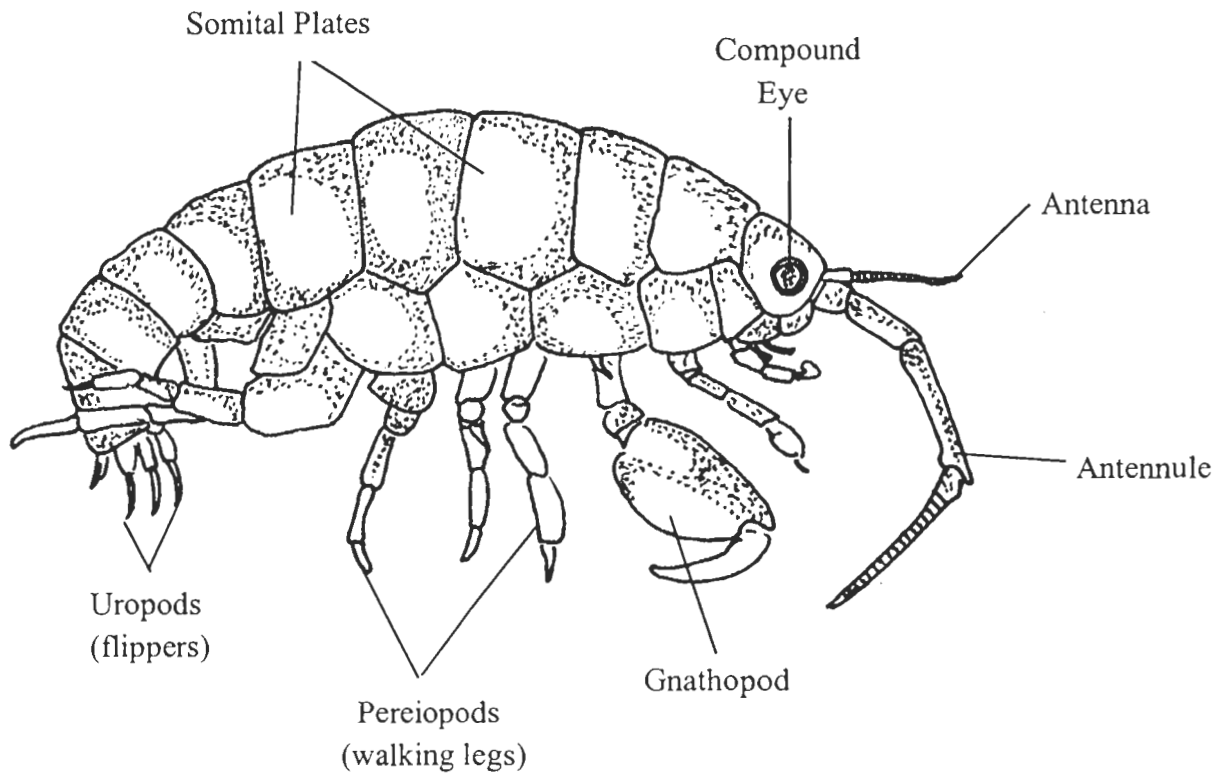
Predators: Numerous shore birds, as well as opportunistic terrestrial birds, feed on amphipods.

Commercial Value: None

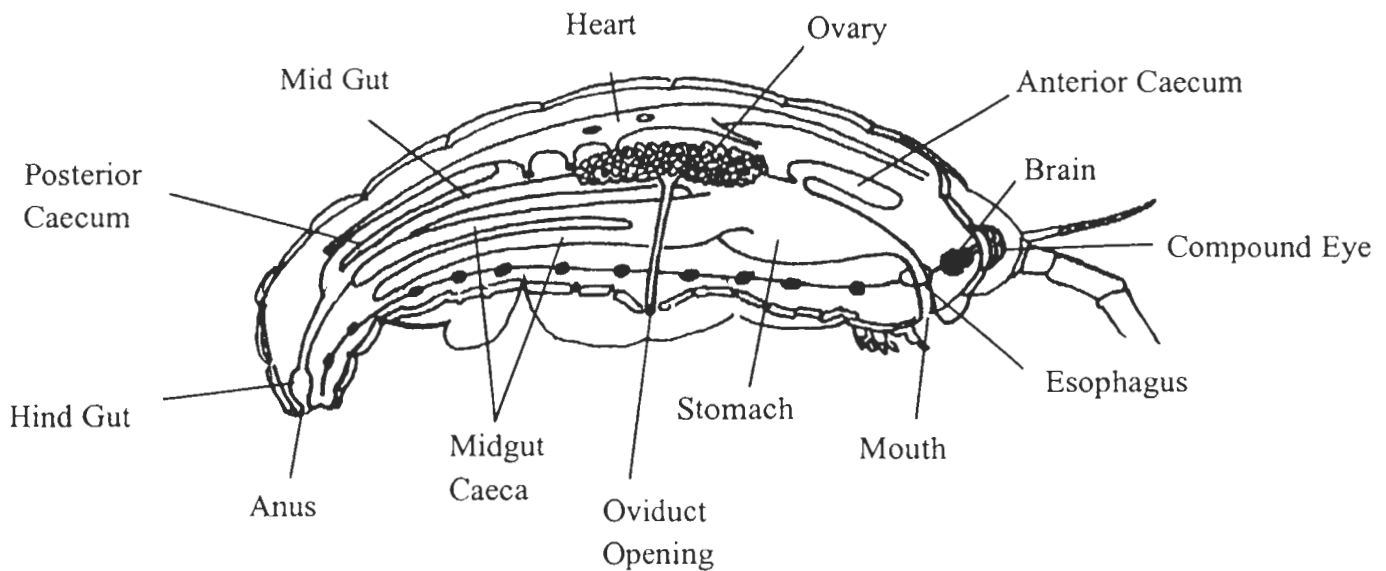
Other Gulf of Maine Species: "scuds" (*Gammarus oceanicus* and *Gammarus mucronatus*), skeleton shrimp (*Caprella equilibra*)

Amphipod

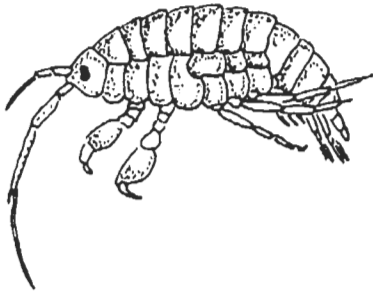
External Anatomy



Internal Anatomy



Gulf of Maine Species of Amphipods



Beach Flea
(*Orchestia* species)

- named for its jumping ability
- body is flattened from side to side
- found living at or above the high tide mark
- will hide under dead seaweeds or debris
- digs tiny burrows high up on sandy beaches



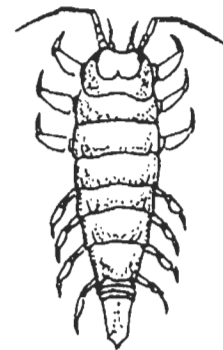
Scud
(*Gammarus* species)

- dark-colored amphipod can grow up to 1 1/2 inches
- called a "side-swimmer" due to its method of swimming.
- lives under seaweed, rocks, or in tidepools in the intertidal zone.



Skeleton Shrimp
(*Caprella equilibra*)

- long, slender, jointed body
- pale buff in color
- resembles a miniature Preying Mantis
- 3/4 of an inch long
- third and fourth body segments have paddle-shaped gills
- found among seaweeds and bushy



Isopod
(*Idotea baltica*)

- body flattened from top to bottom
- body color varies in pattern
- crawls amongst the weeds in tidal pools

Amphipod Activities

1. Observations of a living amphipod
 - a) Place a living amphipod in a container of seawater.
 - b) Observe and describe its size, color, shape and protective adaptations.
 - c) How does it move? What does it use to move?

2. Comparing the scud to a beach flea.
 - a) Collect an amphipod called a scud from a tide pool or under a rock at low tide.
 - b) Collect an amphipod called a beach flea from under the dried seaweed in the strand line on a beach.
 - c) Observe the scud in a clear container of seawater. Observe the beach flea in a tray covered with cellophane. Describe the behaviors of each.
 - d) Examine them with a hand lens to discover the similarities and differences of these two amphipods.

3. Beach hopper race
 - a) Have each student collect a beach flea from under the seaweed found in the strand line. Store them in individual containers.
 - b) Make a circle about three feet in diameter in the sand. Race only two hoppers at a time.

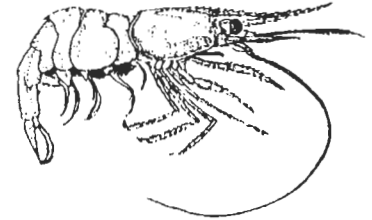
4. Rename it !
 - a) Many marine animals are odd-looking and have unusual names. Have your students write a new name for the scud along with an explanation of why they chose that name.
 - b) They can draw the picture of the animal on an index card, highlight its new name and give a reason for its new name. Example: A scud could be called a "side-swimmer" because it looks like it is doing the side stroke.

5. Sea letter mural
 - a) Roll out a large piece of paper on the floor which will serve as a wall mural..
 - b) Have the students draw or trace around templates of sea animals and sea plants onto the mural. Be sure to choose one plant or animal for each letter of the alphabet.
 - c) Label each drawing with the first letter being bold. Example: **A**mphipod
 - d) Students can choose their own plants and animals. Note the examples listed below.

A mphipod	K elp	U rchin (Sea)
B arnacle	L obster	V ase (Sca)
C lam	M ussel	W hale
D og winkle	N udibranch	<i>Xiphias gladius</i> (swordfish)
E elgrass	O ctopus	Y ellowlegs (sandpiper)
F lounder	P eriwinkle	Z ooplankton
G ull	Q uahog	
H ermit crab	R ibbon worm	
I rish moss	S ea star	
J ellyfish	T oad crab	

6. Crossword fun - Make a crossword puzzle using all of the above ABC words

Northern Shrimp (*Pandalus borealis*)



Classification: Phylum: Arthropoda; Class: Crustacea

Description: Northern shrimp are pinkish to red in color and possess a large set of black eyes. As adults, these clawless crustaceans average three to five inches in length and weigh less than one half an ounce.

Habitat: Northern shrimp live throughout the north-temperate and subarctic seas of the world. The Gulf of Maine is their southernmost limit. They prefer soft, muddy bottoms and can be found at depths of 150-600 ft.

Movement: Northern shrimp walk along the bottom using their spindly walking legs or pereopods. When swimming, they use their swimmerets or pleopods to propel themselves forward or flex their abdomen to move backwards. Schools of shrimp migrate inshore in the winter and offshore in the spring. Vertical migrations within the water column occurs daily.

Respiration: Their gills, used for gas exchange, are protected by their carapace.

Ingestion: Northern shrimp eat microscopic plankton while in their larval stage. As adults, they feed mostly on euphasid shrimp and other bottom organisms.

Growth: In order to grow, northern shrimp molt their exoskeleton. They live to be four to five years old and grow to be about five inches in length.

Excretion: Liquid wastes are removed from the blood by their green glands. The solid wastes are excreted out of the anal opening found under their telson.

Nervous System: Nerves carry impulses from their eyes, antennules and antennae to their brain. Two nerve trunks run from the brain forming a singular ventral nerve cord.

Circulation: Shrimp have an open circulatory system. Blood is pumped through vessels and pools around their major organs.

Reproduction: Northern shrimp are protandric hermaphrodites, maturing first as males before changing into females. At 2 1/2 years of age, shrimp mature as males and fertilize older females in offshore waters. After breeding, the males change into females. Adult females move into inshore waters to spawn.

Common Names: "pink shrimp," "Maine shrimp"

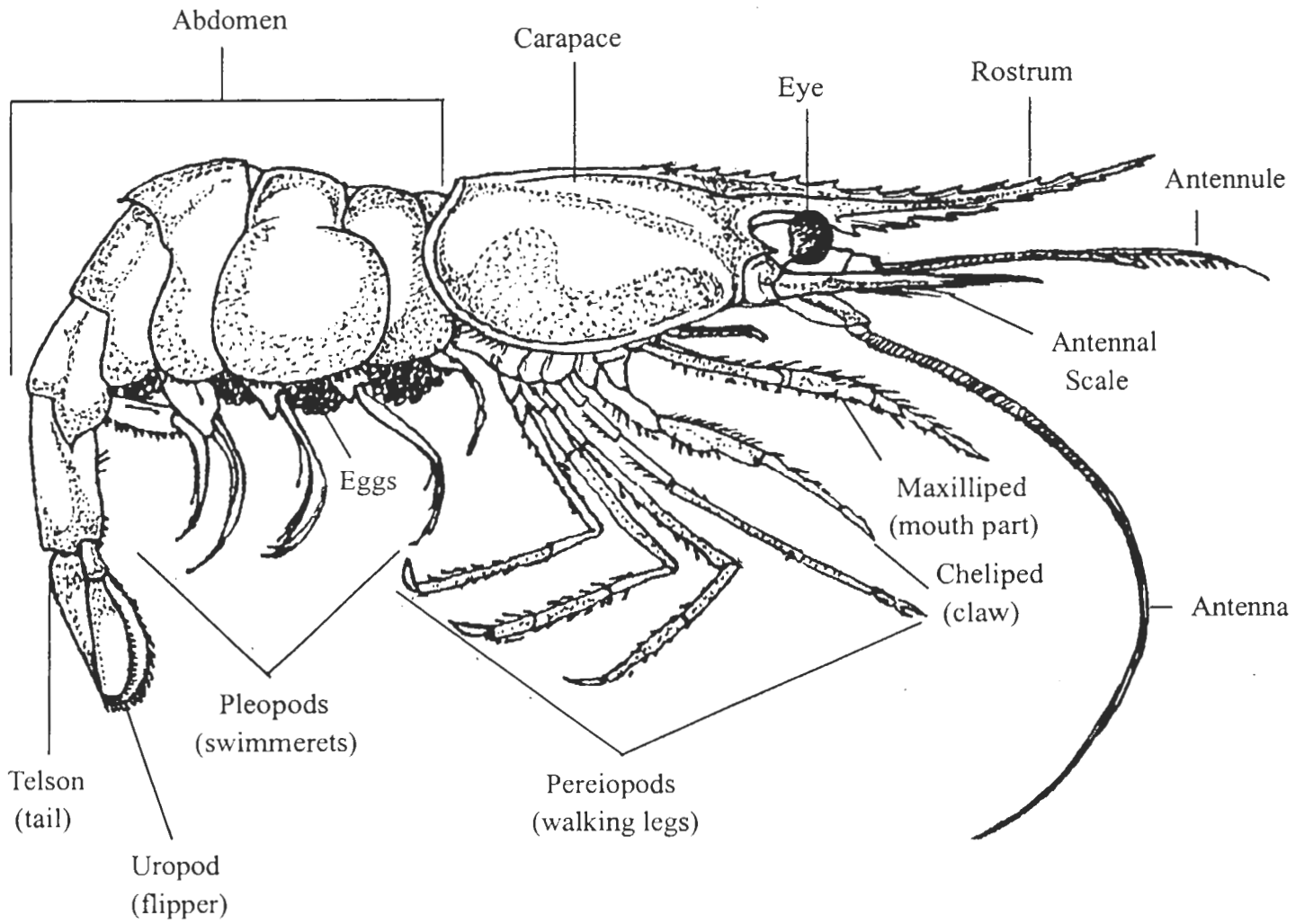
Predators: Many kinds of bottom feeding fish, as well as humans, prey on northern shrimp.

Commercial Value: Maine's 2002 catch was 853,949 pounds valued at \$914,411.00.

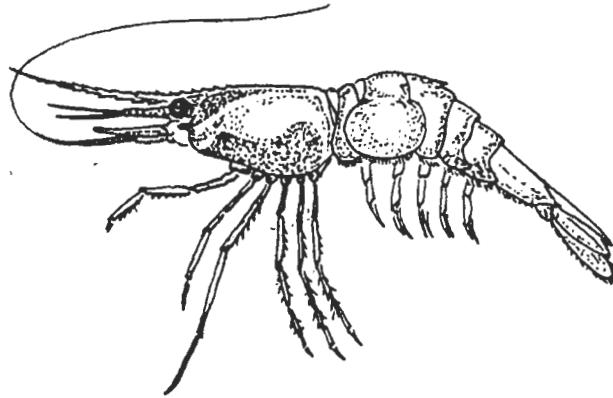
Other Gulf of Maine Species: Sand Shrimp (*Crangon septemspinosa*) and striped shrimp (*Pandalus montagui* and *Dichelopandalus leptocerus*)

Shrimp

External Anatomy

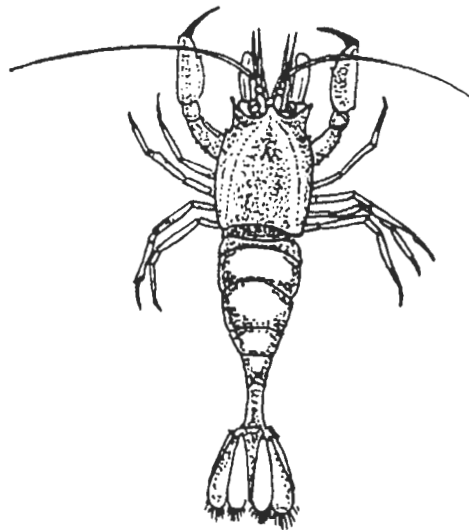


Gulf of Maine Species of Shrimp



Northern Shrimp
(*Pandalus borealis*)

- pink or reddish in color
- grows to about five inches in length
- most common edible shrimp in Maine
- sometimes called the "Maine shrimp"
- found in deep waters
- fished commercially in the winter



Sand Shrimp
(*Crangon septemspinosa*)

- varies in color from transparent to mottled brown
- grows two to three inches in length
- short rostrum
- modified claw on first pair of walking legs
- common shallow water species often found in tide pools on tidal flats

Shrimp Activities

1. Observations of "Maine" or Northern shrimp

- a) Purchase a pound of shrimp from your local fish market or truck vendor during the winter.
- b) Place a shrimp on a paper plate and allow the students to examine it. The small shrimp in the group are males. Remember shrimp are males for the first 2 1/2 years of life and will then transform into females.
- c) Observe and describe: size, color, shape, exoskeleton, sense organs and protective adaptations.
- d) Locate the following parts, count the number of each and describe their functions: eye, antenna, antennule, rostrum, carapace, maxilliped, walking legs, abdomen, swimmerets and uropod.

2. Exploration

- a) What are the bluish spheres under the tail?
 - Use a hand lens to examine the bluish spheres under the tail. Describe what you see. What might these be? The black spot in each egg is the eye of the developing shrimp.
 - Did you see any white eggs? These eggs have been attacked by a flagellated protozoan parasite.
- b) How does your shrimp measure up?
 - Straighten out the shrimp and measure its length with a ruler. How long is it (excluding antennae)? Females are 5-6 inches long and are 4-5 years old. Males are 3-4 inches long and are 2-3 years old.
 - How long are the antennae? How long are the antennules?

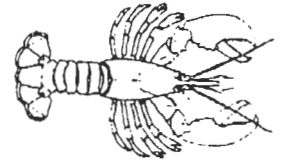
3. Shrimp book

- a) Cut, fold and staple a small booklet together and entitle it "My Shrimp Book."
- b) Glue a picture of a shrimp on the cover.
- c) Write a characteristic about the shrimp on each page.

4. Raising brine shrimp

- a) Brine shrimp are crustaceans along with lobsters, crabs, and shrimp. A bottle of brine shrimp eggs can be purchased from the pet store and they can be raised in the classroom. Your students will be able to watch them hatch and grow into adults reaching a size of 1/3 of an inch long. Students may be familiar with these animals as they are marketed under the name of "Sea Monkeys."
- b) Examining the dry eggs - Sprinkle a few of the eggs on a piece of paper and examine them with a hand lens. Describe their color, shape and size.
- c) Examining hatching eggs - Place some saltwater into a tray or dish and elevate one end. Put one end of a napkin into the saltwater and the other end over the edge of the tray so that the napkin remains moist. Sprinkle a few eggs onto the damp paper and observe the eggs periodically with a hand lens. Some of the eggs may start to split open after six to eight hours.
- d) Fill a wide mouth quart jar or bowl with well water or let chlorinated water set for 24 hours. Dissolve 2 teaspoons of non-iodized salt or "sea salt" in the water.
- e) Place about 20 brine shrimp eggs in the water and put the container where sunlight will reach it. Try to keep the temperature between 70 and 80 degrees Fahrenheit for best results.
- f) Keep only about 10 shrimp in a quart of water. For food, place one grain of dried yeast in the container each day.
- g) Study the parts and behaviors of the shrimp as they grow. You may be able to keep them alive until they produce more eggs.

Lobster (*Homarus americanus*)



Classification: Phylum: Arthropoda; Class: Crustacea

Description: American lobsters are brownish to greenish black in color and are easily recognized by their large claws. Proportionally, this species of lobster can be divided into three equal parts: claws, body and tail.

Habitat: Lobsters can survive on all types of bottoms but prefer a rocky or muddy substrate. Their range extends from Labrador to North Carolina with the largest populations being located in the Gulf of Maine.

Movement: Four pairs of walking legs, as well as four pairs of swimmerets, provide forward movement. Their muscular abdomen and tail fan, composed of a telson and uropods, allow for backward swimming.

Respiration: Gas exchange occurs in the twenty pairs of gills found in the gill chamber under their carapace. A gill bailer attached to one of its mouthparts maintains a flow of water through the gill chamber.

Ingestion: Lobsters use their two large claws called "chelipeds" to catch mussels, crabs, fish, and worms. Appendages, called "maxillipeds" and "maxillae," sort and transfer food to the mandibles for shredding.

Growth: Lobsters shed their exoskeleton in order to grow. Legal-sized lobsters are 5-7 years and have molted 25-27 times. In 1993, it became mandatory that legal-sized lobsters have a carapace length between 3 1/4 inches and 5 inches.

Excretion: Liquid wastes are excreted from their green glands through an opening at the base of their second antennae. Solid wastes pass through the intestine and out the anal opening found under the telson.

Nervous System: Their anterior brain has two nerves that unite to form the ventral nerve cord. This cord which runs toward the tail has nerve masses called "ganglia." Sensory bristles found over their entire body detect chemicals and are used for touch. Odor is sensed by their antennules and touch by their antennae.

Circulation: A simple heart pumps blood through vessels, past the gills, and into sinus cavities which surround the important organs.

Reproduction: Mating occurs shortly after a mature female molts. She produces 3,000 to 75,000 eggs depending upon her size. These eggs are carried under the abdomen for nine to eleven months.

Common Names: "American lobster," "Maine lobster" and "northern lobster"

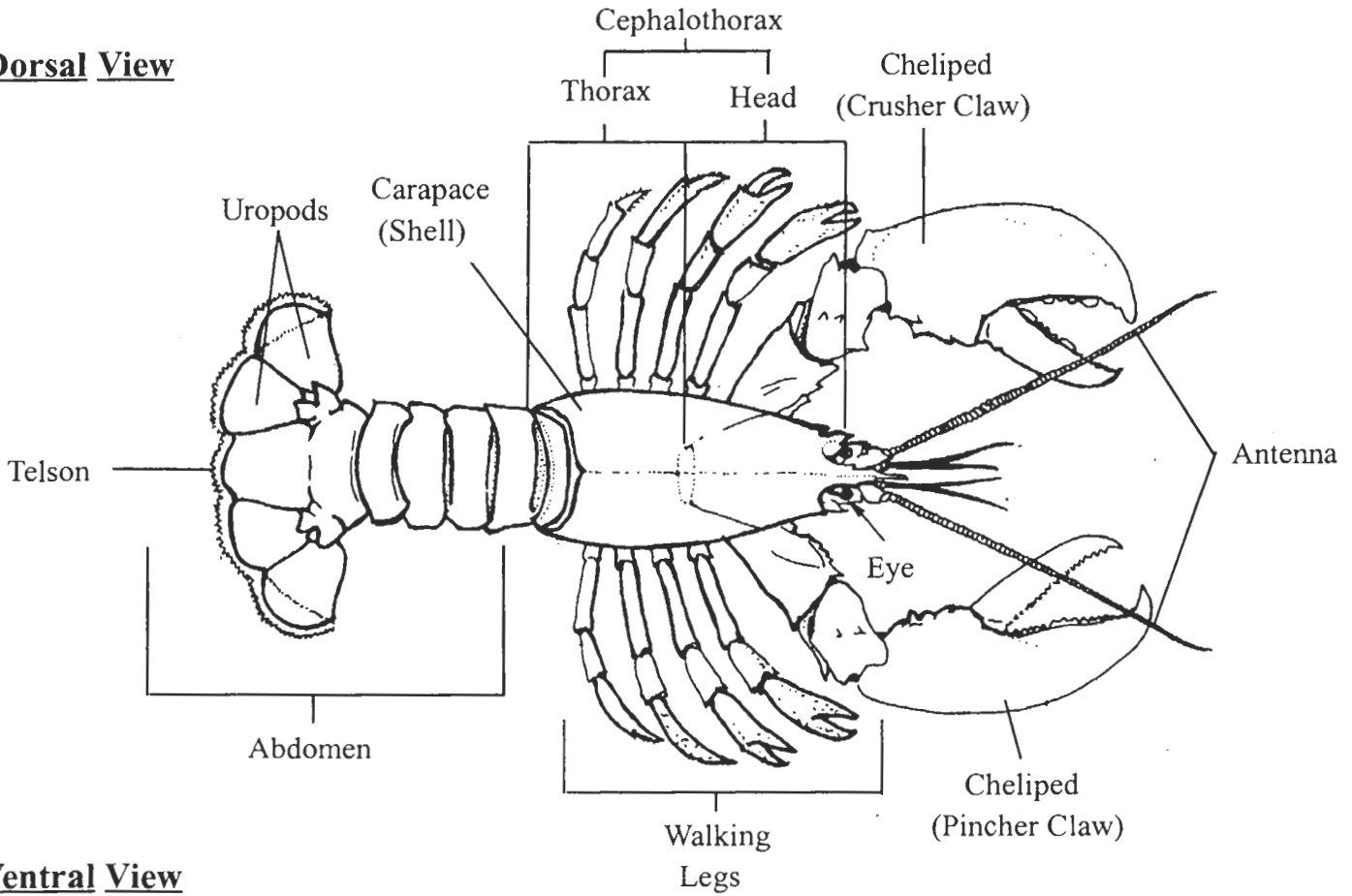
Predators: During their free-swimming larval stages, they are eaten by a large number of organisms. As adults, they fall prey to other lobsters, bottom feeding fish and humans.

Commercial Value: Presently, the lobster industry is one of the most profitable fisheries in the State of Maine. In 2002, a catch of 62,296,093 pounds brought in \$207,307,460.

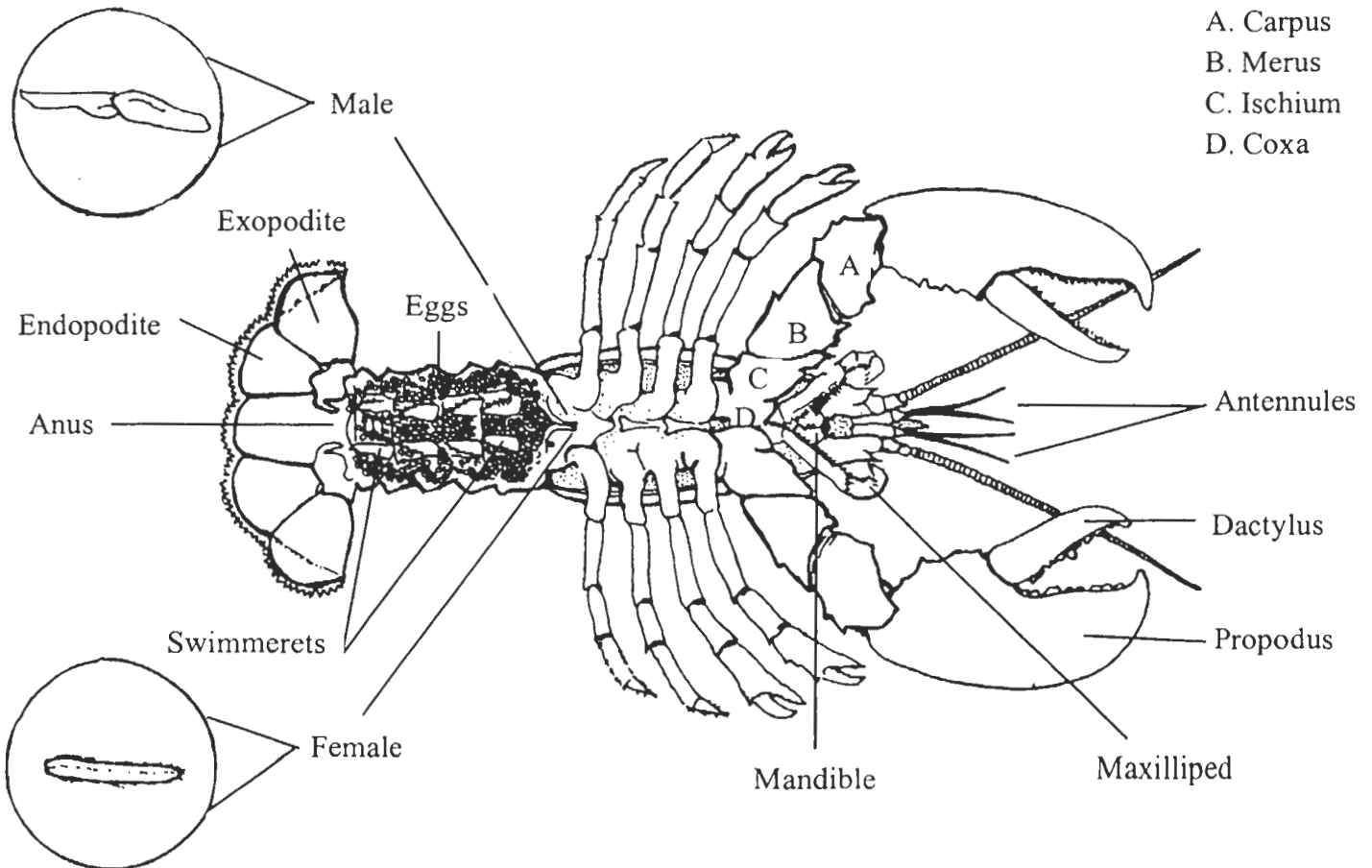
Other Gulf of Maine Species: None

Lobster

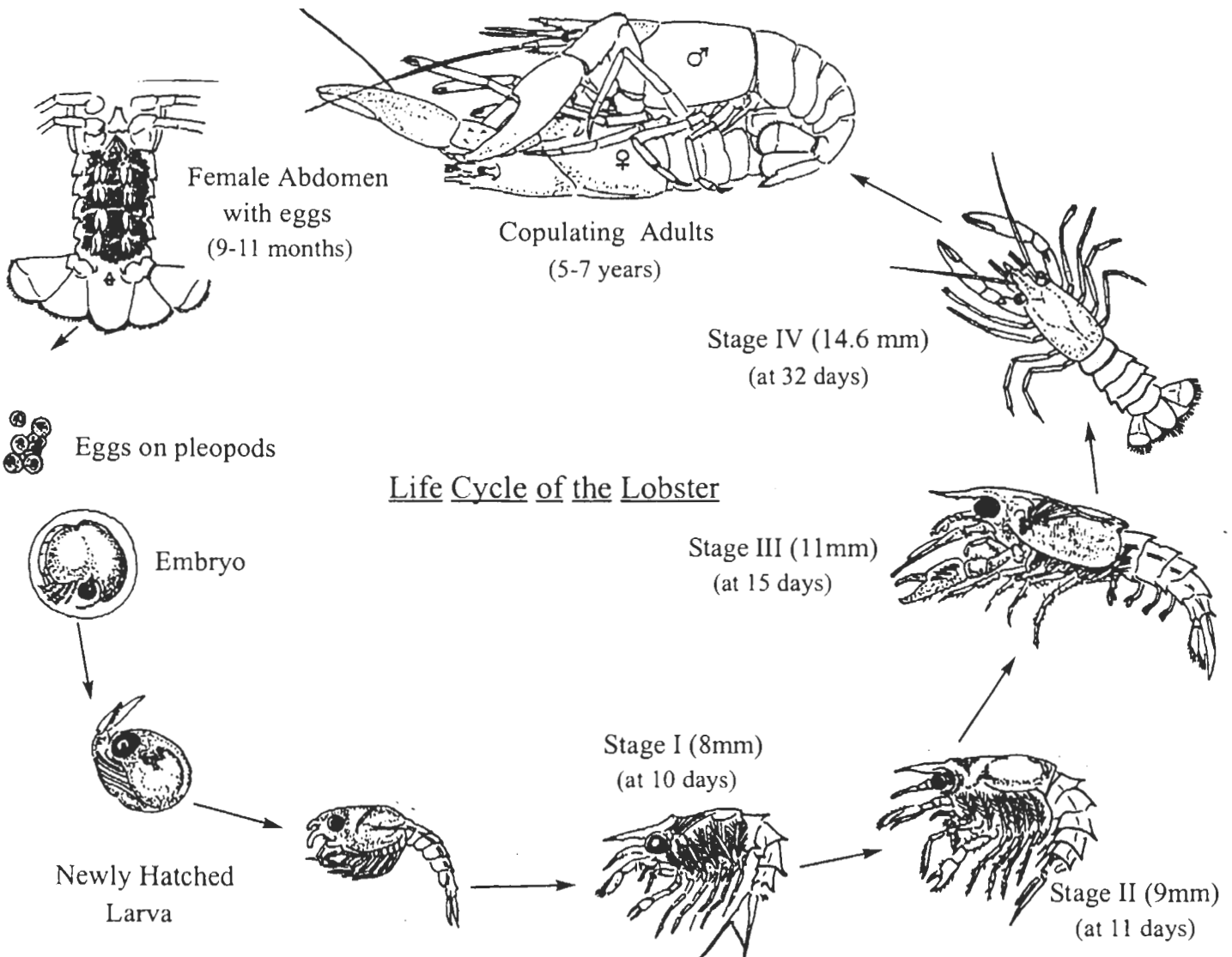
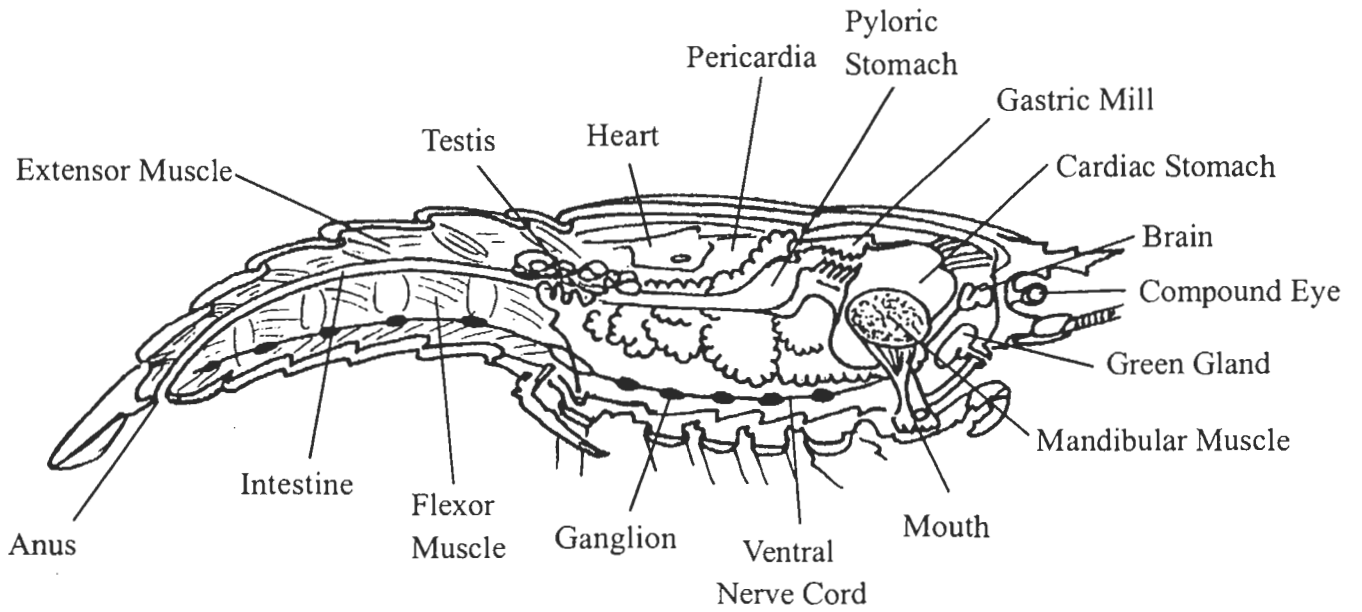
Dorsal View



Ventral View



Internal Anatomy



Lobster Activities

1. Observations of a live lobster

- a) Obtain a live lobster from your local fish market or supermarket. Refrigerate it until needed.
- b) Observe and describe its size, color, shape, exoskeleton and protective adaptations.
- c) Examine its external parts and determine how it moves, eats, senses and protects itself.

2. Points of interest

- a) Is your lobster right or left-handed? (Determined by the position of the crusher claw.)
- b) Is your lobster of legal size? (Measure the carapace from the eye socket back. The legal size limits require that the lobster's carapace be no less than 3 1/4 inches and no larger than 5 inches.)
- c) Is your a lobster a male or female? (Check the first pair of swimmeretts to determine its sex.)
- d) Is your lobster hard or soft-shell? (Squeeze the claw for firmness or rigidity in order to determine if it has recently molted its exoskeleton.)

3. Explorations

It is difficult and expensive to maintain a saltwater tank for extensive behavioral studies of a lobster. It is also necessary to obtain a special permit from the Department of Marine Resources for possession of an under-sized lobster. Thus, it is recommended to use the lobster's freshwater counterpart the crayfish to perform these studies. These crustaceans may be purchased from a bait dealer or biological supply company

- a) What does a lobster or crayfish like to eat?
 - Design a feeding study by placing small samples of food in different corners of the aquarium. Be sure not to use greasy or fatty foods and do not leave excess food that will foul the water.
- b) Does a lobster or crayfish prefer light or dark environments?
 - Darken half of the aquarium and observe the animals reactions.
- c) Where does your crustacean prefer to hide?
 - Provide your animal with a variety of hiding places such as a rock cavern, a PVC pipe, etc.
- d) How does your lobster or crayfish get along with another of its kind?
 - Observe the interaction of the two animals in the same aquarium.

4. Tools of the lobster industry

- a) Study the design of a typical lobster boat.
- b) Study a lobster trap. Label the following parts of an authentic trap: outer eye, kitchen, bait bag or line, inner eye, parlor, escape vent, ghost panel, weight, buoy, warp (rope) and toggle buoy.
- c) What is the function of the following tools: spudge iron, bait bag, bander, V-notcher and gauge.

5. Research

- a) The history of lobstering in Maine.
- b) The operation of a tidal lobster pound; its problems and successes.
- c) Maine's lobster fishery; commercial catch, regulations and management plans.

Northern Sea Star (*Asterias vulgaris*)



Classification: Phylum: Echinodermata; Class: Stelleroidea

Description: Northern sea stars have five rays located around a central disc. Their bodies are covered with small spines. These sea stars are orange to purple in color with a yellow madreporite.

Habitat: Northern sea stars are found intertidally and subtidally from Labrador to Cape Hatteras. North of Cape Cod, they are commonly found intertidally beneath drapes of seaweed and in tidal pools.

Movement: A hydraulic pressure mechanism known as the "water vascular system" allows the sea star to move. Water enters through pores in the sieve plate or madreporite and passes through a series of muscular canals. These canals end in hundreds of tube feet that have suction cups.

Respiration: Delicate, small finger-like projections called "skin gills" emerge from the body cavity through the calcareous skeletal plates. These structures allow for gas exchange between the water and the body fluid.

Ingestion: Sea stars feed primarily on bivalves using their tube feet to open the shells of these mollusks. They are also scavengers feeding on dead organisms. In order to eat, their cardiac stomach exits the mouth, contacts their food, and secretes enzymes for digestion.

Growth: These sea stars are usually five to six inches in size but can grow up to sixteen inches in diameter.

Excretion: A short intestine extends from the pyloric stomach to the anus. This opening is located on the central disc of the aboral surface.

Nervous System: Sea stars have a nerve ring around a short esophagus. Radial nerves extend from this nerve ring down each arm. A tiny red eyespot and sensory tentacles are located at the tip of each ray.

Circulation: Circulation is provided by ciliated cells which line the coelomic cavity.

Reproduction: The males and females release sperm and eggs into the water where fertilization occurs. The resulting planktonic larvae change from bilateral to radial in shape before settling to the bottom.

Common Names: "starfish" (but remember they are not a fish!)

Predators: Seagulls are a predator of adult sea stars, a variety of animals will feed on their planktonic stage.

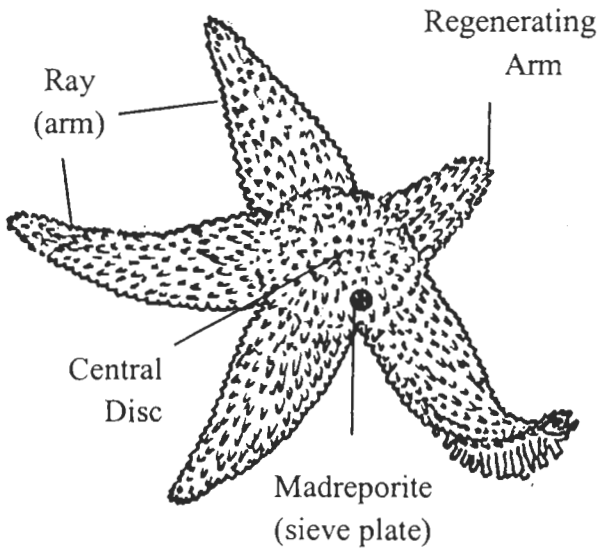
Commercial Value: None

Other Gulf of Maine Species: Common Sea Star (*Asterias forbesi*), Polar Sea Star (*Leptasterias polaris*), Mud star (*Ctenodiscus crispatus*), Blood Star (*Henricia* species), Purple Sunstar (*Solaster endeca*), Spiny sunstar (*Crossaster papposus*), Dwarf Brittle Star (*Axiognathus squamatus*), Daisy Brittle Star (*Ophiopholis aculeata*) and Basket Star (*Gorgonocephalus arcticus*)

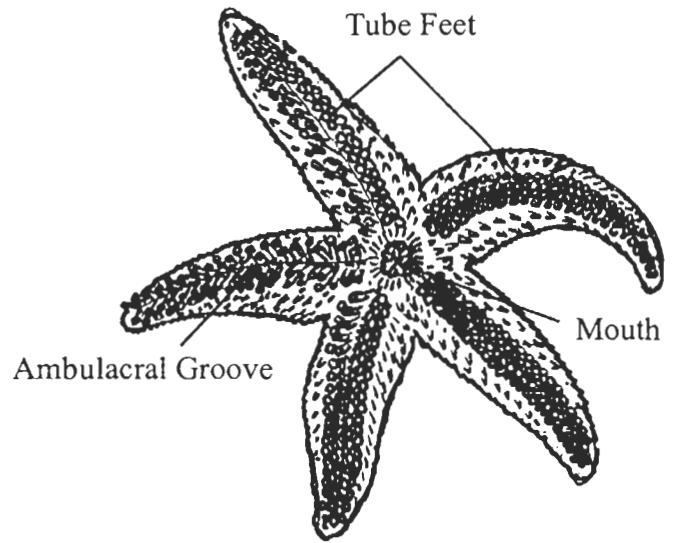
Sea Star

External Anatomy

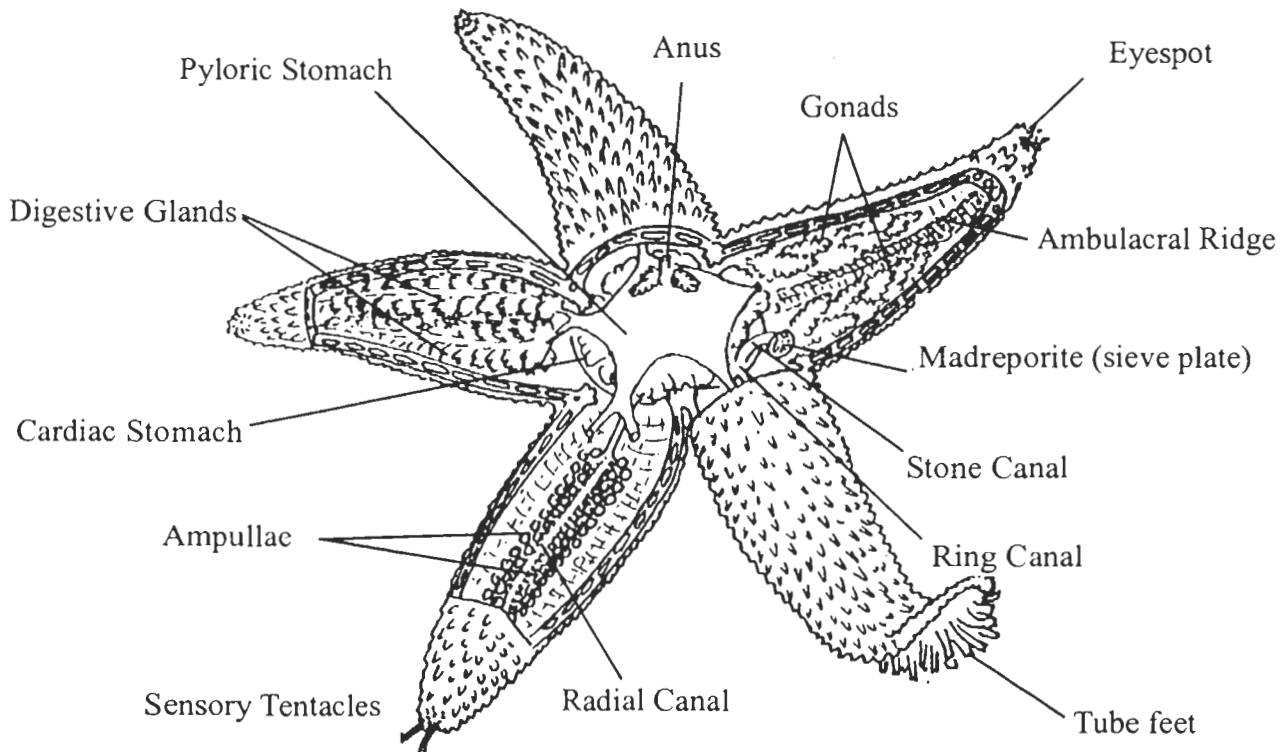
Aboral View



Oral View



Internal Anatomy



Gulf of Maine Species of Sea Stars



Northern Sea Star
(*Asterias vulgaris*)

- purplish-orange in color
- yellow madreporite
- common species north of Cape Cod
- found in tide pools



Common Sea Star
(*Asterias forbesi*)

- greenish-brown in color
- bright orange madreporite
- common species south of Cape Cod, expanding its range northward
- found in tide pools



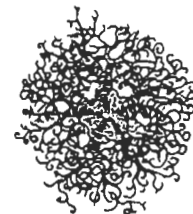
Blood Star
(*Henricha sanguinolenta*)

- usually purple-reddish color
- usually radius is up to two inches
- tube feet in rows of two instead of four
- found in tide pools and rocky shallows
- feeds on sponges



Purple Sunstar
(*Solaster endeca*)

- yellowish red to purple
- usually nine to ten arms
- grows up to a foot across
- found subtidally



Basket Star
(*Gorgonocephalus arcticus*)

- yellowish to brown in color
- branching arms form a dense tangle
- found subtidally



Daisy Brittle Star
(*Ophiopholis aculeata*)

- fragile, thin arms with long spines
- moves like a serpent
- found hidden under rocks in lower intertidal zone or entwined in seaweed holdfasts



Mud Star
(*Ctenodiscus crispatus*)

- brownish yellow in color
- almost pentagonal in shape
- subtidal on mud bottoms
- often in purchased shrimp catch

Sea Star Activities

1. Observations of live sea stars

- a) Place a live sea star in a clear container of seawater.
- b) Observe size, color, shape, sense organs, protective adaptations and behaviors.
- c) Locate the following structures on its oral (underside) surface: mouth, ambulacral groove, tube feet.
- d) Locate the following structures on its aboral (top) surface: madreporite, spines, eyespots.

2. Comparing different species of sea stars

- a) Use a field guide to identify each type of sea star. Observe and record the characteristics for each.
- b) Compare colors, sizes, shapes, rows of tube feet, spines, madreporites, etc.

3. Explorations

- a) Why doesn't a sea star have plants or animals growing attached to it?
 - What happens when you sprinkle some grains of sand on the aboral surface of the sea star.?
 - Use a hand lens or a dissecting microscope to observe the tiny pincers called pedicellariae.
 - Place the spiny surface on the hairs of your arm for a few minutes. Did the pincers grab on?
- b) How does a sea star eat?
 - Place a small clam or mussel in a container of seawater with a sea star. Observe its reaction.
 - How does the sea star go about feeding? How long does it take?
- c) How does a sea star move? Place a sea star in a clear container of seawater.
 - Examine the sea stars method of movement by holding the container above your head.
A system called the water vascular system allows the tube feet to work. Water enters through the madreporite (sieve plate) and then passes through a series of canals before ending with the tube feet.
 - Slowly empty the water from the container and hold it upside down. Observe the ability of the sea star to adhere to the container.
- d) Any signs of regeneration?
 - Measure all of the sea stars arms from the middle of the central disc to the tip of each ray.
 - Compare the lengths and decide if this sea star has regenerated a missing arm.

4. Art Activity

a) Textured Sea Star

Cut out a piece of tan oaktag in the shape of a star. Glue rice grains to the top surface. Glue cherrios in rows to the bottom surface.

5. Osmoregulation

Some organisms are capable of adapting themselves to different environments by controlling their salt and water balance while others can not. In this experiment, you will weigh a sea star before and after it is emersed in water baths of different salt concentrarions.

- a) Prepare containers each having a different salinity: 40 o/oo, 30 o/oo, 20 o/oo, 10 o/oo and 0 o/oo.
- b) Blot the animal dry using paper towels. Weigh and record the initial weight.
- c) Place the animal in 40 o/oo for 15 minutes. Weigh and record.
- d) Repeat this process with the other salinities.
- e) In each solution, determine the percent weight change $\frac{\text{Weight (end)} - \text{Weight (initial)}}{\text{Weight (initial)}} \times 100$
- f) Plot the % weight change versus salinity.

Green Sea Urchin (*Strongylocentrotus droebachiensis*)



Classification: Phylum: Echinodermata; Class: Echinoidea

Description: A Green Sea Urchin's body consists of a globe-like test covered with numerous green spines. When they are submerged in seawater, brownish tube feet can be seen extending from their body. Minute jaw-like appendages called "pedicellariae" surround their spines and are used for defense and for cleaning their body surface.

Habitat: Green sea urchins inhabit intertidal and subtidal waters of the North Atlantic from the Arctic to Cape Cod. Occasionally, this species has been found as far south as New Jersey.

Movement: These animals move by use of their numerous suctioned tube feet. These structures protrude out of five double rows of openings along their globus body. Their spines are also used to push themselves along utilizing a ball and socket arrangement.

Respiration: Five pairs of bushy external projections called "dermal gills" are located around their mouth.

Ingestion: Sea urchins feed on plant and animal matter with a retractable jaw-like structure called an "Aristotle's lantern." This complex gnawing apparatus has five pyramidal teeth.

Growth: Sea urchins can grow up to four inches in width. Growth is accomplished by a process in which these animals continually add new calcareous material to the outer surface of their plates while dissolving the inner surfaces.

Excretion: Waste products pass out through their anus which is located on the upper surface of their test.

Nervous system: A circumoral nerve ring encircles the pharynx and branches into five radial nerves that connect with their spines, pedicellaria (pinchers) and podia (tube feet).

Circulation: A large principal cavity called "the coelom" contains the transport medium. This coelomic fluid circulates nutrients and gases by means of ciliary action.

Reproduction: Sexual reproduction takes place when male and female urchins release sperm and eggs into the water through five minute openings in the upper test region. After fertilization, ciliated larvae undergo metamorphic changes in body symmetry before settling to the bottom four to six weeks later.

Common Names: "sea eggs," "whore's eggs"

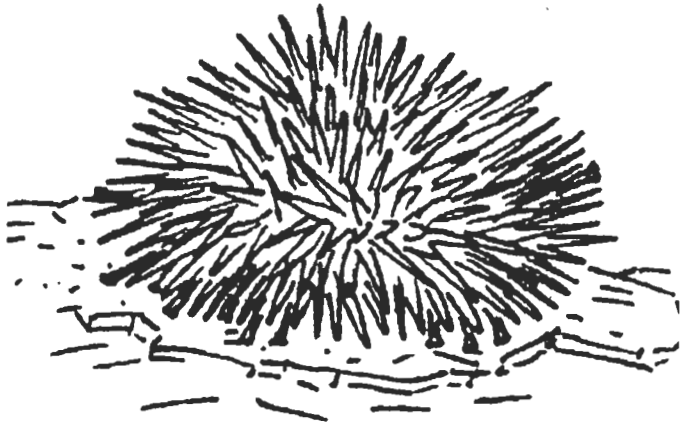
Predators: Humans, lobsters, crabs, sea birds and bottom feeding fish prey upon sea urchins.

Commercial Values: 6,321,232 pounds were harvested in 2002 at a value of \$7,657,398.

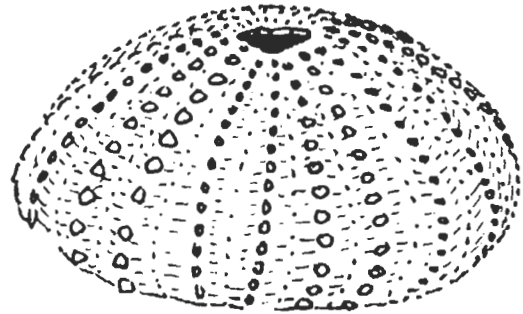
Other Gulf of Maine Species: None

Green Sea Urchin

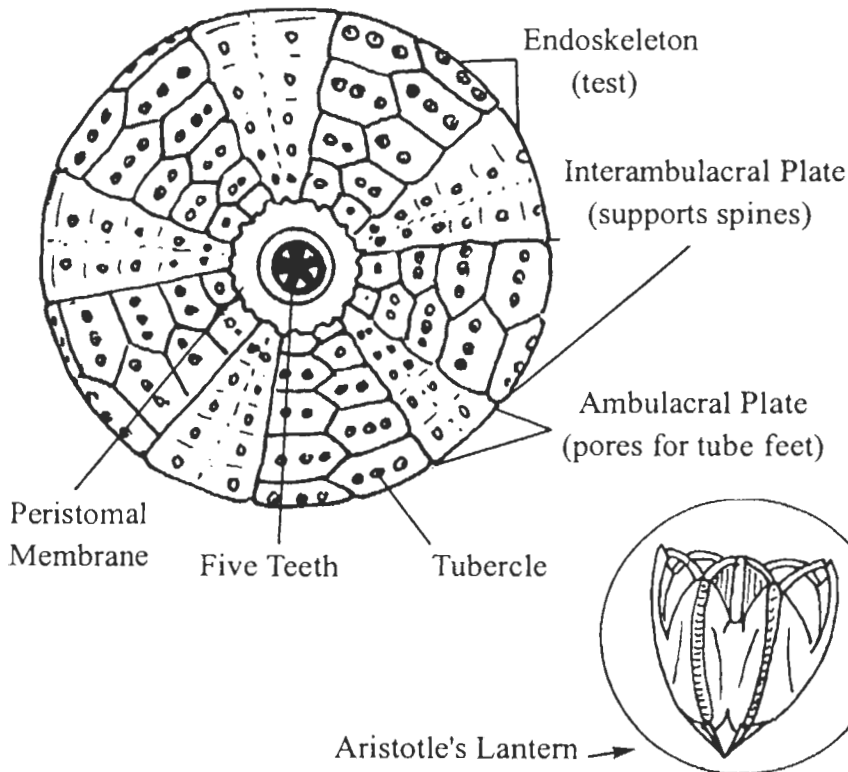
Live Sea Urchin



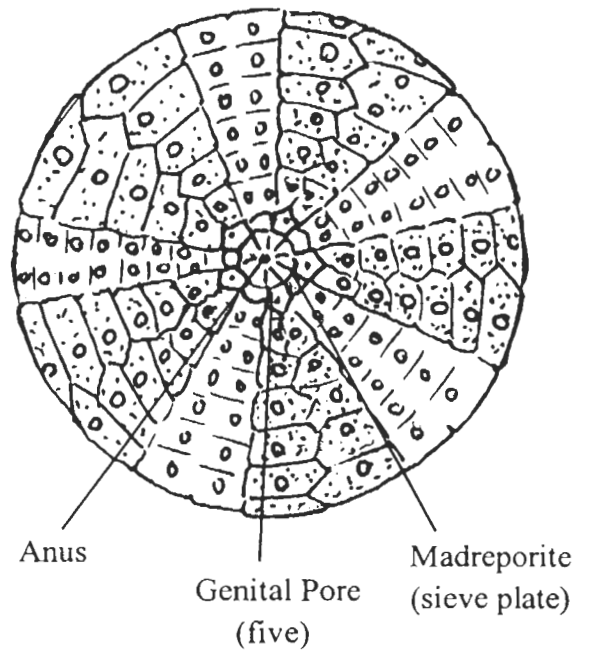
Empty Test



Oral view (spines removed)

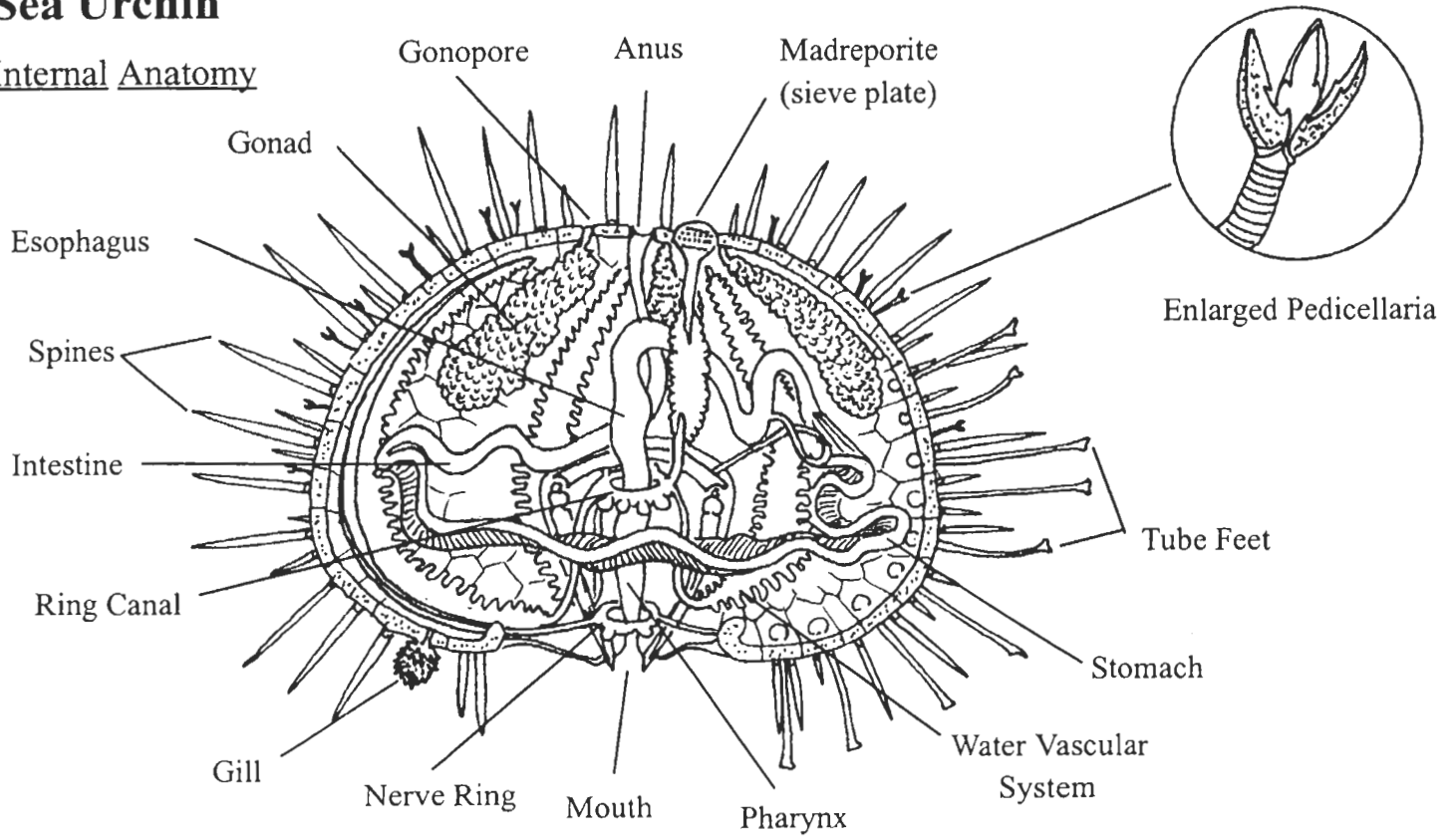


Aboral View (spines removed)

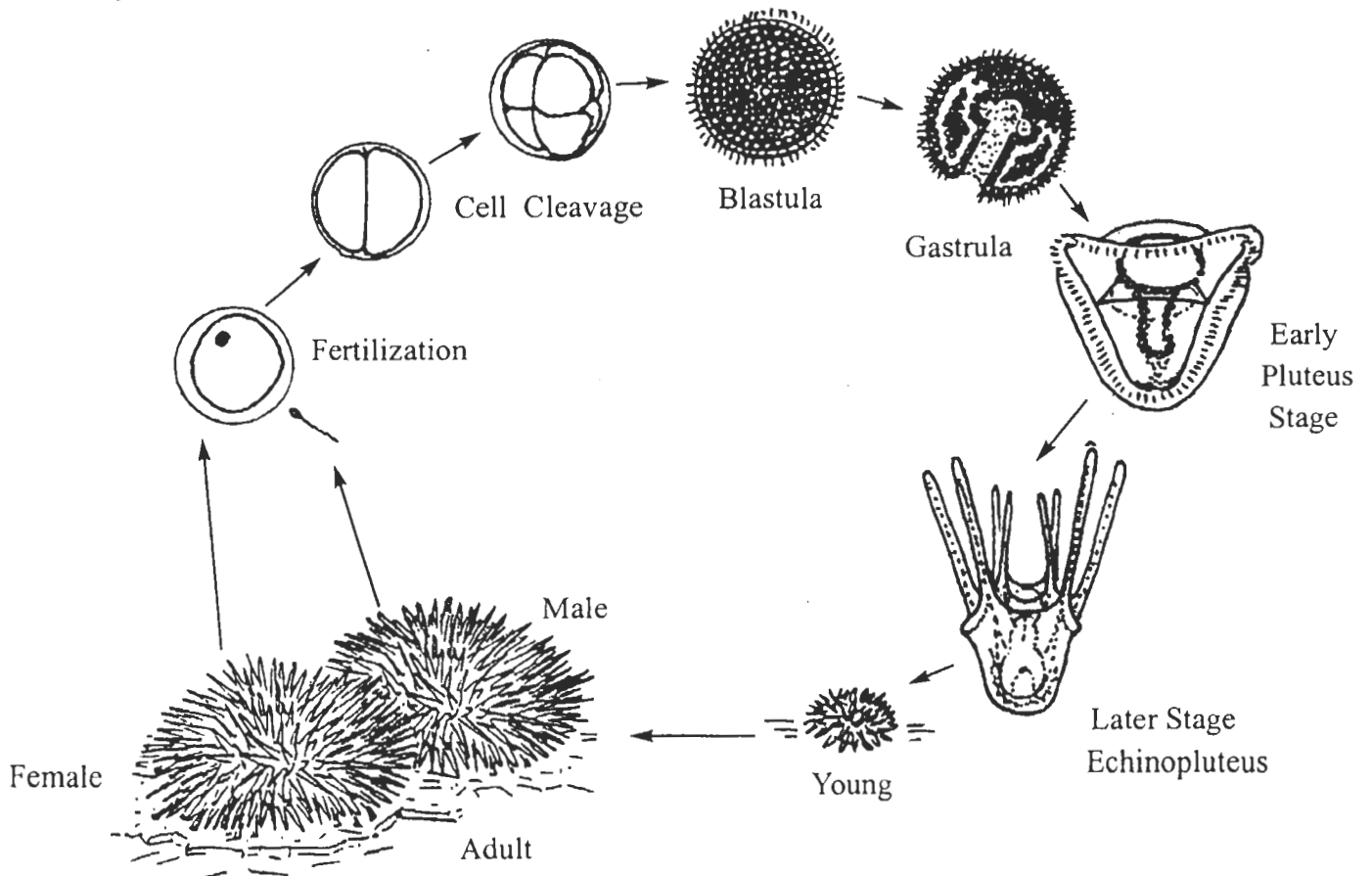


Sea Urchin

Internal Anatomy



Life Cycle of the Sea Urchin



Sea Urchin Activities

1. Observations of live sea urchins

- a) Place a live sea urchin in a clear container of seawater. Be sure that the water covers the urchin.
- b) Observe and describe its size, color, shape, mouth and protective adaptations.
- c) After a few minutes in the water, do you notice a color change taking place? Examine closely and determine what has caused this color change.
- d) Tentacle-like organs called the tube feet appear between the spines. Hold the clear container above your head and observe the large tube feet surrounding the mouth. How do they differ? Observe the movement of the sea urchin as it attempts to cling to the side of the container.

2. Observations of a sea urchin test

- a) Use a hand lens to observe the empty test of a sea urchin. Describe its appearance.
- b) Remove a spine from its attachment point called the tubercle. Examine it with a hand lens or under a dissecting microscope. How does the base of the spine correspond to its point of attachment? What advantage do these ball and socket-like joints give the sea urchin?
- c) Examine the inside of the test by looking through the mouth opening. Describe the skeletal plates. Count the double rows of calcareous plates. Is there an obvious pattern present?
- d) In a darkened room, place the urchin's test on top of a flashlight. Identify the genital pores on the top part of the test and the numerous pores of the tube feet radiating down its body. Does an obvious pattern appear? What other animals exhibit this pentamerous symmetry?

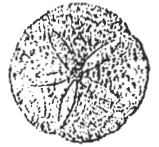
3 Explorations

- a) Can a sea urchin hold on using its tube feet?
 - Place a sea urchin in a clear container of seawater for at least 15 minutes. During this time, the sea urchin may secure itself to the side of the container.
 - Slowly pour the water out and invert the container. How well does the urchin hold on?
- b) How does a sea urchin eat?
 - Examine the flattened oral side of the urchin. Describe the mouth, teeth and lip-like membrane which surrounds the mouth.
 - Place a sea urchin on top of a piece of kelp in a container of seawater. Examine and describe the surface of the kelp with a hand lens after twenty minutes.
 - Their teeth are part of a feeding structure called "Aristotle's lantern." The lantern part of this jaw-like structure can not be seen unless it is removed by dissection or it is still intact within an empty test. This structure is designed to gnaw on seaweed or graze on algae found growing on rocks.
- c) How does a sea urchin keep clean?
 - Place a sea urchin in a container of seawater. Sprinkle some sand or shell particles on its surface. Examine the movement of these particles under a dissecting microscope.
 - Locate the grasping organs called pedicellariae and remove several with sharp scissors.
 - Examine them under the dissecting microscope and observe their reaction to the touch of a human eyelash probe (mount an eyelash to a toothpick in a blob of wax).

4. Research

- a) Sea urchin fertilization and development as a lab activity.
- b) Maine's commercial sea urchin fishery.
- c) The processing of sea urchin roe for shipment to Japan.

Sand Dollar (*Echinarachnius parma*)



Classification: Phylum: Echinodermata; Class: Echinoidea

Description: Sand dollars are brownish wafer-shaped organisms. Their body is covered with a coating of minute spines giving them a velvet-like appearance. An indentation that resembles a star is located on their skeletal test.

Habitat: Sand dollars live subtidally from Labrador to New Jersey. They are most often found living on a sandy type bottom.

Movement: Locomotion is achieved through a coordinated movement of spines and tube feet. They often burrow to shallow depths in order to feed and hide.

Respiration: Small respiratory tube feet protrude from a five petal shaped area located on their upper or aboral surface.

Ingestion: Sand dollars feed on diatoms and other microorganisms as they move over the sand. Specialized podia, located in five ambulacral grooves, direct food particles to their mouth. An internal grinding mechanism is composed of five dove-like structures.

Growth: Their skeleton test is composed of numerous calcareous plates. These plates are called "ossicles" and are fused together to form their familiar shape. Sand dollars may grow to a diameter of three inches.

Excretion: Their waste exits through the anal opening which is located on the edge of their test.

Nervous System: Five radial nerves disperse into a nerve net located in the outer epithelium. This system responds to touch, chemicals and light.

Circulation: Their coelomic or cavity fluid is their principal circulatory medium. This fluid transports nutrients and gases around the body.

Reproduction: Sand dollars release sperm or eggs into the water through four tiny gonopores in their upper disc. Fertilization takes place in the water where the larvae develop, metamorphose and then settle to the ocean floor as tiny sand dollars.

Common Names: "sea dollar"

Predators: Sea stars are the principal predator of sand dollars. Flounder and other bottom feeding fish will also eat them.

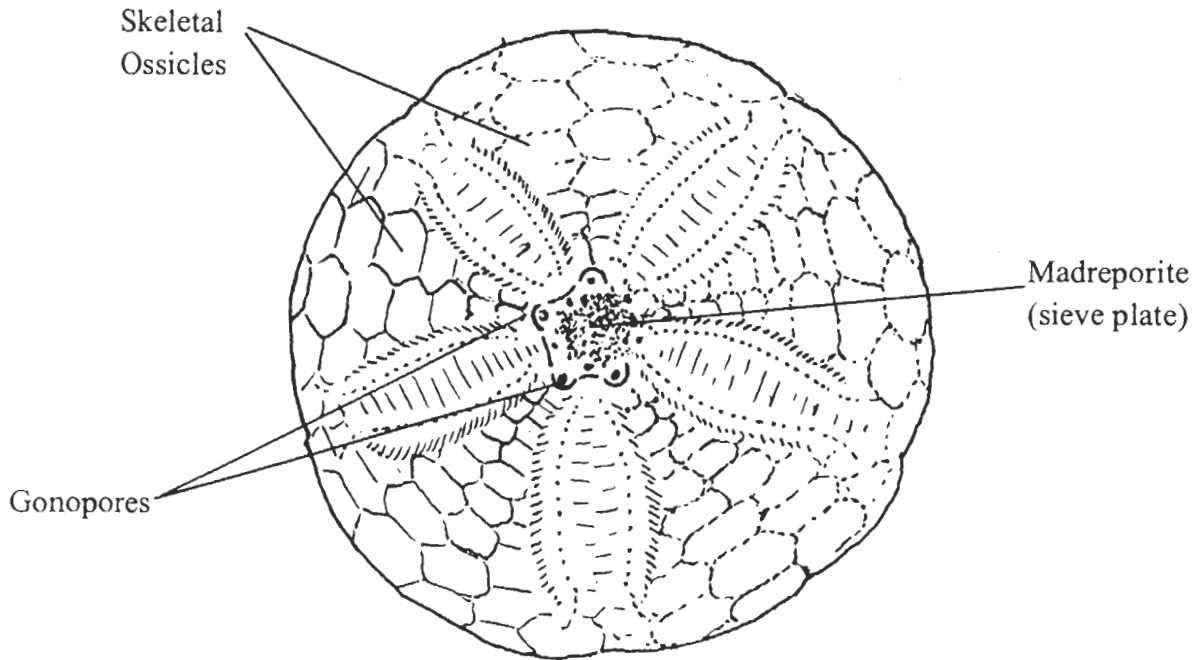
Commerical Value: None

Other Gulf of Maine Species: None

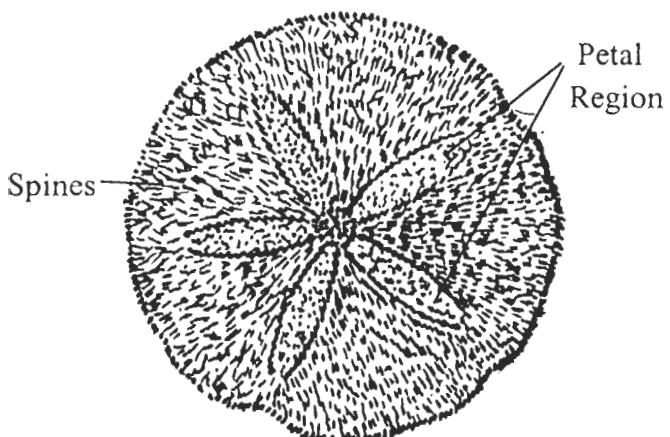
Sand Dollar

Aboral View (test)

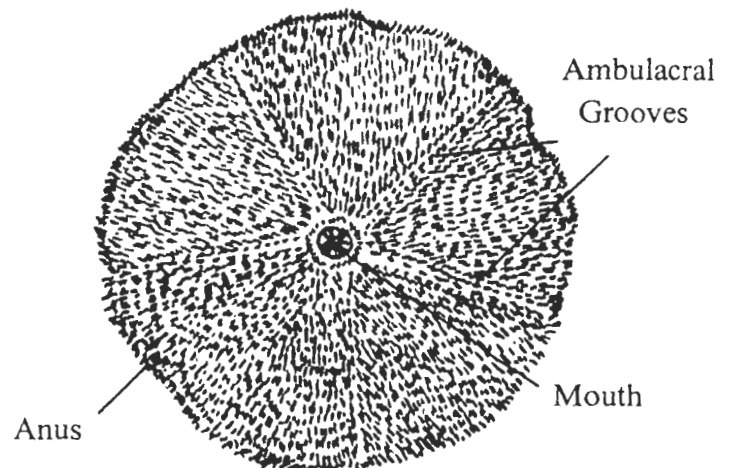
(skeletal test)



Aboral View



Oral View

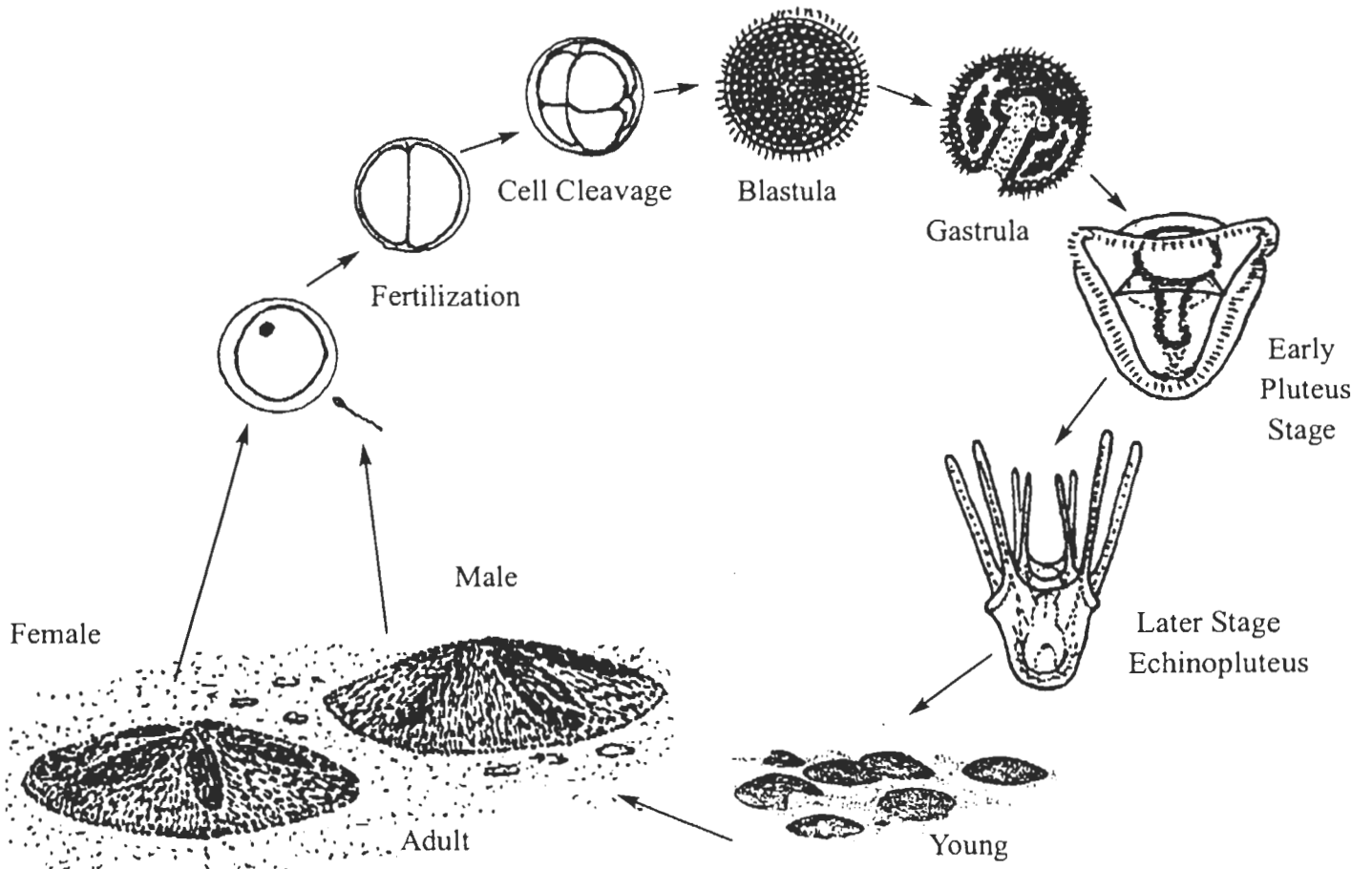


Sand Dollar



Sand Dollars on a Sandy Substrate

Life Cycle of the Sand Dollar



Sand Dollar Activities

1. Comparing the empty test of a sand dollar to a live sand dollar.
 - a) Observe differences in: color, texture, surface patterns, etc.
 - b) Use a hand lens to study the empty test. Are there any holes or perforations on the surfaces? Can you locate these same openings on the live sand dollar?
 - c) In a darkened room, place the empty test on top of a flashlight. Observe the patterns and holes on the test. What might have been the function of these holes?

2. Releasing the doves
 - a) Shake the sand dollar. What do you hear?
 - b) Break open a dead sand dollar onto a piece of black construction paper.
 - c) What did you find inside? The white bone-like structures, commonly called "doves," make up the mouthparts of the sand dollar.
 - d) What are the fine particles within?
 - e) Gently break the remaining test into its five pieces. Describe the inside of the test.

3. Impression
 - a) Purchase a roll of aluminum foil from a draft store that is used for metal tooling.
 - b) Using scissors, cut out circles about five inches in diameter. Do this before the students arrive.
 - c) Use a popsicle stick to depress the petaled image of the sand dollar.
 - d) Paint the surface with India ink for highlighting the indentations.
 - e) Wipe off excess ink with a paper towel.

4. Print of a Sand Dollar
 - a) Use a non-toxic, water-soluble paint to evenly coat a dead sand dollar's shell.
 - b) Gently press newsprint down on the shell.
 - c) Let the paint dry.
 - d) Cut out the prints and mount them on a piece of colored paper.

5. Sand Dollar Game (2 students)
 - a) Cut out twenty outlines of sand dollars.
 - b) Have students draw a star pattern on the top and write a different number on the bottom of each.
 - c) Distribute ten sand dollars to each student in a stack.
 - d) Player one places the top sand dollar with the number down. Player two places their top sand dollar with the number up.
 - e) Player one guesses if his number is larger. If correct, that player will take both.
 - f) Player two guesses next.

6. Sand Dollar Ornament
 - a) Bleach out a number of sand dollar tests until they are white.
 - b) Obtain the thin wires which are inserted into Christmas balls.
 - c) Insert the wire loop into the anal opening, located on the edge of the test. Add a drop of glue.
 - d) Tie a colorful ribbon through the wire loop.

Sea Cucumber (*Cucumaria frondosa*)



Classification: Phylum: Echinodermata; Class: Holothuroidea

Description: Sea cucumbers are elongated, cylindrical shaped echinoderms which lack external spines. These animals have five rows of tube feet that protrude from bands located along their reddish brown body. Ten multi-branched retractible tentacles surround their mouth.

Habitat: This species can be found in lower intertidal and subtidal waters from the Arctic to Cape Cod.

Movement: Sea cucumbers are sluggish animals that use their tube feet for movement. These suction-like structures also serve as a means of attachment to the bottom substrate. The tube feet are controlled by a unique water vascular system.

Respiration: They have two large respiratory trees inside of their body cavity. These multi-branched tubes open into a posterior body cavity called the "cloaca." These organs extract oxygen from water which is sucked in by the cloacal muscles.

Ingestion: The mouth is surrounded by ten bushy tentacles which are covered with a sticky slime. These tentacles trap microscopic organisms. Sea cucumbers then place one tentacle after another into their mouth cavity to clean off food particles.

Growth: Sea cucumbers can grow to be about 10 inches long close to shore and up to 20 inches long in deep, offshore waters.

Excretion: Wastes are excreted out of their anal opening.

Nervous System: A nerve ring located near its oral end sends nerve impulses to its tentacles and five radial nerves that run down its body. When disturbed, they contract their body and pull their tentacles inside.

Circulation: The body cavity called the coelom is lined with hairs called "cilia." The waving action of the cilia produces a current which distributes the gases. Nutrients are distributed by a hemal system of vessels.

Reproduction: Sea cucumbers have separate sexes. A single gonad composed of finger-like tubercles releases gametes into the water where fertilization and development takes place.

Common Names: "Trepang"

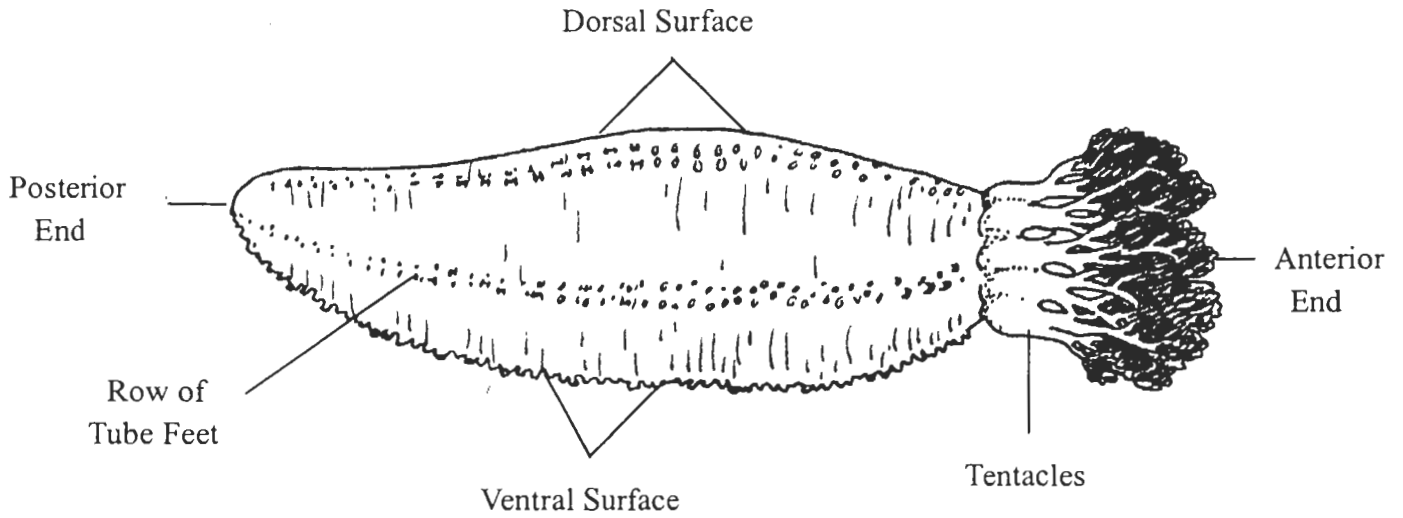
Predators: Fish, crabs and humans prey on sea cucumbers. A novel defense mechanism that sea cucumbers have developed involves releasing sticky, obnoxious threads from their anal region. They can also eviscerate internal body organs, which can later be regenerated.

Commercial Value: Landings for 2002 were 6,271,460 pounds, valued at \$335,971.00.

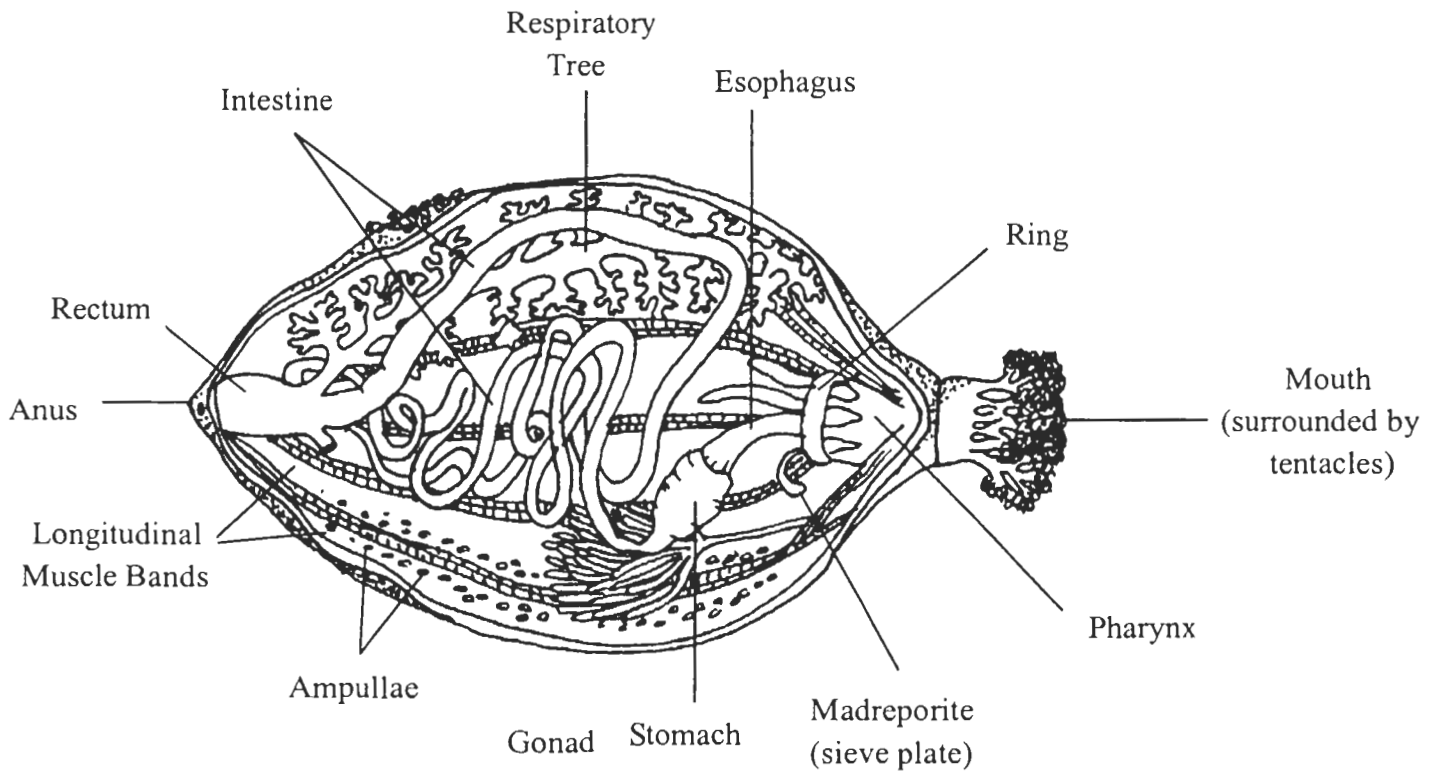
Other Gulf of Maine Species: Scarlet Psolus (*Psolus fabricii*), Pink Synapta (*Leptosynapta roseola*), Silky Cucumber (*Chiridota laevis*) and Rat-tailed Cucumber (*Caudina arenata*)

Sea Cucumber

External Anatomy



Internal Anatomy

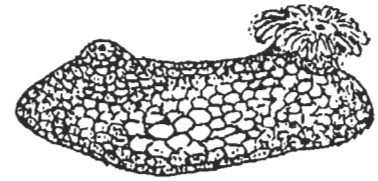


Gulf of Maine Species of Sea Cucumbers



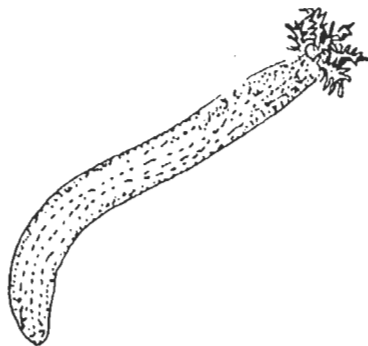
Orange-footed Sea Cucumber
(*Cucumaria frondosa*)

- skin leathery and pale brown to orange in color
- distinctly cucumber shaped
- ten bushy tentacles
- tube feet often orange tipped and arranged in five bands with two on top and three on bottom
- grows to ten inches in length in shallow waters
- found in lower intertidal zone and subtidally



Scarlet Psolus
(*Psolus fabricii*)

- bright red and scaly
- bottom flat like the sole of a shoe and ringed with tube feet
- anus and tentacles on top surface
- grows to eight inches in length
- subtidal on hard substrate



Synaptas
(*Leptosynapta* species)

- worm-like body that is pink or white in color
- twelve tentacles
- without tube feet
- fragile body that breaks into parts when disturbed
- grows four to six inches in length
- usually in sand or under rocks in the lower intertidal and subtidal zones



Rat-Tailed Cucumber
(*Caudina arenata*)

- body short, plump and pinkish to purplish in color
- tail 1/3 of body length and used for respiration
- fifteen tentacles
- without tube feet
- grows to seven inches in length
- burrows in sand or mud

Sea Cucumber Activities

1. Observations of a live sea cucumber

- a) Place a live sea cucumber in a clear container of seawater. Be sure that the water covers it.
- b) Observe and describe its size, color, shape, mouth and protective adaptations.
- c) After a few minutes, do you notice a change taking place? If you see a number of tentacles emerge, this is the cucumber's anterior end where it takes in food.
- d) What type of food might it eat? How would it catch its food?
- e) Lift the sea cucumber out of the water and hold it in the palm of your hand. What happens to its shape? Did it release any water? Why did it do these things?
- f) Some sea cucumbers protect themselves by spitting out their internal organs so please be gentle when handling the cucumber. These organisms do have the ability to regenerate their organs.

2. Comparison of the sea cucumber to other echinoderm classes

- a) Obtain a sea cucumber (Class Holothuroidea), sea urchin and sand dollar (Class Echinoidea), sea star (Class Stellerioidea) and a brittle star (Class Ophiuroidea).
- b) Compare the following characteristics: pentamerous symmetry, tube feet, movable spines, rigid test, ventral mouth and Aristotle's lantern.
- c) Discuss any exceptions or modifications between the classes.

3. Three dimensional models of echinoderms

- a) Use clay or dough to make models of the following echinoderms:
 - Sea cucumber - attach popcorn by toothpicks to represent feeding tentacles.
 - Sea urchin - poke in green toothpicks to represent spines.
 - Sea star - sprinkle and press rice on the surface to represent spines.
 - Brittle star - use pipe cleaners to represent arms.
 - Sand dollar - make a star impression in clay.

4. Sponge prints

- a) Using white construction paper, cut out the shapes of several echinoderms.
- b) Apply paint to the cut outs using a synthetic sponge dipped into tempera paint.
- c) Let the paint dry and glue the shapes to an ocean background.

5. Trepang

- a) A type of southern sea cucumber is prized as a delicacy by the Chinese. It is boiled, dried and sold by Chinese merchants. It is known as "trepang" or "beche-de-mer." Contact a Chinese restaurant or a local citizen of Chinese heritage to inquire about this delicacy.

Sea Vase (*Ciona intestinalis*)



Classification: Phylum: Chordata; Subphylum: Urochordata; Class: Ascidiacea

Description: Sea vases look like true chordates only as larvae. Their adult body is a semi-hardened, translucent, vase-like structure with two siphon openings. Their whitish yellow body has 5-7 muscular bands on either side. When disturbed, they contract and water squirts out; hence, the common name "sea squirt."

Habitat: Sea vases can be found subtidally attached to a solid surface from the Arctic south to Cape Cod.

Movement: Sea vases are sessile, permanently attaching themselves to the substrate that they settle on.

Respiration: Sea vases have a large pharyngeal chamber located below the inhalant siphon. This chamber is lined with numerous gill plates that are used for gas exchange.

Ingestion: These animals are filter feeders which process four to five gallons of water each day. The ciliated surface of the pharyngeal sac passes the trapped food to their mouth.

Growth: The growth of sea vases is limited to their food supply. These animals are normally two to three inches in length, but can reach their largest size of four inches in the plankton rich Arctic region.

Excretion: Wastes are passed out through the anus into the body cavity. Excrement is then washed out of the cavity via the exhalant siphon.

Nervous System: Like all chordates, these animals show advanced neural development as larvae but lose most of this as they metamorphose. As adults, their central nervous system is reduced to a nerve mass located between the siphons.

Circulation: Sea vases have a closed circulatory system consisting of a two-chambered heart with blood vessels running throughout their tunic or body wall.

Reproduction: Sea vases are hermaphroditic. Their fertilized eggs develop into free swimming, tadpole-like larvae. After a short planktonic existence, the larvae settle and attach their anterior end to the bottom.

Common Names: "sea squirt," "tunicate"

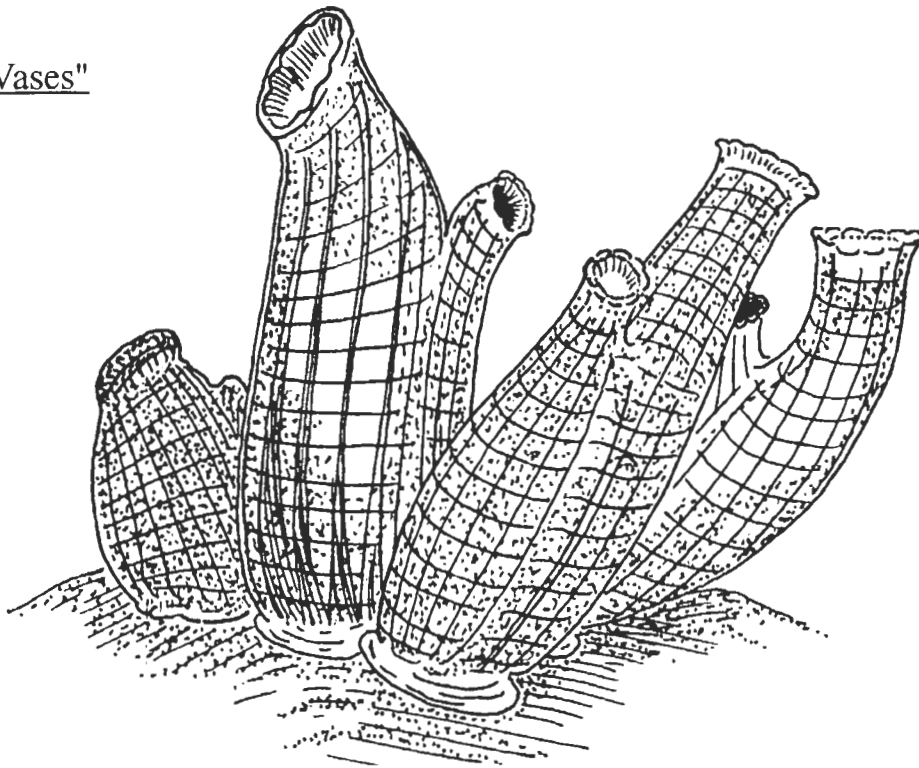
Predators: Marine snails and sea stars prey upon sea vases.

Commercial Value: None

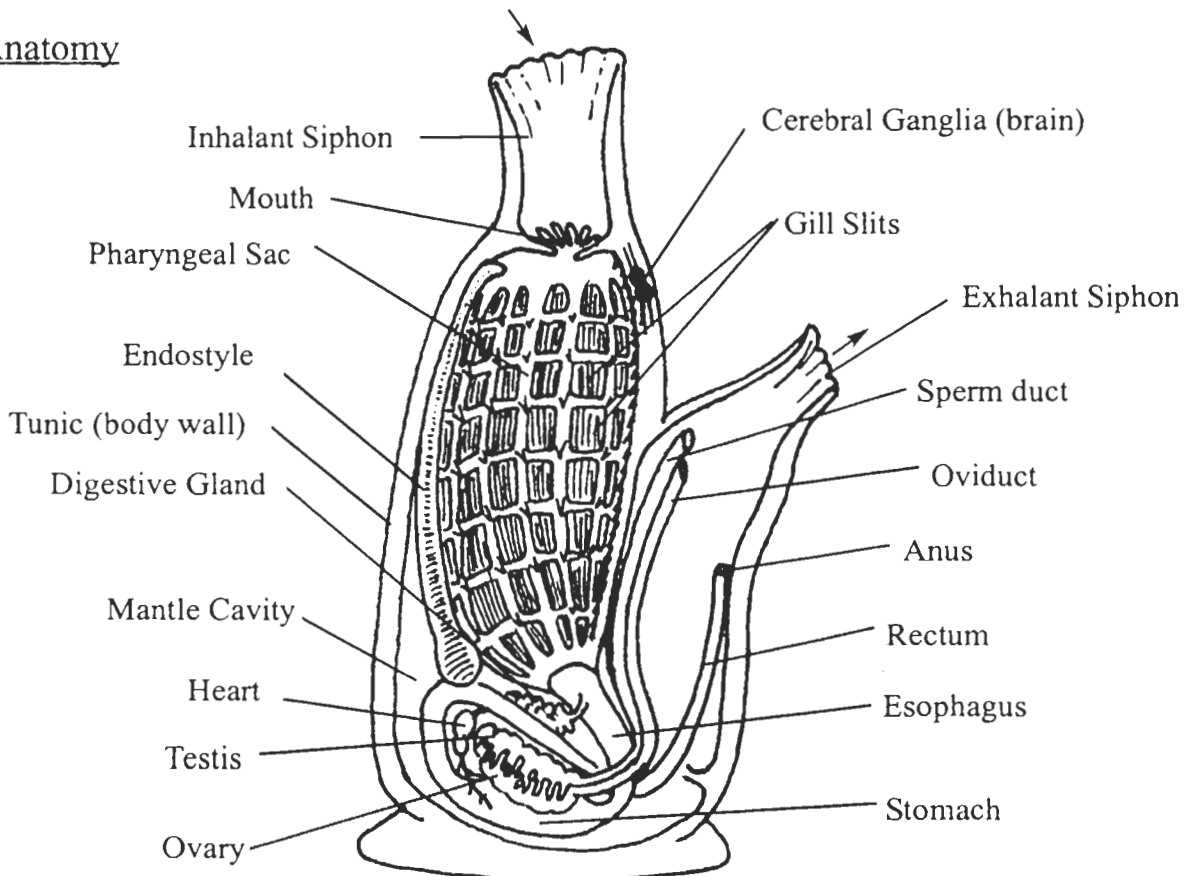
Other Gulf of Maine Species: Sea grapes (*Molgula siphonalis*, *Molgula retortiformis*), Sea peach (*Halocynthia pyriformis*), Stalked sea squirt (*Boltenia ovifera*), Cactus sea squirt (*Boltenia echinata*), Rough sea squirt (*Styela partita*) and Callused sea squirt (*Ascidia callosa*)

Sea Vase

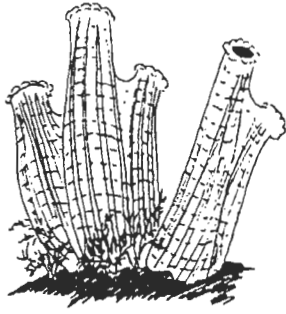
Colony of "Sea Vases"



Internal Anatomy

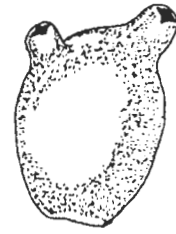


Gulf of Maine Species of Sea Squirts



Sea Vase
(*Ciona intestinalis*)

- tall, vase-shaped, transparent body which is often covered with bryozoan colonies
- whitish or yellow in color
- five to seven muscle bands on each side
- one siphon has eight lobes and the other six
- grows two to four inches in height
- found attached to wharf pilings or other solid substrates



Sea Peach
(*Halocynthia pyriformis*)

- tough, barrel-shaped, fuzzy body
- yellowish to peach or red-orange in color
- both siphons have four lobes
- usually found up to 2 1/2 inches in height
- usually subtidal attached to a solid substrate



Sea Grapes
(*Molgula* species)

- body somewhat flattened and often encrusted with debris
- short siphons that are widely separated
- one siphon four lobed and the other six lobed
- grows to 3/4 of an inch
- attached subtidally in depths of fifteen to seventy-five feet



Stalked Sea Squirt
(*Boltenia ovifera*)

- oval body on a long stalk that is two to four times its body length
- yellow to pinkish or orange-red in color
- body may grow up to three inches
- usually attached subtidally to great depths

Sea Squirt Activities

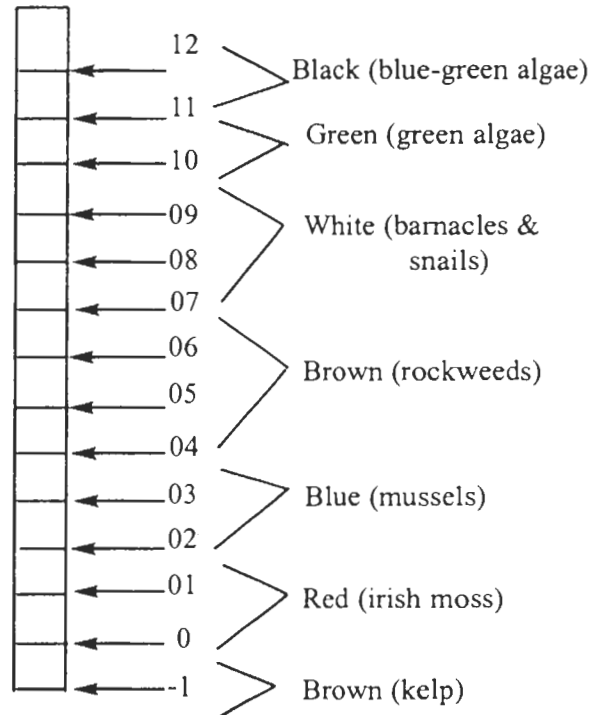
1. Observations of a live sea squirt; Sea Vase, Sea Peach or Sea Grapes
 - a) Place a live sea squirt in a container of seawater.
 - b) Observe and describe its size, color and shape.
 - c) Do you notice any openings in the sea squirt? How would these holes relate to its name?
 - d) Place a couple of drops of food coloring next to one opening. What happened? Place a couple of drops next to the other opening. What happened?
 - e) Sea squirts like to live attached to wharf pilings. Can you see where they were once attached?

2. Comparing various types of sea squirts
 - a) Obtain live, preserved samples or pictures of the following: sea vase, sea peach and sea grapes.
 - b) What are their similarities and differences.
 - c) Research why these animals are placed in the phylum Chordata, animals with a vertebra?

3. The study of a fouling community
 - a) Sea squirts are often found attached to man-made structures such as floats. They and other marine organisms crowd onto the submerged surfaces of these floating habitats which move up and down with the tides. Examine a fouling community attached to a float at a marina.
 - b) Lie on the dock and make a general survey of the types and distribution of the flora and fauna.
 - c) Scrape off all of the life found in a ten centimeter wide vertical strip of the float. Collect and study these animals in detail.
 - d) Return to this site after a period of time to study the ecological succession of plants and animals.

4. Zonation on a wharf piling

- a) You will be creating a wharf piling which illustrates the zonation of the plants and animals and the depths that they live.
- b) Tape two paper towel rolls together.
- c) Cut out two six inch by eleven inch strips of paper and glue them together to make a twenty-two inch strip. This strip of paper will wrap around two connected paper towel rolls and serve as a wharf piling.
- d) Leave two inches of the piling exposed out of water. Divide the remaining twenty inches into 1 1/2 inch segments. Mark each line on the right side as a foot in depth from the top being the zero foot mark to the bottom being twelve foot.
- e) Draw and color the plants and animals at the indicated depths following the pattern at the right.
- f) Wrap and glue the finished product to the paper towel rolls.



Glossary

Aboral: Refers to the body surface opposite the oral surface or mouth.

Adaptation: A variation in an organism that makes life easier.

Adductor muscle: A muscle used to close or draw together two body parts or valves.

Ambulacral ridge: Protects the radial canal of the water vascular system and separates the tube feet.

Ampullae: A bulb-like part of a tube foot that controls internal water pressure.

Antennae: A sensory appendage found on the head of an animal. An example is the second pair of "feelers" in crustaceans.

Antennules: An anterior appendage that acts as a sensory organ. An example is the first pair of "feelers" in crustaceans.

Anterior aorta: A large blood vessel that carries blood away from the heart toward the head.

Aperture: The opening into the main cavity of a snail shell.

Apex: The point of the spire or shell of a snail.

Arthropod: The phylum name for the most numerous form of animal life - meaning "joint footed."

Asexual: Refers to reproduction without the use of sex cells or fertilization.

Asymmetrical shells: Not equal or of two different shapes.

Axial ridge: Raised areas on the shell of a snail that run the length of the shell, base to apex.

Basal disc: the flattened circular base of an organism used for attachment to a substrate.

Bivalves: Mollusks possessing two shells or valves, like a clam.

Book gill: A specialized abdominal respiratory organ composed of many blood filled plates resembling the pages of a book.

Branchial heart: A heart associated with the gill of a cephalopod. Two of these keeps a rich supply of oxygen passing to the systemic heart and then to the rest of the body.

Bulbous proboscis: A large rounded feeding tube.

Byssal fibers (threads): Tough flexible protein fibers secreted by the foot of certain mollusks that are used for attachment.

Byssal notch: A groove on the foot of certain bivalves that secretes threads used for attachment.

Caecum: A digestive pouch or sac.

Calcareous: Composed of calcium carbonate or limestone.

Calcified: Impregnated and/or hardened by calcium salts deposits.

Carapace: The exoskeleton that covers the dorsal surface of the cephalothorax of a crustacean.

Carnivorous: A flesh eating organism often referred to as a "meat eater."

Carpus: The segment behind the claw of a decapoda. The fifth segment from the body.

Cephalic: Refers to the concentration of nerve tissue in the head region.

Cephalopods: The most advanced class of mollusks which include the squid and the octopus.

Cephalothorax: The fused head and thorax areas of an arthropod. Segmentation is only visible on the ventral surface. The dorsal surface is covered by the carapace.

Chelicera: The first pair of appendages used in feeding by certain arthropods like spiders and horseshoe crabs.

Chelipeds: The enlarged claws of certain decapods like lobsters and crabs.

Chiliarium: The last pair of appendages associated with the cephalothorax of a horseshoe crab. It has been reduced to a hairy base plate only.

Chromatophores: Specialized skin cells that contain pigment which are capable of changing size and shape in response to external stimuli.

Cilia: Minute hairlike projections associated with specialized cells on the bodies outer or inner surfaces that aid in movement.

Ciliated cells: Epithelium with small hairlike projections on their outer surface.

Circulatory system: That part of the body that normally functions in the transportation of gases, nutrients, and metabolic wastes.

Circumoral nerve ring: In radial animals a mass of nerve fibers that surround the mouth.

Cirri: Small antenna like projections used as sensory organs.

Closed circulatory system: A system in which the blood is normally contained within vessels where capillaries connect arteries to veins.

Cnidoblasts: Specialized cells of Cnidarian that contain nematocysts, commonly called "sting cells."

Coelomic cavity: The body cavity.

Coelomic fluid: A watery liquid associated with the body cavities of some invertebrates.

Columella: The internal center axis of a snail's shell. The central axis of shell around which the whorls spiral.

Compound eyes: An eye with multiple lens that allows the organism a mosaic view of its surroundings.

Copper-based respiratory pigment: This chemical compound gives the blood a bluish tint and is used to carry oxygen in the blood.

Cornea: The clear outer window of the eye.

Coxa: The first segment of a thoracic appendage of a crustacean.

Crenated margin: The toothed edge of the shell of certain mollusks.

Crop: That part of the digestive tract that stores ingested food. Located between the esophagus and gizzard.

Crustaceans: A class of arthropods having two major body divisions and at least five pairs of major appendages. These organisms all have a chitinous exoskeleton.

Crystalline style: A transparent, rod-like organ that aids in ingestion and digestion in some mollusks.

Ctenidium: A gill or gill-like respiratory organ.

Dactylus: The seventh segment of a thoracic appendage of a crustacean. The moveable finger of the claw.

Decapods: An order of crustacea having five dominant pairs of thoracic appendages.

Demersal: Refers to fish or other organisms that spend most of their life on or just above the ocean bottom.

Desiccation: To dry out or dehydrate.

Detritus: Organic particles that float or settle out on the bottom. Detritus is a major source of food for many invertebrates.

Dinoflagellate: A microscopic protozoan whose body is protected by cellulose plates and propelled by two whiplike flagella.

Diorama: A three dimensional model or scene.

Dorsal blood vessel: A major blood vessel found in many invertebrates that normally carries blood toward the anterior end.

Dorsal flabellum: A fan shaped structure used to clean the surface of the gills of a crab.

Echinopluteus stage: The second level of embryonic development in echinoderms that show transition from bilateral to a radial symmetry.

Ectoderm: The layer or layers of cells associated with the outside skin of a multicellular animal.

Endoderm: The layer or layers of cells associated with the inner or digestive cavity of a multicellular animal.

Endopodite: The inner branch of the terminal segment of a crustacean's appendage.

Entapophysis: Internal abdominal ridges used for muscle attachment in horseshoe crabs.

Epithelium: The skin or outer most living tissue of an organism.

Esophageal gland: Associated with the passage and digestion of food materials prior to entering the stomach.

Estuarine: Refers to areas that are tidal and where a mixing of fresh water from rivers and the saltwater of the oceans occur.

Eversible proboscis: A feeding tube capable of being extended out through the mouth.

Excretory canal: A passage way for liquid wastes in multicellular animals.

Excretory pores: Body openings used to eliminate liquid wastes.

Exopodite: The outer branch of the terminal segment of an appendage of a crustacean.

Exoskeleton: A hardened shell composed of calcium or chitin that covers the skin of an arthropod.

Filter feeders: An organism that feeds on organic material suspended in the water.

Fouling organism: Any marine organism that grows on man-made objects and impairs their usefulness.

Gametes: Reproductive cells (sperm or eggs).

Ganglia: A mass of nerve cell bodies located outside the central nervous system.

Gastrovascular cavity: The tubular gut or digestive cavity of a simple animal.

Genital operculum: A protective covering, part of the exoskeleton, that covers the reproductive openings.

Gill: An organ of respiration in an aquatic animal.

Gnathopods: A jaw-like appendage found in certain arthropods, used in the feeding process.

Gnathobase: A grinding organ formed at the base of the walking legs of a horseshoe crab. It is used to shred food products.

Gonad: A general term for a reproductive organ like the ovaries or testes.

Gonophore: A specialized abdominal appendage used in reproduction.

Gonopore: An opening out of the reproductive system for the passage of gametes.

Green glands: Excretory organs located in the head of crustaceans. Controls internal fluid pressure and the body's salt content.

Hemoglobin: An iron rich, reddish pigment associated with oxygen transport in animals.

Hepatic caecum: Branched digestive pouches that run off of the stomach.

Hermaphroditic: Refers to an organism that is both male and female.

Holdfasts: The multibranched, tubular, rootlike attachment used by many seaweeds to secure themselves to a substrate.

Hydroids: Colonial Cnidarians that have a polyp type of body structure.

Ink sac: An organ associated with the lower intestine of a cephalopod that produces a chemical used by the animal for defense.

Intertidally (Intertidal): The region associated with the area found between the high and low tide mark.

Iris: The colored part of an eye that regulates the light transmitted to the retina.

Ischium: The third segment of a thoracic appendage of a crustacean.

Krill: Small shrimp like marine crustaceans that are a favorite food of whales and other animals.

Labial palps: Lip like structures that direct food into the mouth.

Labrum: The fused upper lip of some arthropods that directs food into the mouth.

Lamellae: The plate like structures that compose the gills of many marine organisms.

Madreporite: A specialized valve in the water vascular system of an echinoderm that regulates entry of water into the system. It is located on the aboral surface of the animal.

Mandibular muscle: The major muscle associated with the jaws for chewing.

Mandibular plate: An internal projection of the jaw used for muscle attachment.

Mantle: A protective covering that surrounds the soft body of a mollusk and produces the shell material.

Mantle cavity: The space between the mantle and the visceral mass or body of a mollusk.

Mantle curtain: See mantle. The outer loose edge of the mantle.

Maxillae: Two pair of laterally moving mouth parts located behind the jaws or mandibles.

Maxillipeds: Specialized mouth parts used to taste and sort food.

Mechanical stimuli: Touch or pressure that induces a response in an organism.

Merus: The third segment of a thoracic appendage of a crustacean.

Mesoglea: A non-cellular, jelly-like layer found between the ectoderm and endoderm of a Cnidarian animal.

Metabolic activity: Something that uses and/or produces energy in the body.

Metamorphose: To change the shape and or function of the body.

Mid ventral ridge: A line that runs the length of the bottom of a sea squirt.

Molting: The periodic elimination of the old exoskeleton allowing for overall growth as well as the replacement of missing or damaged appendages.

Mutualism: A type of symbiosis in which both organisms benefit from the relationship.

Negatively phototropic: To react against or move away from light.

Nematocysts: The specialized "stinging" organelles found in certain cells of a Cnidarian animal.

Nephridia: A coiled tube used to excrete liquid wastes in an invertebrate.

Neural centers: See ganglia.

Nudibranchs: A slug like marine snail that does not possess a shell.

Open system: Refers to a circulatory system in which the blood is not always contained in vessels but gathers in sinus pools around the body organs. It does not have any capillaries to connect arteries to veins.

Operculum: A chitinous plate used by some snails to protect the body when it is retracted within the shell. Also applies to the gill cover of bony fish.

Oral side: Refers to the body surface that contains the mouth.

Ossicles: The calcified or bony plates that make up the endoskeleton of an echinoderm.

Oviduct: The passage way for the egg from the ovary to the outside.

Ovoid: A rounded shape, like an egg.

Pallial line: Where the mantle and shell join together or the growth line where the mantle produces new shell material.

Pallial sinus: The area where the muscular siphon of the bivalve is attached to the shell.

Paralytic shellfish poisoning (PSP): A disorder caused by a dangerous chemical compound that acts on the nervous system of vertebrates. This poisonous material, produced by some dinoflagellates, is concentrated within the flesh of marine bivalves.

Parapodia: Fleshy paddle-like appendages used for locomotion and/or respiration in segmented worms.

Parasitic: An organism that lives on another host organism causing it harm.

Pearly layer: The shiny, smooth innermost layer of a mollusk's shell, sometimes called "nacreous."

Pedal disc: The muscular base of an animal's body used for both attachment and/or movement.

Pedicellariae: Small sharp pincer-like structures that act as protectors of the skin of an echinoderm.

Pelagic: Refers to the deep water or the open ocean outside the continental shelf.

Pentamerous symmetry: Having a five part body plan.

Pereiopods: The thoracic appendages that are used for walking or swimming in a crustacean.

Pericardium: A membrane or chamber around the heart.

Peristaltic movement: A wave like action accomplished by the alternating contraction and relaxation of muscles.

Peristomal membrane: A thin tissue that surrounds the mouth opening.

Pharyngeal tube: See "proboscis".

Pharynx: The "throat" of an organism's digestive system.

Photoreceptors: Light sensitive or ultraviolet (U.V.) ray sensitive organs found on many arthropods and other invertebrates.

Phylum: The most general classification in the Linnaean system below kingdom.

Plankton: Small, usually microscopic, organisms that float or swim weakly in the waters of lakes and the ocean. Movement is usually provided by currents within the water.

Planular larvae: The ciliated free swimming stage of a Cnidarian animal.

Pleopods: Abdominal appendages called swimmerets in crustaceans.

Pluteus stage: The free swimming bilateral stage in the development of an echinoderm.

Polychlorinated biphenals (PCB's): A dangerous chemical pollutant produced by industry that can cause pathogenic and teratogenic malformation in animal life.

Polyp: The stage commonly developing from a planula larva. Having a tubular body with a mouth surrounded by tentacles on one end and a basal disc on the other.

Proboscis: A feeding tube associated with some insects or mollusks and worms.

Propodus: The sixth segment of a thoracic appendage of a crustacean. The non-moveable part of the claw.

Prosoma: The anterior part of an invertebrate that is fused showing no signs of segmentation.

Prostomium: The "head" or anterior segments of a worm or mollusk located in front of the mouth.

Protandric hermaphrodite: Individual that is able to change sex from male to female.

Radula: A rasping file-like tongue used for feeding in many mollusks.

Regeneration: The ability to regrow missing or damaged body parts such as appendages.

Retina: The inner, light sensitive lining of the eyeball where the visual image is focused.

Retractor muscle: A muscle used to pull in or withdraw a body part.

Rostrum: An anterior beak like projection of the carapace that extends beyond the head.

Salinity: Refers to the percentage of dissolved salt in a solution.

Salivary gland: Associated with preliminary digestion and swallowing.

Scrimshaw: An art form made by inking in lines etched in ivory or polished bone.

Sedentary: Refers to staying in one place or showing limited mobility.

Septum: A thin wall or membrane between two cavities or soft tissues.

Sessile: To grow attached to one spot, not capable of movement.

Shell whorl: See "spire".

Sieve plate: See "madreporite."

Sinuses: A body cavity associated with the passage of blood in an invertebrate.

Siphonal notch: An extension of a snail's shell toward the anterior that holds or protects the siphon used for respiration.

Somital plates: The exoskeletal units covering a body segment.

Spawn: A term related to reproduction. The release of gametes from marine and aquatic organisms.

Spiral ridges: Raised areas on the shell of a snail that spirals around each whorl of the shell.

Spire: A single turn of a whorl in the shell of a snail.

Sterna: A ventral plate, part of the exoskeleton of the thoracic region.

Stimuli: Anything that creates a response.

Strand line: The debris left on the shore line by a receding tide.

Subtidally (subtidal): That region in the ocean below the lowest low tides down to a depth of approximately sixty meters. This region below the low tide line is affected by wave action.

Substrate: The surface on which a plant or animal grows or is attached.

Symbiotic: The living together of two or more different species of life.

Symmetry: Refers to the form and arrangement of body parts.

Systemic heart: One of three hearts found in a cephalopod. It pumps blood to the general body via a closed system of blood vessels.

Telson: The last body segment or tail of a crustacean.

Template: A pattern to be followed.

Tentacle: An elongated, flexible protrusion or appendage, usually sensory in function.

Test: The fused plates of the endoskeleton of a sea urchin or sand dollar.

Trochophore larvae: A free swimming ciliated stage of development in certain mollusks and segmented worms.

Umbilicus: The opening or depression at the base of a snail's shell.

Umbo: The oldest part of the shell or valve of a clam.

Unisexual: Refers to an organism that is either a male or a female.

Univalve: A mollusk with only one shell like a snail.

Uropod: The last pair of abdominal appendages sometimes called "flippers" of a crustacean.

Valve: The shell of a mollusk.

Vas deferens: The sperm tube.

Veliger stage: A ciliated swimming stage of development that follows the trochophore stage in many mollusks.

Visceral mass: The soft body of a mollusk or one of three major body parts of a mollusk - head, foot and visceral mass.

Wampum: The Indian name given to beads once used as currency and jewelry. They were made from the nacreous or pearly layer of shells.

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For more information on species, harvesting and marine resources in general please visit the Maine Department of Marine Resources website at www.maine.gov/dmr