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Bulletin No. 23: Plants and Animals of the Estuary

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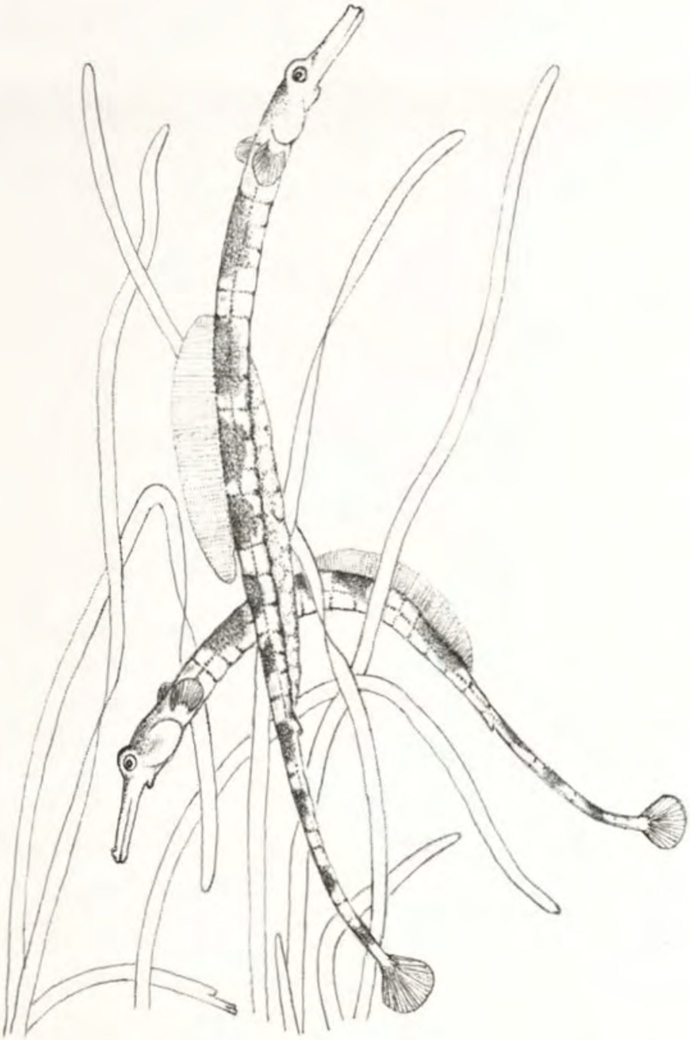
PLANTS AND ANIMALS OF THE ESTUARY



THE CONNECTICUT ARBORETUM
CONNECTICUT COLLEGE

BULLETIN NO. 23
NEW LONDON, CONNECTICUT

THE CONNECTICUT ARBORETUM

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Front Cover-Pipefish (*Syngnathus fuscus*) and eelgrass (*Zostera marina*).

PLANTS AND ANIMALS OF THE ESTUARY

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Nancy C. Olmstead, *Editor*

Drawings by Sibyl A. Hausman

THE CONNECTICUT ARBORETUM

BULLETIN NO. 23 JUNE 1978

FOREWORD

This bulletin represents part of a continuing effort by the Connecticut Arboretum to highlight various facets of our wetlands heritage—in this case the coastal estuarine environment. Since our initial wetlands bulletin, *Connecticut's Coastal Marshes: A Vanishing Resource*, was published in 1961, three others have appeared on the algae, tidal marsh plants, and tidal marsh invertebrates.

Our estuaries are recognized as being one of the most productive biological systems in the world. Here at the salt-freshwater interface we find an abundance of nutrients trapped and a rich flora and fauna responding to a diversity of environmental gradients. In the northeast we also find the contiguous tidal marshes being bathed diurnally by these shallow estuarine waters. In fact, together the estuary and tidal marsh comprise a highly integrated ecological unit—the tidal marsh-estuarine ecosystem. Two researchers in Rhode Island, Scott Nixon and Candace Oviatt[1], have found that the estuary is highly dependent upon the tidal marsh for its high nutrient level.

Although the estuary can be an extensive body of water of considerable depth, the authors here have chosen to restrict themselves to the relatively shallow nearshore waters. The typical animals—both invertebrates and fishes—and seaweeds are here described and illustrated. Within the animal section, Paul Fell and Nancy Olmstead have essentially produced a sequel to their *Tidal Marsh Invertebrates of Connecticut* (Bulletin No. 20). Sally Taylor and Martine Villalard-Bohnsack, authors of *Seaweeds of the Connecticut Shore* (Bulletin No. 18) have further explored the common algae of the estuary.

The authors are to be commended on the clarity with which the information is presented and an especial debt is owed our skillful artist, the late Sibyl Hausman, who died suddenly prior to publication of this work. It is to Sibyl, a dedicated teacher, artist and loyal friend of the Arboretum, that we dedicate this bulletin. She generously shared her enthusiasm with many students in her invertebrate course. And now it is our hope that this bulletin will serve to inspire in the same manner all those who are challenged to explore the life of the estuary.

[1]Nixon, Scott W. and Candace A. Oviatt. 1973. Ecology of a New England Salt Marsh. Ecol. Monogr. 43:463-498.

William A. Niering

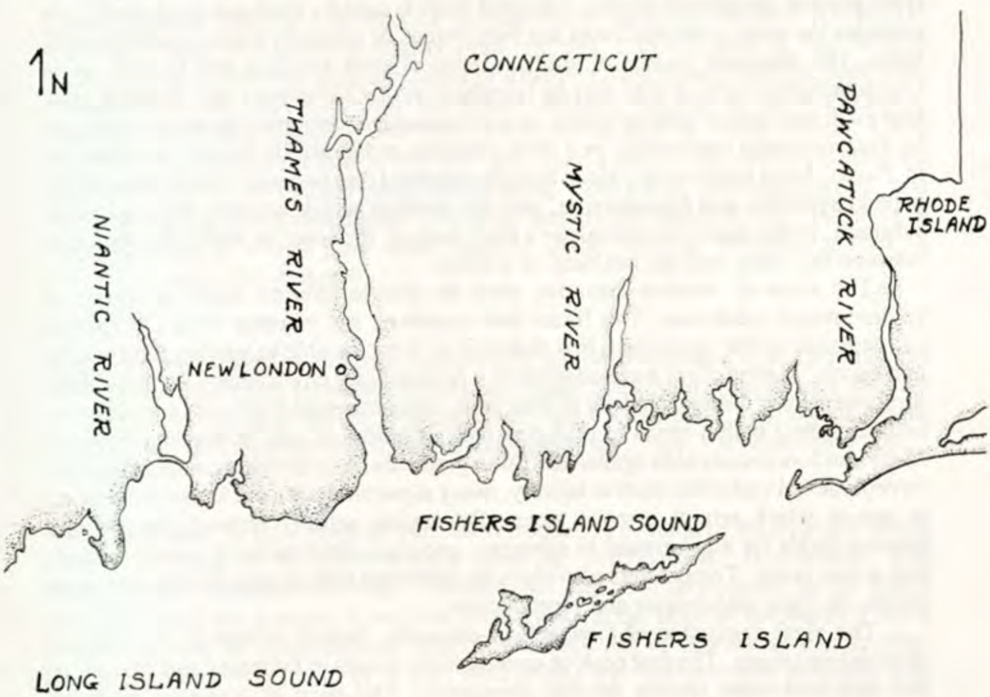
THE ESTUARINE ENVIRONMENT

Paul E. Fell, *Connecticut College*

This bulletin focuses on the common organisms of shallow estuaries, such as the mouths of the Mystic and Niantic rivers on Long Island Sound, where the water is frequently one meter or less in depth. An estuary may be defined as the region of a river where fresh water and sea water interact, resulting in a brackish environment with a salinity range of about 0.5 to 30‰ (parts per thousand). In contrast, ocean water is generally considered to be about 30 to 36‰. The lighter fresh water tends to flow seaward over the heavier sea water which moves in the opposite direction during tidal surges. However, in shallow estuaries the tidal currents, together with wind, often produce vertical mixing so that the boundary between fresh and sea water is so obscured that there is a continuous increase in salinity from the surface to the bottom. These vertical salinity gradients are frequently steep in the upper estuary and progressively smaller toward the mouth of the river.

The salinity at any one place in the system may vary considerably depending upon the amplitude of the tidal currents and the rate of river flow. The range of variation is greatest at the upstream end. The waters of shallow estuaries not only undergo substantial changes in salinity but they also are subject to greater and more rapid temperature changes than most of the adjacent ocean. During the winter the water temperature may drop to about −2°C and large areas of the estuary may be actually covered by several inches of ice. Under such conditions anchor ice forms on the shallow flats. At the opposite extreme, the water temperature may reach 29°C or more during the warmest part of the summer.

The sediment of our shallow estuaries generally ranges from moderately coarse sand to fine silt, forming a bottom that may vary in consistency from firm to very soft. Locally, boulders may be scattered over the bottom, especially near shore.



PLANT LIFE OF THE ESTUARY

Sally L. Taylor, *Connecticut College*, and Martine Villalard-Bohnsack, *Roger Williams College, Rhode Island*

The most conspicuous plants of the shallow estuaries are the red, green, and brown algae, along with the ribbon-like eelgrass. In addition, tidal marshes may also be present which are bathed by the estuarine waters and dominated by cordgrasses and colorful forbs as described in *Tidal Marshes of Connecticut* (Connecticut Arboretum Reprint Series No. 1). In this section we will describe the commonest algae which one might expect to find in the shallow estuarine waters of Long Island Sound. A more complete treatment of the algae may be found in *Seaweeds of the Connecticut Shore* (Connecticut Arboretum Bulletin No. 18). A discussion of eelgrass, which provides the life support system of innumerable animals, is also included.

ALGAE

The algae (singular: alga) comprise a large and heterogeneous group of organisms. Most possess chlorophyll and are therefore photosynthetic organisms; that is, they are autotrophic (produce their own food), using light energy and carbon dioxide, in the presence of chlorophyll, to produce carbohydrates. This conversion of light energy to chemical energy is extremely important since all of the chemical energy used by higher organisms enters the earth through the photosynthetic process.

Although the algae exhibit a great diversity in size and appearance, they are relatively simple organisms and possess little cellular differentiation. They are non-vascular plants and have no true roots, stems, or leaves. Only a few advanced types possess elementary tissues. The algal body is called a thallus (plural; thalli). In estuaries the most common forms are filamentous or parenchymatous (soft-tissued) thalli. The filaments consist of simple chains of cells attached end to end, as in *Chaetomorpha linum*, or they may be branched, as in *Cladophora* spp. Parenchymatous thalli may have a leafy structure, as in *Ulva lactuca;* a simple tubular structure, as in *Enteromorpha intestinalis;* or a more complex and generally thicker structure, as in *Fucus*. Most macroscopic algae are differentiated into two parts: the blade, which is photosynthetic and reproductive, and the holdfast which anchors the alga to its substrate. In the more complex algae a third section, the stipe, or stalk-like structure between the blade and the holdfast, is present.

The algae of shallow estuaries must be able to tolerate wide variations of environmental conditions. This limits their numbers, and whereas over 120 species can be found on the open coast, less than half of those are able to survive in estuarine conditions. Marine algae have adapted to a high salinity environment by regulating the movement of water in and out of their cells. They maintain high osmotic pressures and can adjust within limits to changing concentrations of salt in the environment. Many can concentrate salts against diffusion gradients. As a further protection against environmental variations such as salinity, many algae produce a thick protective layer of mucus which retards osmotic stress. Decreasing salinity remains the greatest limiting factor for algal growth in estuaries, and algal distribution is usually closely tied to this factor. Temperature also plays an important role in algal distribution in its effects on algal metabolism and reproduction.

The algal vegetation of Connecticut estuaries, though perennial, has distinct seasonal variations. The first peak of development occurs in February and March. At this time cold water species develop abundantly. This burst of growth is probably related to the gradual rise in temperature during these months. The second peak of development, by far the greatest, occurs in July and August. At this time, the estuarine waters have reached their highest temperatures and a group of warm water species, mainly red algae, develop in great quantities. The highest numbers of species are recorded during this period and then start disappearing with the decrease in temperature which usually takes place in September.

Habitats and Species Distribution

Different types of algal associations or communities are found in the estuaries. Their distribution depends on environmental conditions such as substrate availability, salinity and temperature variations, and sedimentation. The more common habitats are boulders and rocks, sand and mud bottoms, eelgrass growing in the estuary, and tidal marshes.

Rocky Shores. In tidal areas, exposed boulders may exhibit zonation which appears as distinct color bands. Around the high tide level or splash zone, a black zone may be found. This consists of microscopic blue-green algae such as *Microcoleus* sp. and *Calothrix* sp. They appear as a blackish paint-like covering on the rocks. In the middle of the intertidal area two colored bands may be present; a brown and/or a green zone. The brown zone usually consists of *Fucus vesiculosis, Ralfsia verrucosa,* or *Ascophyllum nodosum* in protected areas. The green zone usually comprises different species of *Enteromorpha* and *Cladophora*, as well as *Ulva lactuca*. These two zones may extend below low tide or they may be replaced by a red zone made up of *Chondrus crispus* and *Hildenbrandia prototypus*.

Open Shallow Waters. Free floating associations of algae are common in relatively shallow protected areas over sand or mud bottoms. Large masses of free floating green algae may become well developed in areas receiving some pollution, especially sewage effluent. Here one may encounter different species of *Enteromorpha, Cladophora, Chaetomorpha,* and *Rhizoclonium,* as well as *Ulva lactuca*. Often they may be so abundant that, at low tide, they form a carpet completely covering the sand or mudflats. In cleaner areas free floating *Gracilaria, Neoagardhiella,* and *Spyridia* may develop abundantly. These are usually covered with large numbers of epiphytes (algae which grow upon another plant) such as different species of *Ceramium* and *Polysiphonia*.

Eelgrass Communities. Eelgrass, a grass-like submerged aquatic vascular plant, can provide an important substrate for various algae. The following species may be epiphytic on eelgrass leaves: *Polysiphonia* spp., *Ceramium rubrum, Spyridia filamentosa, Antithamion cruciatum, Cladophora* spp., and *Enteromorpha* spp.

Tidal Marshes. In tidal marshes the mud is frequently covered by an algal mat which usually consists of blue-green algae such as *Microcoleus, Oscillatoria,* and *Phormidium*. A filamentous alga, *Ulothrix* sp., can also be frequent on the marsh surface among the grasses. Along the tidal creeks at the edge of the marsh a green zone consisting of *Ulva lactuca* and different species of *Enteromorpha* is often found. Scattered specimens of *Fucus vesiculosus* and *Ascophyllum nodosum* also occur there.

Key to the Major Division of Algae

The most common macroscopic algae found in estuaries include the green algae (Chlorophycophyta), brown algae (Phaeophycophyta), and the red algae (Rhodophycophyta). These are distinguished in the following way:

1. Plant green, staining black with iodine* ....GREEN ALGAE
1. Plant not green, not staining black with iodine 2
   2. Plant light to dark brown or dark green, pigment not diffusing out in boiling water ....BROWN ALGAE
   2. Plant usually light to dark red, red color diffusing out in boiling water ....RED ALGAE

*Solution can be made by dissolving 2 grams of potassium iodide in 100 milliliters of water, then dissolve 1 gram of iodine crystals in this solution. Water with tincture of iodine added to give a color like medium strong tea can also be used for this test.

GREEN ALGAE

Enteromorpha (*Enteromorpha intestinalis*): This alga is a pale to bright green (sometimes yellowish), *elongated, unbranched, hollow tube,* generally about 1 cm wide and 30 cm in length, although it may range from a few millimeters to 8 cm in width and reach a length of 4 m. In cross section the walls of the tube are one cell thick. Its name derives from the common constricted form which is sometimes filled with air bubbles. The blades may be flattish when the volume of air trapped within the tube is minimal. The plants occur singly, in tufts, or in dense populations.

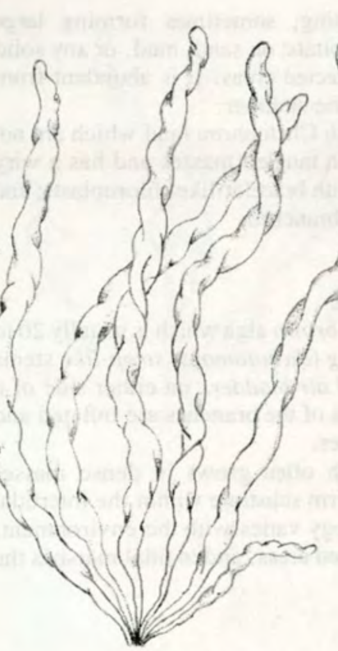
This alga is very abundant in the brackish waters of estuaries, where it reaches its maximum development. It is usually found attached to rocks, wood, shells, sand, or other algae. Most species of Enteromorpha are tolerant of widely varying environmental conditions, particularly salinity, and specimens have been found growing actively in waters of very low salinity. Most will also thrive in moderate pollution, and this species itself will tolerate very high degrees of pollution. These plants are used for food in certain countries.

Sea Lettuce (*Ulva lactuca*): Sea lettuce occurs in *bright green, flat, lettuce-like sheets* which are two cell layers thick and may reach 60 cm or more in length. The sheets are perforated, rounded, longer than wide, but sometimes fan-shaped, lobed, folded, or ruffled at the edges.

Sea lettuce can be found throughout the year, usually attached to rocks, wood, shells, or other algae in the intertidal zone or lower, or growing in tidal marshes at the base of the intertidal tall salt water cordgrass. Large specimens (one meter or more in length) may also be found floating in quiet areas on mudflats or sandy bottoms. Highly productive and very common, sea lettuce is tolerant of wide variations in environmental conditions and is particularly well adapted to brackish and polluted waters.

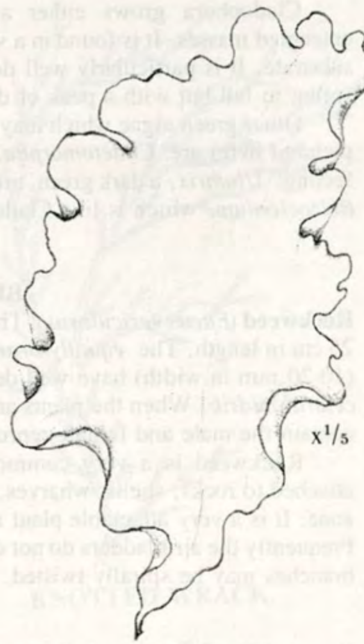
Cladophora (*Cladophora* spp.): In color this alga is bright green to yellow-green. It is *filamentous* and *uniseriate* (with single cells attached end to end which are only visible with a good hand lens or a microscope). The filaments are very fine, usually *soft, highly branched,* and up to 30 cm tall. There are many species of Cladophora. These are distinguished on the basis of the size of the cells, the branching pattern, and the habitat.

x½



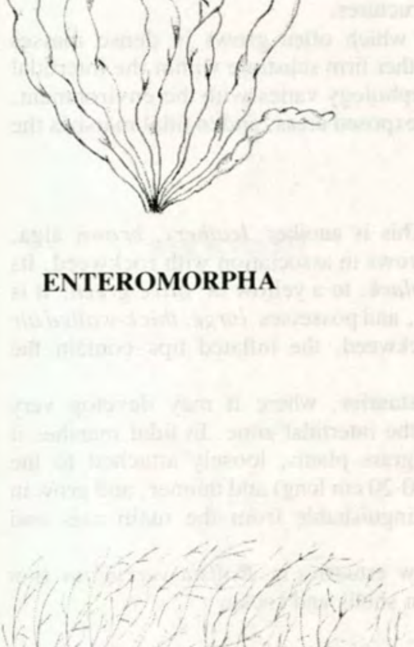
ENTEROMORPHA

$x^{1}/_{5}$

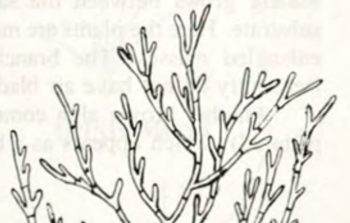


SEA LETTUCE

$x^{1}/_{3}$



CLADOPHORA



Detail of Branching Pattern of Cladophora

Cladophora grows either attached or floating, sometimes forming large entangled masses. It is found in a wide range of habitats; on sand, mud, or any solid substrate. It is particularly well developed in protected areas. It is abundant from spring to fall but with a peak of development in the summer.

Other green algae which may be confused with Cladophora (and which are not pictured here) are: *Chaetomorpha*, which occurs in tangled masses and has a wiry feeling; *Ulothrix*, a dark green, unbranched alga with bracelet-like chloroplasts; and *Rhizoclonium*, which is like Cladophora but is unbranched.

BROWN ALGAE

Rockweed (*Fucus vesiculosus*): This is a *leathery, brown* alga which is usually 20 to 25 cm in length. The *equally-branching* or *forking (dichotomous) strap-like* stems (10-20 mm in width) have well developed *paired air bladders* on either side of a *central midrib*. When the plants are mature the tips of the branches are inflated and contain the male and female reproductive structures.

Rockweed is a very common species which often grows in dense masses attached to rocks, shells, wharves, and any other firm substrate within the intertidal zone. It is a very adaptable plant and its morphology varies with the environment. Frequently the air bladders do not develop in exposed areas, and in tidal marshes the branches may be spirally twisted.

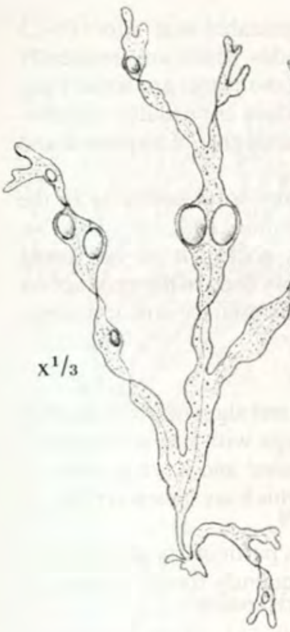
Knotted Wrack (*Ascophyllum nodosum*): This is another *leathery, brown* alga, averaging 40-50 cm in length, which often grows in association with rockweed. Its color varies from *dark brown*, sometimes *black*, to a yellow or *olive green*. It is *irregularly branched, does not have a midrib*, and possesses *large, thick-walled air bladders* which are *not paired*. As in rockweed, the inflated tips contain the reproductive structures at maturity.

Knotted wrack is very common in estuaries, where it may develop very abundantly throughout the year on rocks in the intertidal zone. In tidal marshes it usually grows between the salt water cordgrass plants, loosely attached to the substrate. Here the plants are much smaller (10-20 cm long) and thinner, and grow in entangled masses. The branches are indistinguishable from the main axis and frequently do not have air bladders.

Another brown alga common in shallow estuaries is *Ralfsia verrucosa* (not pictured), which appears as a brown crust on shells and rocks.

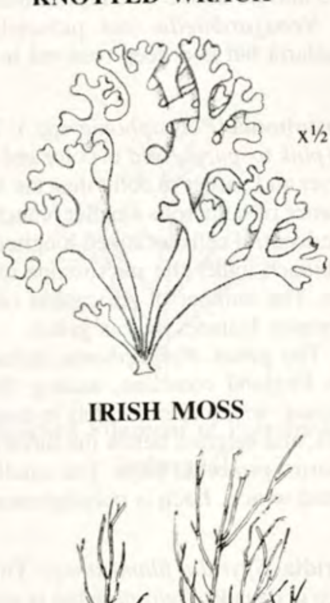
RED ALGAE

Red Ceramium *(Ceramium rubrum):* This is the commonest filamentous red alga of the eastern Connecticut shoreline. It grows at all levels, forming firm *masses* or *tufts* 10-40 cm tall, attached to any convenient substrate. The filaments are *dichotomously branched* (forking), with the thin apex having *curved "pincers"*. There is a pronounced *horizontal banding* of the branches, easily visible without a hand lens, which is due to cortication (thickened cells). The bands are used for distinguishing it from other species of Ceramium. *Spyridia* and *Polysiphonia* resemble Ceramium in texture but do not bear the tiny terminal "pincers". All three may grow in the same area of the estuary and are frequently found in floating masses of algae. *Antithamnion cruciatum* (not pictured) is a smaller filamentous red alga which is found attached in short tufts to rocks and other seaweeds or eelgrass. The branching is opposite or whorled and there are glands on all the branches, visible only with a microscrope, which are a distinguishing feature of this alga.

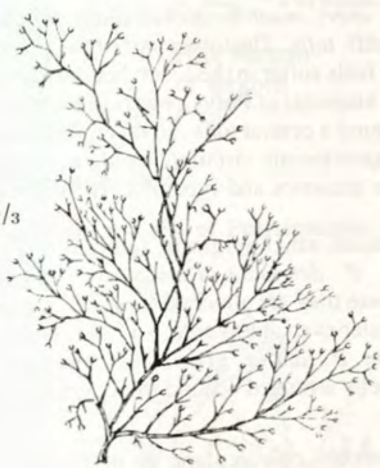


ROCKWEED

KNOTTED WRACK



IRISH MOSS



RED CERAMIUM

Detail of Branched Filaments of Red Ceramium

GRACILARIA

Irish Moss (*Chondrus crispus*): Irish moss is readily recognizable as a *short* (8-15 cm), *bushy, stiff* alga with *flattened, rubbery, leaflike* blades which are frequently curled. The color is usually deep red, with a purple tint, but the plants are sometimes bleached by the sun and become whitish-green. The branches are usually dichotomous but the morphology of this alga varies greatly with the degree of exposure and variations in salinity.

Irish moss is found throughout the year attached to any solid substrate in the lower intertidal zone and below. It is exceedingly common and can grow so abundantly that it seems to form thick carpets on the rocks. It is harvested commercially for the extraction of carageenin, which is widely used in the production of some dairy products, baked goods, pharmaceuticals, cosmetics, and industrial compounds.

Gracilaria *(Gracilaria verrucosa):* Although Gracilaria is a red alga, its color is often *yellow-green* or *yellow-brown-purple*. It is a *bushy, firm* alga with *coarse* branches (10-30 cm tall and 0.5-2 cm in diameter) which are *rounded* and have a *rubbery* texture. The main branches bear *short lateral projections* which are characteristic of the species.

Gracilaria is found in warm, shallow, quiet bays and is particularly abundant in the summer. As with many red algae in estuaries, it is frequently found floating in large masses above a sandy or muddy bottom.

Neoagardhiella (not pictured) is another bushy red alga which resembles Gracilaria but is a deep rose-red in color.

Polysiphonia *(Polysiphonia* spp.): This is an *erect, much branched* plant which is *light pink* to *purple-red* in color and grows in stiff *tufts*. The lower part of the plant is coarser and darker in color than the top, which feels softer to the touch because of the presence of numerous smaller branchlets. The filaments of Polysiphonia are made up of pericentral cells arranged longitudinally around a central axis, so that a section of the branch under the microscope reveals a characteristic circular, banded arrangement. The number of pericentral cells and the presence and type of cortication are diagnostic features of this genus.

The genus *Polysiphonia* includes 11 species which might be found along the New England coastline, among them being *P. denudata*, *P. harveyi*, and *P. elongata*, which occur widely in estuaries, where they are attached to wood, stones, shells, and eelgrass below the surface of the water even at low tide, and are common in warm, protected bays. The smaller epiphyte, *P. lanosa*, grows only attached to knotted wrack. Each is polysiphonous, with cells arranged around the central axis.

Spyridia (*Spyridia filamentosa*): This is a relatively *coarse* plant, up to 20 cm tall, which is usually *light pink* but is often bleached and *straw-colored*. The texture is *brittle* to the touch, especially when the plant is taken out of water. The main branches are thicker than the lateral ones, and both are covered with short, deciduous hairs. Microscopic examination is necessary to clearly identify the species. The main branches are composed of rows of short pericentral cells alternating with rough, long pericentral cells. The ultimate branches are much shorter and thinner.

Spyridia is commonly found in warm water during the summer only. It grows on rocks, shells, and eelgrass, and is also found floating in large masses.

A further red alga which is common in estuaries is *Hildenbrandia prototypus* (not pictured), an encrusting plant which appears as bright red or rusty-red patches on rocks.

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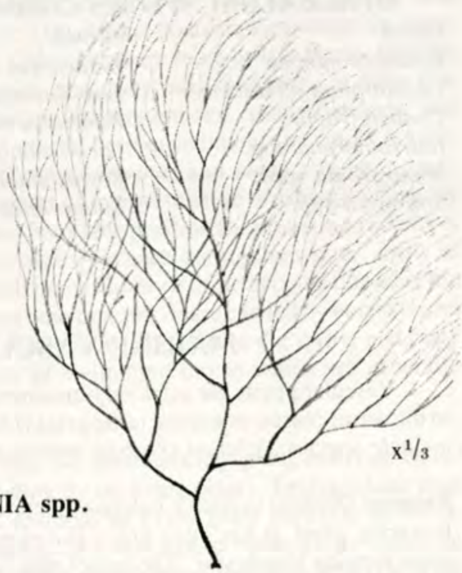
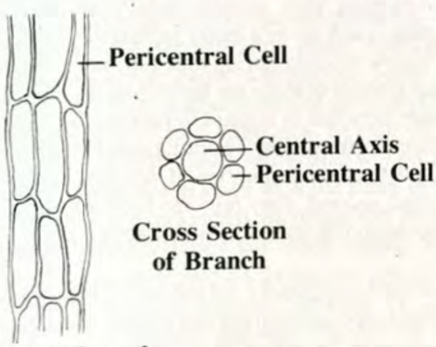


x¹/₃

POLYSIPHONIA spp.



Cross Section of Branch

Portion of Branch

Pericentral Cells of Polysiphonia

Branched Filament of Polysiphonia (enlarged)

x ¹/₃

SPYRIDIA

Detail of Spyridia Showing Deciduous Hairs

OTHER ALGAL SPECIES COMMONLY FOUND IN ESTUARIES

Green	Brown	Red
Blidingia minima	*Ectocarpus* spp.	*Champia parvula*
Capsosiphon fulvescens	*Laminaria saccharina*	*Chondria* spp.
Codium fragile	*Punctaria plantaginea*	*Gelidium crinale*
Enteromorpha spp.	*Sargassum filipendula*	*Griffithsia* spp.
Monostroma spp.	*Scytosiphon lomentara*	*Lomentaria baileyana*
Spirogyra spp.	*Sphacelaria* sp.	*Palmaria palmata*

MARINE VASCULAR PLANTS

Vascular plants are relatively uncommon in marine environments. Southward, in the warm coastal estuaries, turtle grass (*Thallasia* spp.) is common. In the northeast a single species, eelgrass (*Zostera marina*), can become very abundant.

Eelgrass (*Zostera marina*): Eelgrass (pictured on cover) is not an alga but a grass-like flowering plant. It has *long green leaves* with *thin, parallel edges* and three main veins running lengthwise. The leaves may reach up to a meter in length. The flowers are very small and inconspicuous and bloom in early spring and summer. The leaves die back in the fall, and after storms great masses of them are thrown upon the shore.

Eelgrass grows on muddy and sandy bottoms in relatively protected areas, from low tide to a depth of eight meters or more, forming dense populations extending over many acres. The eelgrass beds are important for a number of reasons. First, they prevent erosion of mud and sand particles; second, they provide food and protection for many marine animals; and third, the decaying leaves provide recyclable nutrients for the surrounding waters.

Although the eelgrass beds were almost completely devastated in the 1940s by a microscopic aquatic fungus, *Labyrinthula,* the plants have developed a resistance to the fungus and after a slow recovery are now as luxuriant as ever.

ESTUARINE ANIMALS

Nancy C. Olmstead and Paul E. Fell, *Connecticut College*

Since estuaries are enclosed by fresh water, land and the sea, members of the estuarine fauna derive from all three habitats. However, the animals penetrating estuaries from the sea constitute the largest component.

Many estuarine organisms are able to tolerate wide ranges of salinity and temperature. For example, the blue crab, *Callinectes sapidus,* is frequently found in waters that range in salinity from nearly 0 to 32‰, although mature females migrate to waters of higher salinity to spawn. Similarly the ribbed mussel, *Modiolus demissus,* which is exposed at low tide, can tolerate air temperatures as low as −20°C and as high as 38°C. Animals with narrower tolerance ranges are frequently subtidal and/or are restricted to the upper or lower reaches of the estuary. Some become dormant or migrate to deeper off-shore waters during periods when unfavorable conditions prevail. Other, generally nonmotile organisms may not survive severe conditions, but the estuary may subsequently be repopulated by motile larvae carried in from the sea.

The estuarine animals may be generally divided into four major groups with respect to their position within this habitat: 1) those that float or swim within the water column (ex. many fishes and jellyfish); 2) those that are more or less firmly attached to a hard surface (ex. barnacles, bryozoans, tunicates, and sponges); 3) those that move freely over various surfaces including the bottom (ex. snails, isopods, and many crabs); and 4) those that burrow into the bottom sediment (ex. most bivalve molluscs and many worms). Eelgrass (*Zostera marina*) and algae provide a large surface area for the attachment and/or support of many estuarine organisms which are held above the frequently silty bottom in a favorable position for removing food from the water. However, since most of these plants die back during the winter, many of the animals which they support perish with them. Some of these become buried in the bottom sediment and others are washed up onto beaches or are carried by currents into other unfavorable situations. When the plants redevelop during the spring and early summer, they are colonized by a variety of swimming larvae which are generally produced at this time of the year.

Many of the estuarine animals feed on decomposing plant material called detritus; relatively few organisms graze directly on living plants. Eelgrass beds may contain four times as much dead plant material as living plant material; and this, together with detritus from the neighboring tidal marshes, constitutes an important food source. The decomposing plant material also releases nutrients which support the growth of estuarine phytoplankton. Some animals, known as suspension feeders, filter fine detritus, bacteria and/or phytoplankton from the water. Sponges, many bivalve molluscs, and tunicates belong to this group. Other forms, including amphipods, shrimp, many snails and worms and some fish, feed on bottom deposits of organic material enriched with the feces of other animals. The feeding activities of many of the deposit feeders facilitate the breakdown of plant material by producing uneaten fragments which are more readily acted upon by decomposers. Detritus is enriched in protein and its cellulose content is reduced through the activities of bacteria which consequently increase the nutritional value of detritus to many organisms. Also associated with the detrital material are large numbers of protozoa and minute multicellular animals, including nematodes.

Still another group of estuarine forms are predators. These may feed on small zooplankters, such as the larvae of oysters, clams, etc., or on larger organisms. Among those feeding primarily on small prey are barnacles and many cnidarians. Those feeding on larger prey include some snails and crabs, starfish, many fish and a number of shore birds. Some animals feed on a variety of types of food. Regardless of their mode of feeding, estuarine organisms excrete ammonia and other nutrients and produce feces and other biodeposits. For example, many bivalve molluscs not only filter material from the water and deposit some of it on the bottom in the form of feces, but they also deposit large quantities of material not actually taken into the gut (pseudofeces). The animals therefore play an important role in nutrient recycling within the estuarine system. A food web diagram appears on the back cover.

Illustrations accompany the description of most of the animals discussed below. Drawings are included of isolated body parts where these are important for identification. A bar near the drawing indicates the actual size of the animal. For a few of the larger animals the bar is in two or more sections. Only the common names of animals are given with the illustrations except where there is no common name; in these cases the generic name is used. (The drawing of the bay scallop, on page 31 is by Hugh Niering. The food web diagram on the back cover is by Allen Carroll.)

SPONGES

Sponges (phylum Porifera) are simple, non-motile animals made up of a few different kinds of cells which are not formed into distinct organs. The framework of the sponge consists of siliceous or calcareous spicules and/or the protein, collagen. The size and shape of the spicules differ in each species of sponge. Since the body form of sponges may vary according to such environmental factors as the nature of the substrate and the strength of water currents, it is primarily these spicules which are used for identification. Sponges most apt to be found in estuarine waters along the New England coast belong to the class Demospongia. These sponges are irregular in shape and have siliceous spicules. Water passes through a system of incurrent canals to flagellated chambers, where it is filtered. It then passes out of the sponge through excurrent canals which terminate in a chimney-like structure known as an osculum. Sponges efficiently remove from the water bacteria-size particles, both dead and alive, as a food source.

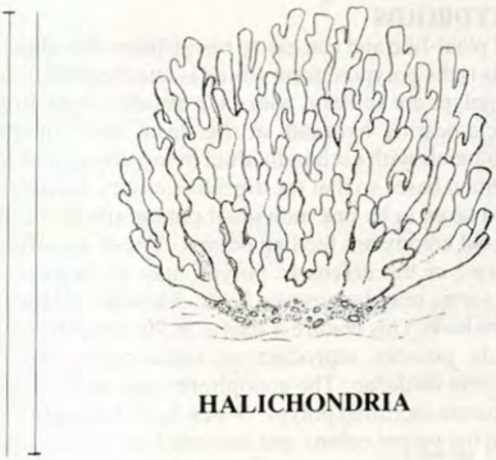
Halichondria (*Halichondria* sp.): The species of Halichondria found in the shallow estuarine waters of southeastern Connecticut frequently has *upright, branching, finger-like* lobes but also occurs in a flatter, encrusting form. It is *yellow-tan to brilliant gold* in color. Specimens may measure up to 12 cm in diameter but small specimens resulting from recent sexual reproduction, and measuring no more than a few millimeters, are common during the summer.

Haliclona (*Haliclona loosanoffi*): This is a *low-growing* sponge, up to 7 cm in diameter, with *rounded oscular chimneys*. The color varies from *tan* to a rich *salmon* color. It is rare to common during the summer on eelgrass and algae or on the sandy mud bottom. During the summer, small round bodies known as gemmules are formed at the base of the sponge. These gemmules consist of food-filled cells surrounded by a hard covering, and are the form in which the sponge overwinters. Clusters of gemmules can occasionally be seen on eelgrass in the fall and winter after the parent sponge has disintegrated.

Boring Sponges (*Cliona* spp.): These boring sponges, *found in empty mollusc shells*, are a bright *sulfur-yellow* in color. The different species can be identified by the size of the bored holes. The sponge first excavates galleries in an empty shell and spreads over both surfaces. It then overgrows, absorbs, and completely destroys the shell and becomes free-living. The free-living stage, in which the sponge may form a sphere up to 30 cm in diameter, is not found in shallow estuaries.

CNIDARIANS

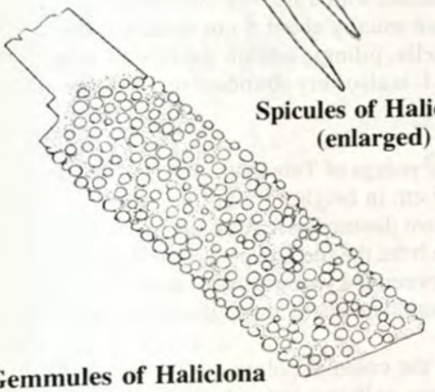
Members of the phylum Cnidaria are characterized by the possession of stinging cells, or nematocysts, with which prey is caught. The nematocysts are situated on tentacles surrounding a mouth which leads into the digestive cavity, the only internal cavity of the members of this phylum. There are three classes of Cnidaria: Hydrozoa (hydroids and siphonophores), Scyphozoa (jellyfish), and Anthozoa (sea anemones and corals). In two of these classes, the Hydrozoa and the Scyphozoa, there may be two life forms: the non-motile, columnar, polypoid form, and the free-swimming, bell-shaped, medusoid form. Most cnidarians are predators.



HALICHONDRIA

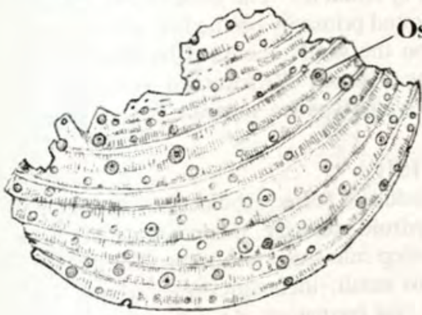
Spicules of Halichondria (enlarged)

Spicules of Haliclona (enlarged)



Gemmules of Haliclona (enlarged)

HALICLONA



BORING SPONGE in Clam Shell

Spicules of Boring Sponge ***(Cliona)*** **(enlarged)**

HYDROIDS

Hydroids are inconspicuous and plant-like and can easily be mistaken for algae. The dominant life form of the hydroids is the polypoid form which is attached to some solid substrate. In some hydroids the polyps are solitary, with each usually consisting of a stem with a flower-like, tentacle-bearing hydranth at the distal end. In the majority of hydroids the polyps are colonial, with each individual being connected to every other individual through a common base, so that the digestive cavity is shared by all members of the colony and food taken in by one individual potentially benefits all. Most of the individuals in a hydroid colony are feeding polyps. These are often capable of serving as defensive polyps, or the defensive polyps may be separate. Polyps of both solitary and colonial forms may be covered by a chitinous cylinder known as a hydrotheca, or they may be bare. This feature is useful in identification of the different species. All hydroids possess reproductive individuals called gonophores which develop asexually into medusae. The gonophores may arise from the feeding polyps or they may be separate modified polyps. When fully formed, the young medusae may break away from the parent colony and become free-swimming members of the zooplankton, or they may exhibit varying degrees of reduction and remain attached to the parent. In either case, medusae reproduce sexually. Eggs are fertilized internally or externally and the resulting larvae, which are free-swimming, attach themselves to the substrate and develop into hydroid polyps.

The following hydroids are typical of those found in estuaries of southeastern Connecticut:

Obelia *(Obelia* sp.): This *feathery, branching, colonial* hydroid is *whitish* in color. It is *thecate* (with a hydrotheca) and the medusae, which are free-swimming, develop in specialized, modified polyps. Colonies are usually about 5 cm in height but may reach 20 cm. Obelia is very abundant on shells, pilings, and on the tips of eelgrass, particularly in late spring and early summer. It is also very abundant on the large alga, *Laminaria,* in deeper water.

Tubularia (*Tubularia crocea*): The *colonial* polyps of Tubularia are *unbranched or sparsely branched* and are from 3 cm to 15 cm in height. There are *two whorls of tentacles*. The hydrotheca is lacking. The most distinctive feature of Tubularia is the *rose* color of the polyp heads. Medusae arise from the feeding polyp itself and remain attached to the parent. They are situated between the two whorls of tentacles. These hydroids are abundant on wharf pilings, floats, and shells throughout the summer.

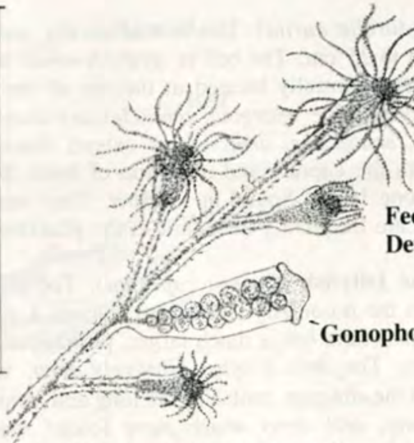
Hypolytus (*Hypolytus perogrinus*): Unlike the colonial polyps of the two hydroids discussed above, the polyps of Hypolytus are *solitary*. Individuals are usually less than 1.5 cm in height, and have *two whorls of tentacles*. The base of the hydranth bears a *swollen ring*. This small hydroid is found primarily on the tips of eelgrass.

The pink, fuzzy covering often seen on the shells occupied by hermit crabs consists of colonies of the small encrusting hydroid *Hydractinia echinata* (not pictured). Feeding, defensive, and reproductive polyps are separate in this species.

JELLYFISH

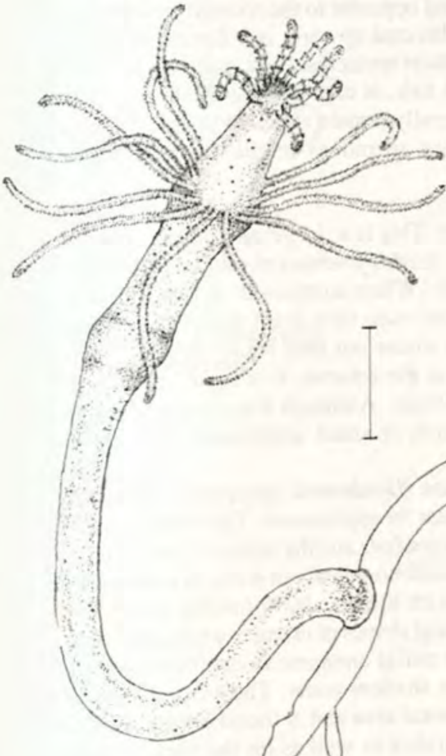
In the jellyfish (class Scyphozoa) the medusoid form is the dominant life form. Although they are much larger in size than hydroid medusae, the internal structure is much the same. Fertilized jellyfish eggs develop into free-swimming planula larvae which attach to the bottom and develop into small, inconspicuous polyps. These polyps reproduce asexually by budding and cyst formation. At certain times of the year special medusoid buds break away from the polyps and form into sexually reproducing adult jellyfish. The jellyfish common in Long Island Sound are:

OBELIA
(Colonial Hydroid)

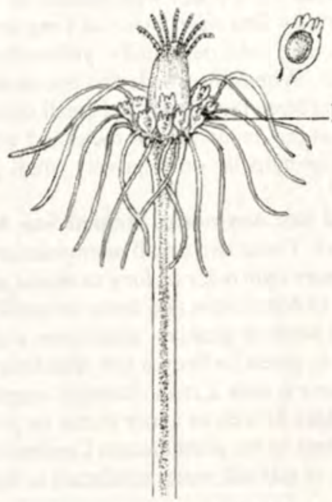


Obelia Polyps (enlarged)

TUBULARIA
(Colonial Hydroid)



HYPOLYTUS
(Solitary Hydroid)



Feeding Polyp of Tubularia
(enlarged)

Moonjelly (*Aurelia aurita*): This is a relatively *small* jellyfish with a diameter of about 15 cm to 25 cm. The bell is *grayish-white* and quite *flat*. Four horseshoe-shaped gonads, centrally located at the top of the bell, can be seen through the translucent body. The *marginal tentacles are short and numerous*, and there are *four longer, broad oral arms* which extend downward from the mouth and are involved with the capture and ingestion of food. Moonjellies are common in the waters of Long Island Sound in summer. Tiny immature medusae are known as ephyrae and are frequently abundant in the plankton in the spring.

Lion's Mane Jellyfish (*Cyanea capillata*): The lion's mane jellyfish is a *larger* jellyfish than the moonjelly. It seldom reaches a diameter of more than 25 cm in estuarine waters here but is much larger, perhaps as much as 2.5 m in diameter, in Arctic waters. The *bell is often relatively deep*, with the rim divided into eight sections, and the stinging tentacles are long and arranged in eight clusters. There are also four long, oral arms which have folded margins. The color is generally *brownish-red* to *yellow-red* in the center but in large specimens the central region and the oral tentacles may be purple. This is a very common jellyfish in these waters in the spring.

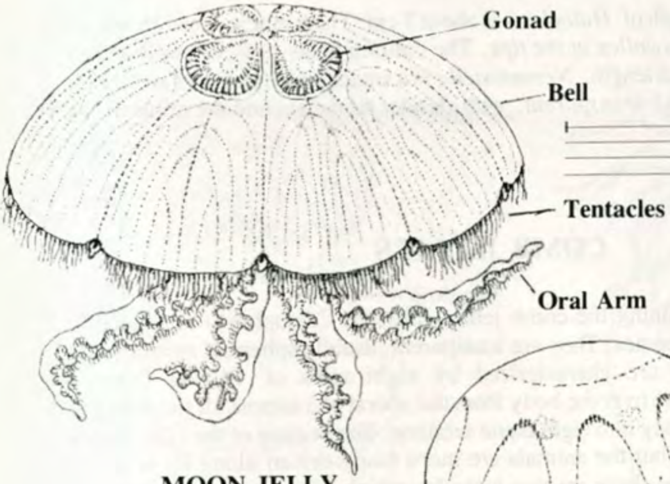
SEA ANEMONES

In the sea anemones (class Anthozoa) there is no medusoid state. Sea anemones are solitary polyps, larger than hydroids. The heavy, cylindrical body (the column) is attached to the substrate at the aboral end (end opposite to the mouth) by means of an adhesive disc. The oral end of the column, directed upward, is a flattened disc with a mouth in the center which is surrounded by short tentacles. Prey, ranging in size from small members of the zooplankton to small fish, is captured by these tentacles and transferred to the mouth. Sea anemones generally remain attached to the substrate but are capable of moving about. Common sea anemones in the shallow waters of southeastern Connecticut are:

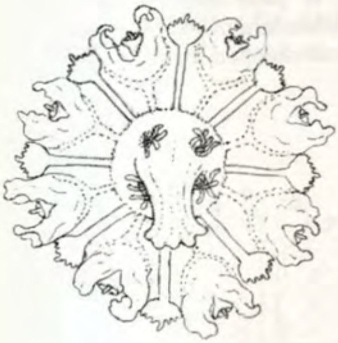
Common Sea Anemone (*Metridium senile*): This is a *large* anemone, up to 10 cm high and 7 cm wide, with masses of *short, feathery tentacles*. When extended, the column is *less than twice as long as broad*. When contracted, it resembles a low cone. The color is usually *yellow-brown* but may vary from whitish-pink to dark brown. When disturbed, this anemone may throw out thin white threads known as acontia from the mouth and small openings in the column. It is found in dark places such as the undersides of rocks and wharf pilings. Although it is a large anemone, it feeds principally on relatively small prey such as small amphipods.

Pallid Sea Anemone, Striped Sea Anemone (*Diadumine leucolena, Haliplanella luciae*): These two small anemones are similar in appearance. The columns of both are *more than twice as long as broad when extended*, and the tentacles are longer than those of Metridium and fewer in number. *Diadumine* is about 4 cm in column length and is white or pinkish, sometimes mottled with brown. *Haliplanella* (not pictured) is olive, green, or brown and often bears vertical stripes of orange, white, or yellow. It seldom exceeds 2 cm in column length. The pallid anemone is common on eelgrass and algae as well as under stones or pilings in shallow water. The striped anemone is abundant in the southeastern Connecticut coastal area and is found on the mud or the stalks of tall salt water cordgrass in tidal marshes as well as on the rocks offshore.

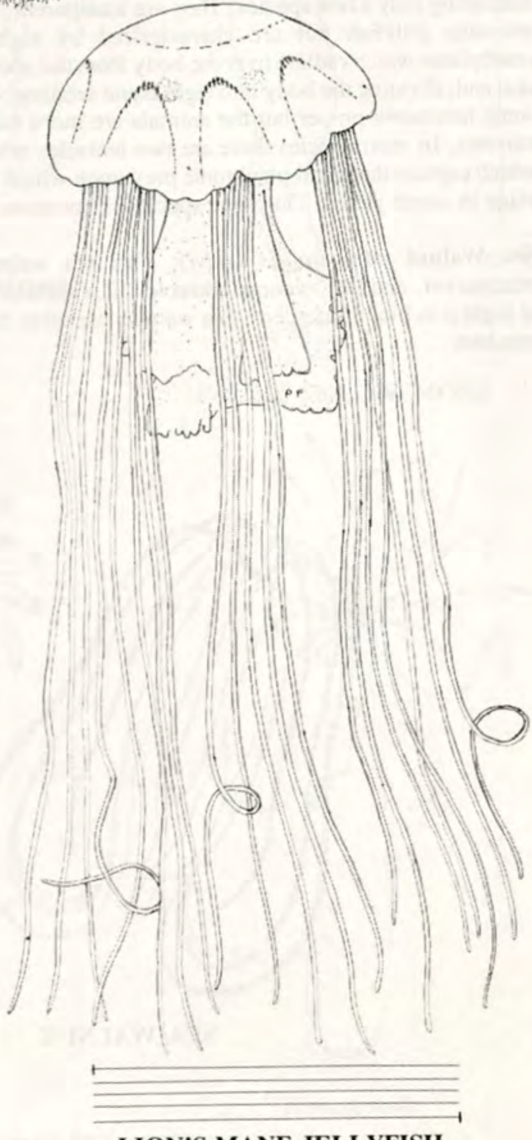
Burrowing Sea Anemones *(Haloclava producta, Nematostella vectensis):* Burrowing anemones bury themselves in the mud or sandy mud with only the tentacles



MOON JELLY



Ephyra of Moon Jelly (enlarged)



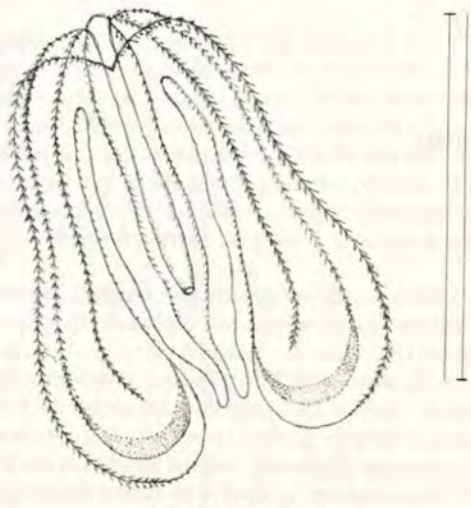
LION'S MANE JELLYFISH

exposed. The body length of *Haloclava* is about 7 cm. The tentacles, which are *20 in number, are blunt* and *swollen at the tips*. The column bears rows of papillae (small protruberances) along its length. *Nematostella* is a smaller anemone, not over 2 cm in length. It is *delicate* and *transparent*, with slender tentacles, and the column *lacks papillae*.

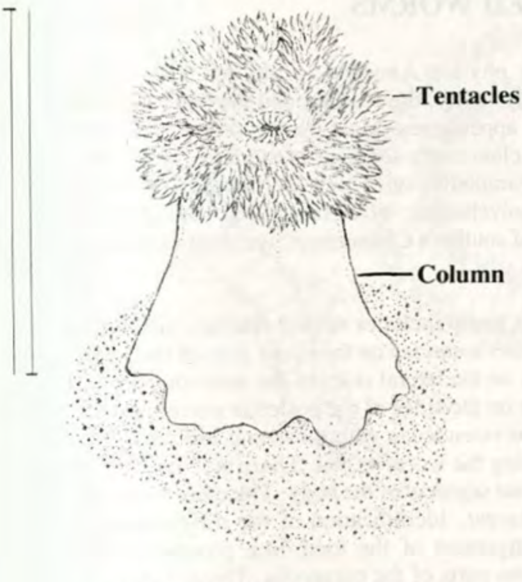
COMB JELLIES

The phylum containing the comb jellies (phylum Ctenophora) is a small one containing only a few species. They are transparent, usually spherical animals which resemble jellyfish but are characterized by eight rows of ciliated (hair-like) combplates which radiate over the body from the aboral end almost all the way to the oral end, dividing the body into eight equal sections. The beating of the cilia provides some locomotor power but the animals are more easily driven along by winds and currents. In most species there are two tentacles which arise from the oral end and which capture the small planktonic prey upon which they feed. There is no polypoid stage in comb jellies. Only one species is common in this coastal region.

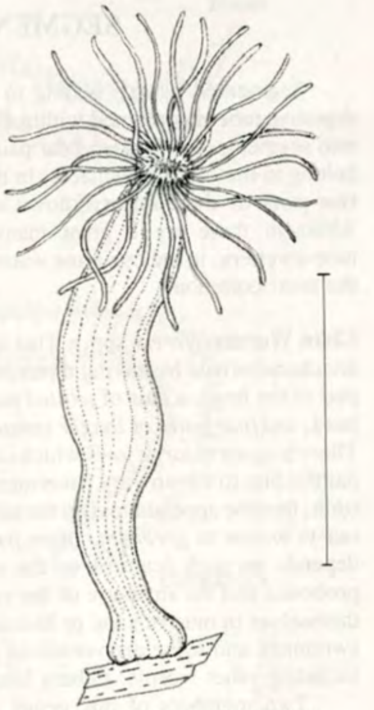
Sea Walnut (*Mnemiopsis leidyi*): This sea walnut is *pear-shaped, bi-lobed, transparent,* and has *reduced tentacles*. It is about 10 cm in length. When disturbed at night it is bioluminescent. Sea walnuts are often found clumped together in great numbers.



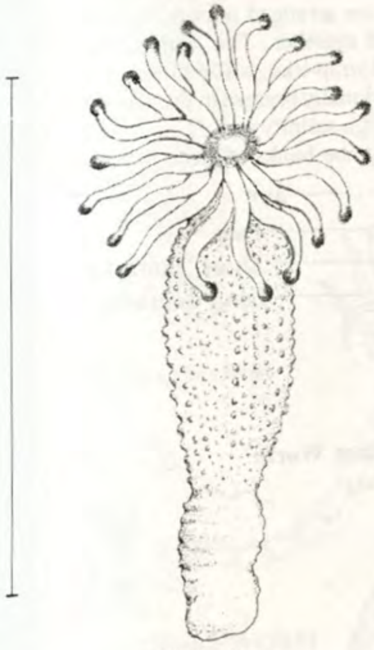
SEA WALNUT



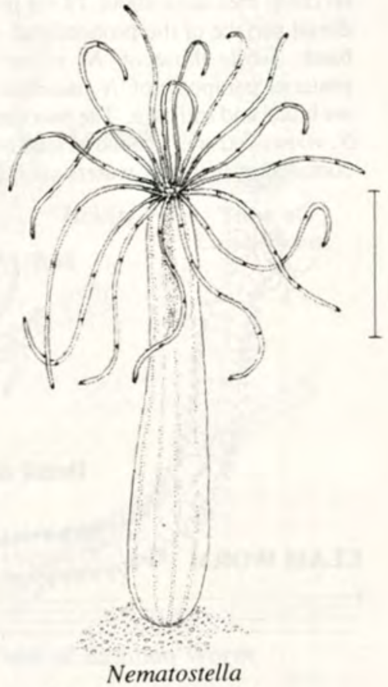
COMMON SEA ANEMONE
(Metridium)



PALLID SEA ANEMONE



Haloclava



Nematostella

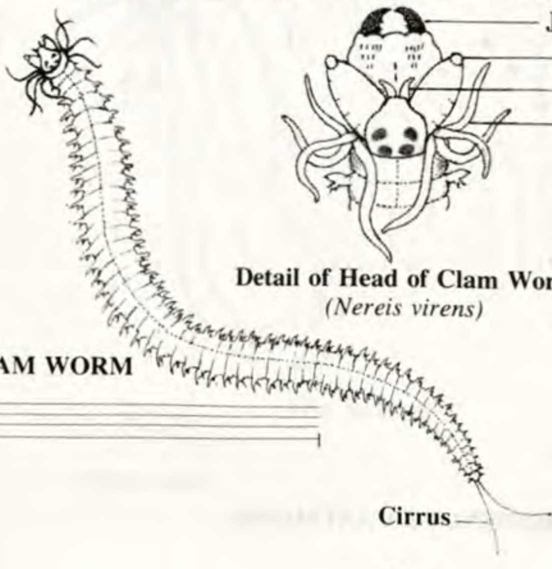
BURROWING SEA ANEMONES

SEGMENTED WORMS

Segmented worms belong to the phylum Annelida, a phylum in which the digestive tube is contained within a body cavity, the coelom, and the body is divided into segments which often bear paired appendages. Most marine segmented worms belong to the class Polychaeta. In this class every segment of the body bears one or two pairs of short limbs, known as parapodia, on which are bundles of bristles. Although there are a great many polychaetes, both free-living and sedentary tube-dwellers, in the estuarine waters of southern Connecticut, we shall include only the most common.

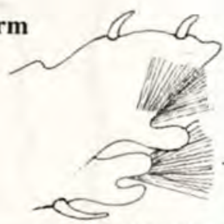
Clam Worms *(Nereis* spp.): This large group includes several species, all of which are characterized by having a pair of *short tentacles* on the upper side of the anterior part of the head, a pair of *jointed palps* on the lateral sides of the anterior part of the head, and *four pairs of longer tentacles* on the sides of the posterior part of the head. There is a pair of *large jaws* which can be extended or withdrawn and which can give a painful bite to the unwary fisherman using the worm as bait. There are *two long cirri* (thin, flexible appendages) on the terminal segment of the body. The color varies from *red* to *brown* to *greenish*, often *irridescent*. Identification of the different species depends on such features as the arrangement of the tooth-like processes on the proboscis and the structure of the various parts of the parapodia. These worms bury themselves in mud or sand or hide among algae or under rocks. They are also active swimmers and some are voracious predators on various forms of small marine life, including other worms. Others feed on algae.

Two members of this genus which are common here are *N. virens* and *N. succinea*. The former is a large worm which may reach a length of 45 cm, while *N. succinea* measures about 19 cm in length. The terminal tooth-like processes on the dorsal surface of the proboscis of *N. succinea* are arranged in two crescent-shaped bands, while those of *N. virens* are clumped together. The upper lobes of the posterior parapodia of *N. succinea* are long and strap-like, while those of *N. virens* are broad and leaf-like. The two worms are occasionally present in the same areas, but *N. virens* is usually found in shallow waters of high salinity and *N. succinea* is more common in brackish waters such as those along the banks of tidal marshes.

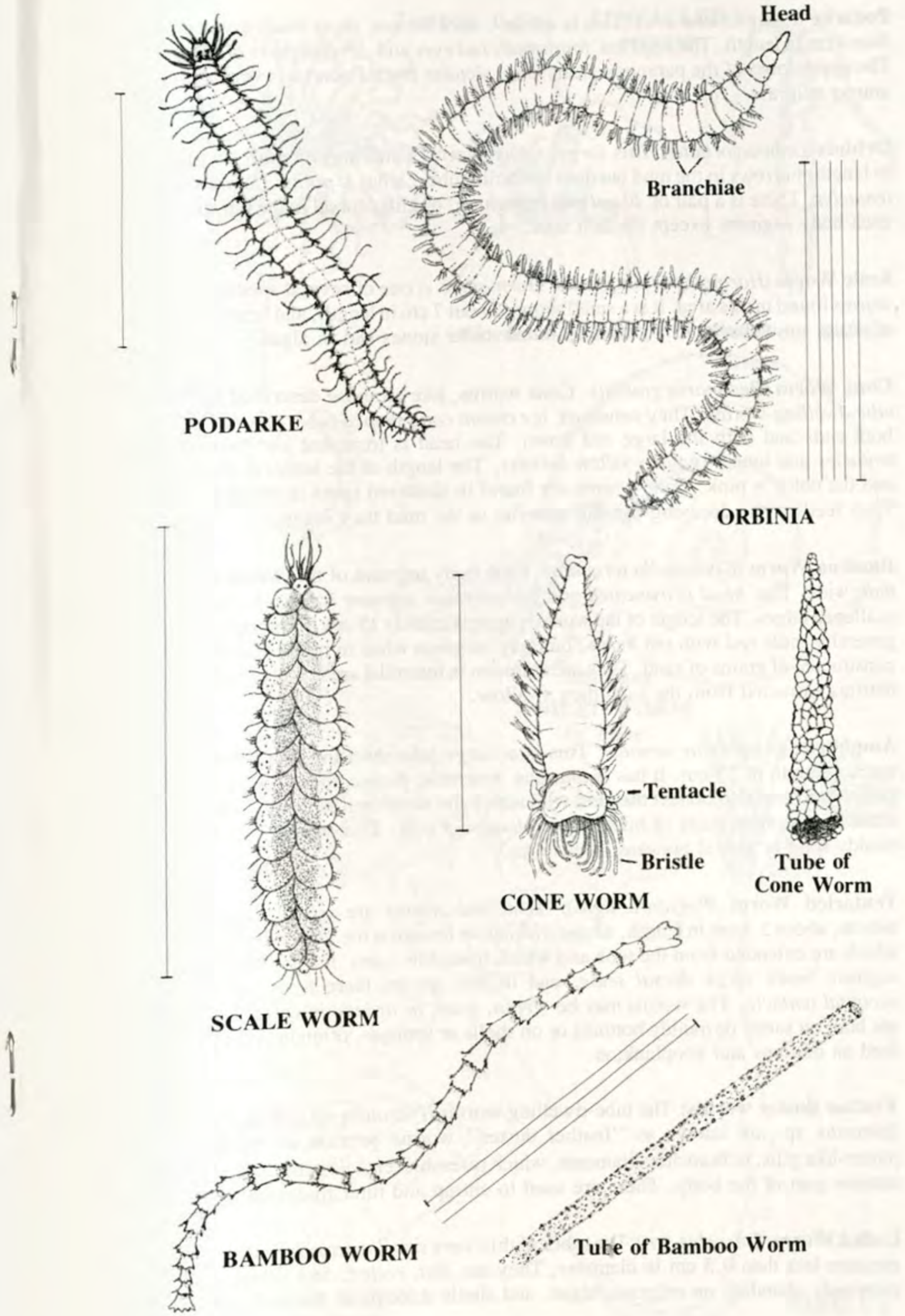


Detail of Head of Clam Worm
(Nereis virens)

CLAM WORM



Detail of Parapodia of Clam Worm



Head
Branchiae
PODARKE
ORBINIA
Tentacle
Bristle
Tube of Cone Worm
CONE WORM
SCALE WORM
BAMBOO WORM
Tube of Bamboo Worm

Podarke (*Podarke obscura*): This is a *small, dark brown, short-bodied* worm, less than 4 cm in length. The head has *four small, red eyes* and *several pairs of tentacles*. The upper lobes of the parapodia bear *long, slender cirri*. Podarke is very abundant among eelgrass.

Orbinia (*Orbinia ornata*): This *large, robust* worm (which may measure up to 25 cm in length) burrows in the mud but does not build tubes. It has a *pointed head* with *no tentacles*. There is a pair of *blood-red branchiae*, or gills, dorsal to the parapodia on each body segment except the first four.

Scale Worm (*Harmothoe imbricata*): *Harmothoe* is one of several species of scale worms found in this area. It is a small worm, about 7 cm in length, and bears *15 pairs* of scales on its back. It is generally found under stones and in algae.

Cone Worm *(Pectinaria gouldii):* Cone worms, like all those described below are *tube-dwelling* worms. They construct *ice cream cone shaped tubes of sand*, open at both ends and with the large end down. The head is truncated and bears *short tentacles* and longer *golden-yellow bristles*. The length of the worm is about 4 cm and the color is pink. Cone worms are found in sheltered spots in intertidal areas. They feed on the decaying organic material in the mud they ingest.

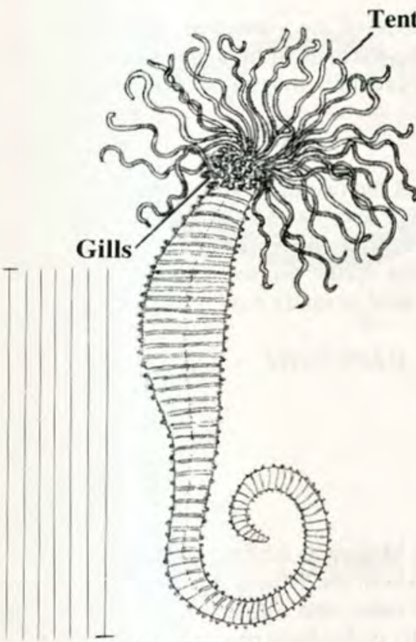
Bamboo Worm (*Clymenella torquata*): Each body segment of this worm is *longer than* wide. The *head is truncated* and the *terminal segment is funnel-shaped* with scalloped edges. The length of the worm is approximately 15 cm. Bamboo worms are generally *pale red* with red bands, but may be green when in mud. Their tubes are constructed of grains of sand. They are common in intertidal areas where they feed on detritus extracted from the sand they swallow.

Amphitrite (*Amphitrite ornata*): This is a *large* tube-dwelling worm which may reach a length of 35 cm. It has *numerous, extensile, flesh-colored tentacles* which gather food and also collect the sand with which the worm builds its tube. Behind the tentacles are three pairs of branching, *blood-red gills*. This worm is common on muddy sand or gravel bottoms in this area.

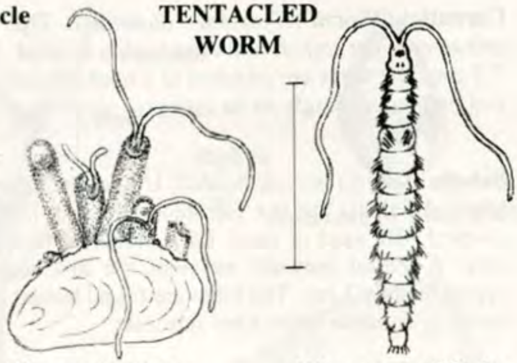
Tentacled Worm (*Polydora ligni*): Tentacled worms are *small* tube-dwelling worms, about 2.5 cm in length, whose distinctive feature is the *pair of long tentacles* which are extended from the tube and which resemble *rams' horns*. The fifth body segment bears *large dorsal setae*, and in this species there is a *short median occipital tentacle*. The worms may be *green, gray, or orange* in color. Their tubes are built on sandy or muddy bottoms or on shells or sponges, often in colonies. They feed on diatoms and zooplankton.

Feather duster worms: The tube-dwelling worms *Hydroides* sp., *Sabella* sp., and *Spirorибs* sp. are known as "feather duster" worms because of the wreath of plume-like gills, or branchial filaments, which resemble tentacles and extend from the anterior part of the body. These are used to entrap and filter microscopic food.

Coiled Worm *(Spirorbis* sp.): The tubes of this *very small* worm are *calcareous* and measure less than 0.3 cm in diameter. They are *flat, coiled,* and *white*. They are extremely abundant on eelgrass, algae, and shells throughout the summer.



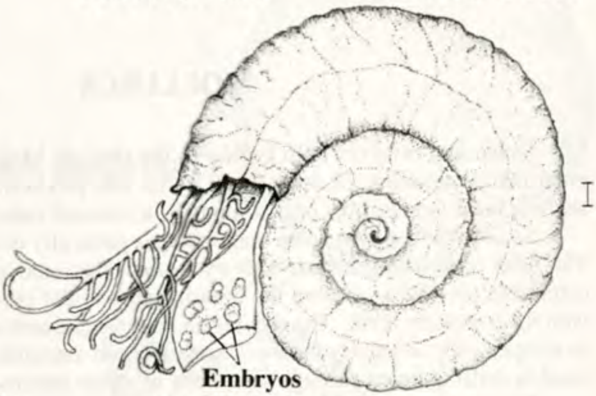
AMPHITRITE



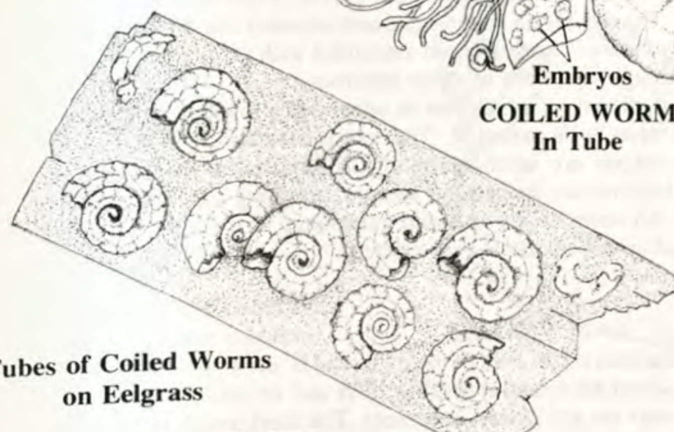
TENTACLED WORM

Worms in Tubes

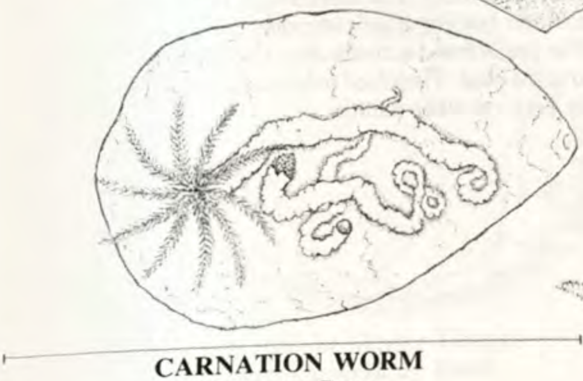
Worm out of Tube



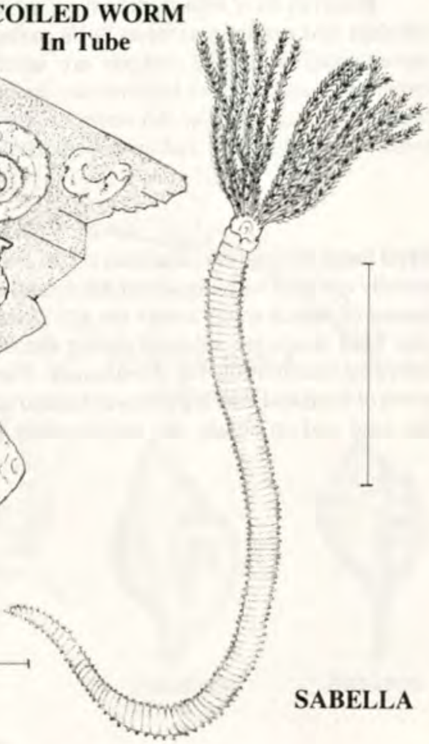
COILED WORM
In Tube



Tubes of Coiled Worms
on Eelgrass



CARNATION WORM
Tubes on Stone



SABELLA

Carnation Worm *(Hydroides dianthus):* The tubes of the carnation worm are *calcareous, not coiled,* and often highly twisted. The worm itself may measure up to 7.5 cm. The tubes are attached to a hard substrate, generally mussel or clam shells, and may occur singly or in groups.

Sabella (*Sabella micropthalma*): Unlike the tubes of the two preceding worms, the tubes of Sabella are not calcareous but are *leathery* and *flexible* and are usually covered with sand or mud. Each branchial filament of these worms bears *several eyes.* A *collar* partially envelops the first segment of the worm. The length is approximately 3 cm. The tubes are found buried in sand or sandy mud or attached to shells or to some other hard substrate.

MOLLUSCS

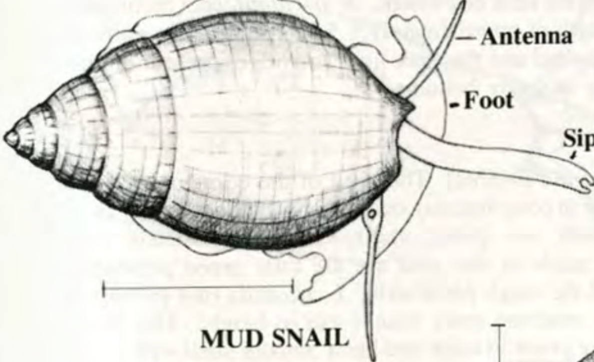
Snails and bivalves both belong to the phylum Mollusca. Although there are a great many variations of body form within this phylum, the typical member has a shell, a head (sometimes only a mouth), a visceral mass, and a foot.

Snails have a single valve shell which is generally in the shape of a conical spire. The head is well developed, with eyes, tentacles, and sometimes a siphon and an extensible proboscis. Within the mouth cavity is the radula, a ribbon-like structure with rows of sharp teeth. The radula can be extended and retracted and the teeth serve as scrapers. Occasionally there is a boring organ associated with the radula, which is used in drilling holes through the shells of other molluscs.

Bivalves have two shell valves, which can be opened to allow the foot and the inhalant and exhalant siphons to be extended. The foot is used for digging and for locomotion, while the siphons are used for taking in food-laden water and for expelling wastes. Most bivalves are suspension feeders, ingesting particles of food which are filtered out of the water on the gills and transported to the mouth by cilia (small beating hairs). Indigestible particles are ejected.

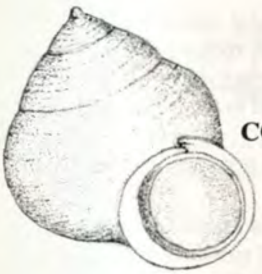
SNAILS

Mud Snail (*Nassarius obsoletus*): The shell of the mud snail is *dark brown* or *black,* usually covered with algae and debris and appearing *dirty* and *eroded.* A *siphon,* by means of which water enters the gill cavity, is present. The shell length is up to 2.5 cm. Mud snails are subtidal during the winter but are often extremely abundant on intertidal mudflats during the summer. The snails crawl actively about, following the scent of food and leaving grooves behind in the mud. They feed on organic material in the mud and on algae, and occasionally prey on other molluscs.

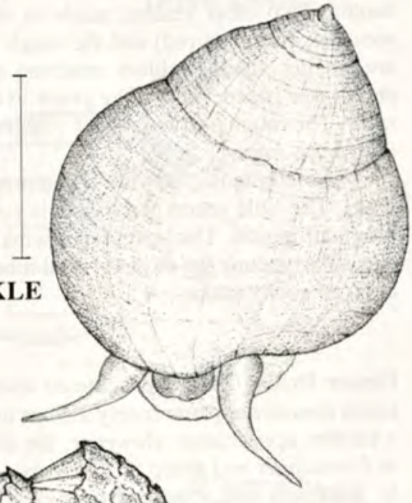


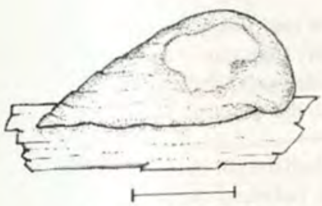
MUD SNAIL

Aperture of Mud Snail

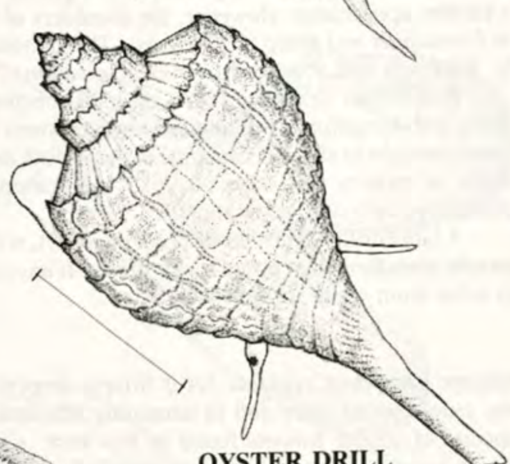


COMMON PERIWINKLE

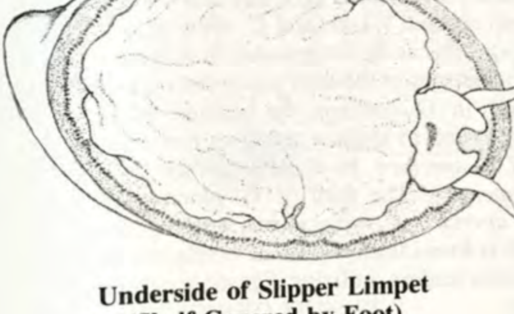




SLIPPER LIMPET
(Crepidula convexa)



OYSTER DRILL
(Eupleura)



Underside of Slipper Limpet (Shelf Covered by Foot)

Urosalpinx

Eupleura

A smaller, related snail, the little dog whelk, *N. trivittata*, (not pictured) is gray in color and has a shell length of approximately 1.5 to 2.0 cm. The spire is more pointed than that of the mud snail and there are lines and ridges present on the shell. This snail is more common on sandy bottoms.

Common Periwinkle (*Littorina littorea*): The shell of the common periwinkle is usually *dark gray* or *brown* in color but may occasionally be lighter gray or yellow. It is *round, relatively smooth, low-spired,* and reaches approximately 2.5 cm in height. Two other related snails in this area are the little green periwinkle, *L. obtusata*, (not pictured) and the rough periwinkle, *L. saxatilis* (not pictured). Both are smaller snails, seldom reaching more than 1 cm in height. The little green periwinkle is generally *olive green* in color and has a *smooth* shell with a *very low spire*. The rough periwinkle has *rough yellowish* shell with irregular raised lines and a *definite spire*.

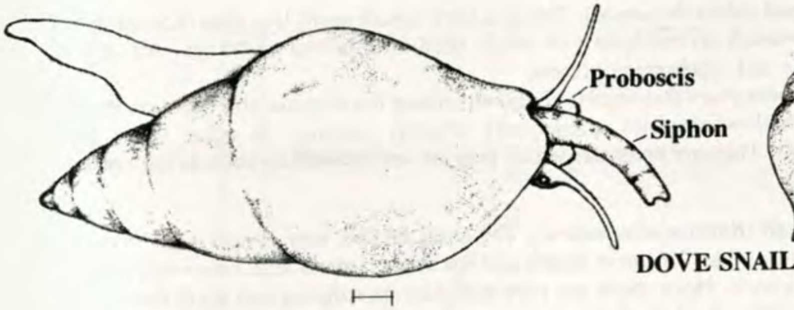
The common periwinkle is abundant on rocks and in tidal pools in mid-tide areas. The little green periwinkle is commonly associated with rockweeds in lower intertidal areas. The rough periwinkle is found in the higher intertidal areas, particularly along the edges of tidal marshes, and it is also found in the high intertidal areas of rocky shores.

Oyster Drills (*Urosalpinx cinerea* and *Eupleura caudata*): The shells of both these snails measure approximately 2.5 cm in height and bear vertical ribs which give them a knobby appearance. However, the shoulders of the spire and the ribs are rounded in *Urosalpinx* and sharp in *Eupleura*. The siphonal aperture is long and constricted in *Eupleura* and short and open in *Urosalpinx*.

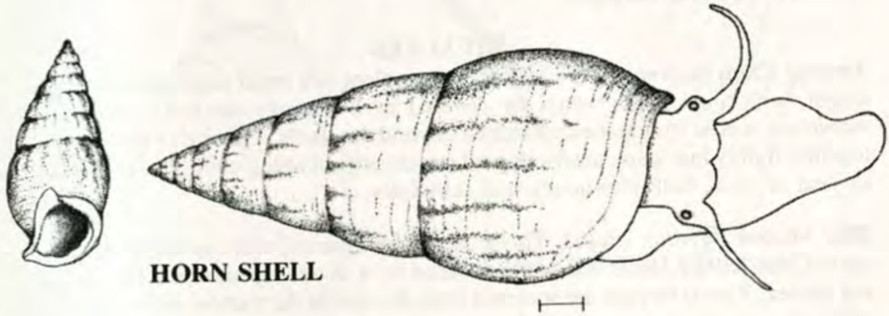
Both oyster drills are found on hard substrates in low intertidal and subtidal areas, but *Urosalpinx* can tolerate water of lower salinity than can *Eupleura* and is more common in shallow estuarine waters. Both are predaceous, drilling holes in the shells of oysters and other shellfish and sucking out the juices. They are very destructive to oyster populations.

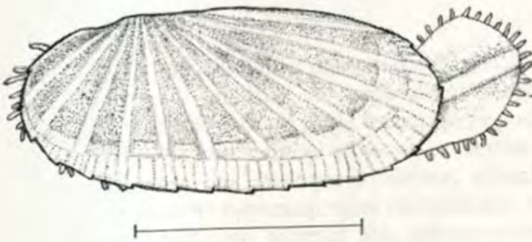
A large drill, *Thais lapillus* (not pictured), with a shell height of up to 3 cm, may be very abundant on exposed rocky shores. It has a thick, polished shell which ranges in color from white to light yellow.

Slipper Limpets(*Crepidula* spp.): Slipper limpets differ from other snails in lacking the usual conical spire and in remaining attached to the substrate. There are three species of slipper limpets found in this area: *Crepidula fornicata*, (not pictured) which has a shell length of approximately 5 cm and is generally found in stacks; *C. plana*, (not pictured) with a shell length of about 3.3 cm; and *C. convexa*, with a shell length of about 1.3 cm. The different species can be distinguished from each other not only by their size but also by the characteristics of the shelf which partially covers the aperture on the underside of the shell. In *C. convexa*, the smallest of the slipper limpets and the one most commonly found in shallow estuaries here, the shelf is *brown* and *covers about one third of the aperture*. In *C. fornicata* the shelf is *white* and *covers about one half of the aperture*. The shelf of *C. plana* is also *white* and *covers less than one half of the aperture*. *C. convexa* has a more *convex* shell than those of the other two species. It is found firmly attached to eelgrass or to other molluscs. Slipper limpets are suspension feeders, utilizing digestible particles which are filtered out of the water currents.

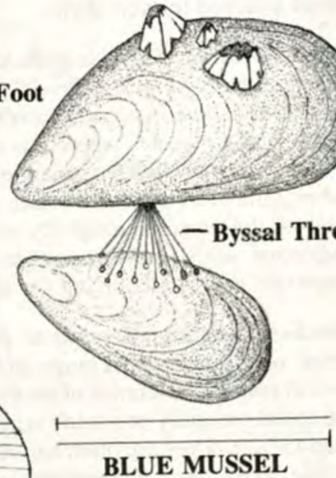


DOVE SNAIL

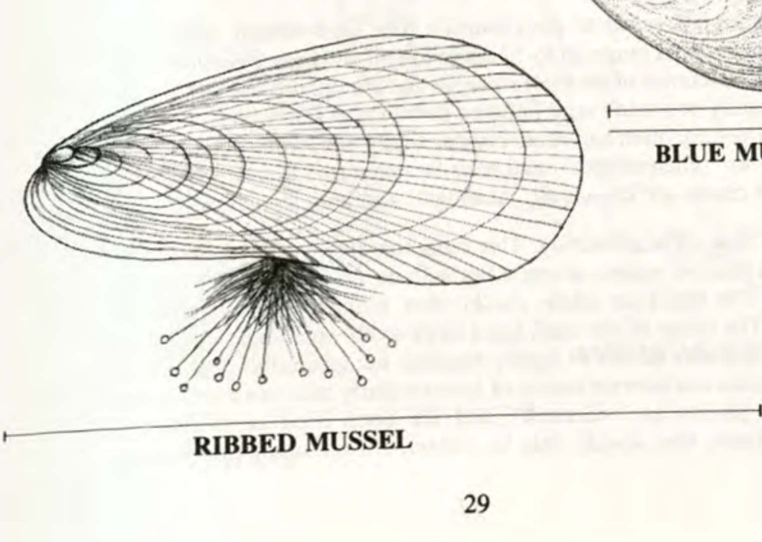

HORN SHELL



AWNING CLAM



BLUE MUSSEL


RIBBED MUSSEL

Dove Snail (*Mitrella lunata*): This is a very *small* snail, less than 0.5 cm in length, with a *smooth yellow-brown* or *beige* shell with brown markings. An *extensible proboscis* and *siphon* are present.

In some years this snail is abundant among the eelgrass and algae on the bottom of the shallow estuaries, particularly in early summer. In other years they are infrequent. They are predators which prey on sessile animals such as the colonial sea squirts.

Horn Shell *(Bittium alternatum)*: The shell of this very *small dark brown* snail measures less than 0.6 cm in length and has many *spirals* and *cross ridges* on its six to eight whorls. Horn shells are very abundant on eelgrass and algae throughout the summer. They feed on algae.

BIVALVES

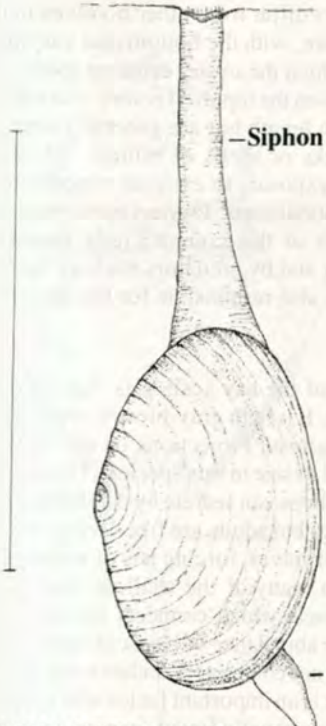
Awning Clam (*Solemya velum*): The awning clam is a small clam, up to 3.0 cm in length, with *oval shells* which are covered by a *radially marked, yellow-brown membrane* whose irregular edges extend beyond the shells. The shell valves do not fit together tightly but *gape* anteriorly and posteriorly. Awning clams are found buried in sand or mud, both intertidally and subtidally.

Blue Mussel (*Mytilus edulis*): This is an edible mussel, with *straight* or *slightly curved, violet-blue shells* which are covered by a *darker epidermis*. The shells are *not ribbed*. Byssal threads are secreted from the foot at the narrow end of the mussel and serve to attach it to the substrate. Mussels of various lengths from a few millimeters to about 7.5 cm are found clumped together. They are very abundant on rocks and dock pilings in marine or slightly brackish waters. Barnacles are often found attached to their shells.

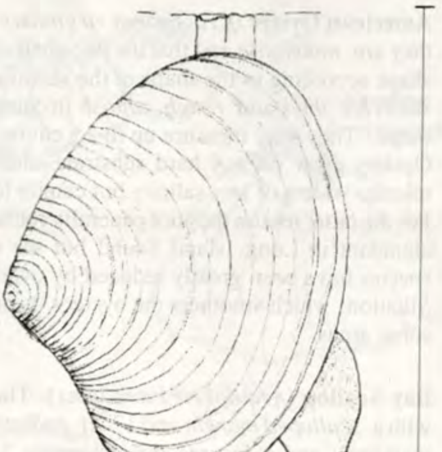
Ribbed Mussel (*Modiolus demissus*): The ribbed mussel, which reaches about 10 cm in length, has *elongated, strongly ribbed shells* which are *dull* and *dark blue-black* or *greenish-blue* in color. It is often very abundant along the banks of the intertidal zone of tidal marshes where it is attached to stones or to other mussels with byssal threads. This mussel can tolerate longer periods of exposure and wider ranges of salinity than can the blue mussel. It concentrates large quantities of minerals in the mud of the marsh through its water-pumping and filtering activities, and, since sediments settle and accumulate around the closely packed shells, it plays an important role in stabilizing the edge of the marsh.

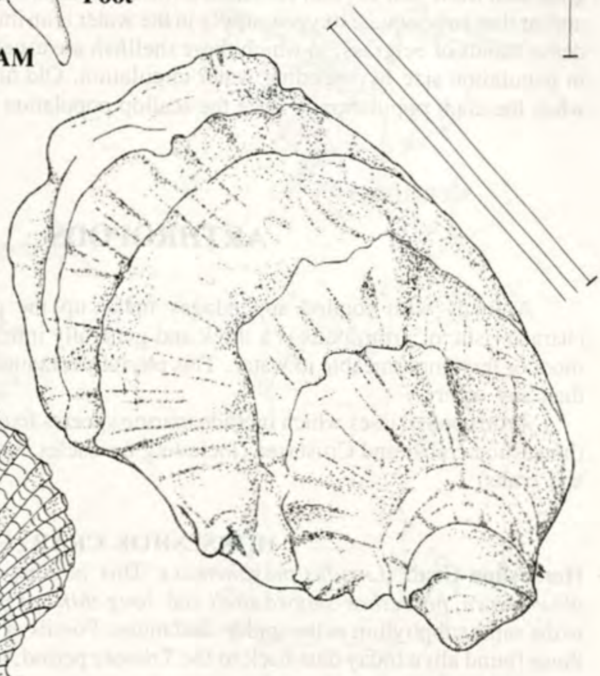
Hard-shell Clam (*Mercenaria mercenaria*): The hard-shelled clam has *heavy, white, oval shells* which range up to 10 cm in length and bear *prominent concentric growth rings*. The interior of the shell is *purple* and the siphons are short. These clams are found on sandy or muddy sand bottoms in waters of fairly high salinity (not less than 15‰). They are often harvested commercially and, when small, are known as "little necks" or "cherrystones" and may be eaten raw if taken from unpolluted waters. Larger clams are known as "quahogs" and are eaten cooked.

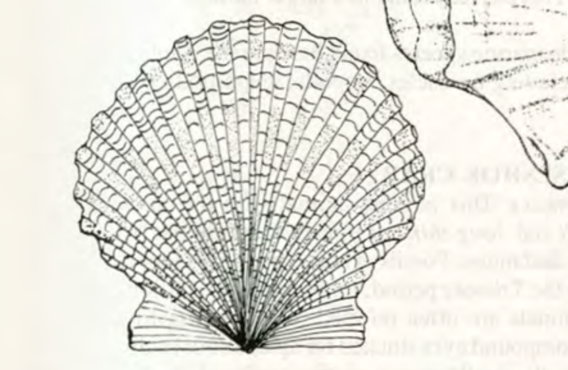
Soft-shelled Clam (*Mya arenaria*): This common clam is found buried in mud or muddy sand in shallow waters, where it lies with its *large, joined siphons* extending to the surface. The shells are *white, chalky, thin, elliptical in shape* and from 5 to 7 cm in length. The hinge of one shell has a large tooth which fits into a socket in the other shell. The shells do not fit tightly together but generally *gape* at both ends. Soft-shelled clams can tolerate waters of lower salinity than can hard-shelled clams. They are also known as "steamers" and are eaten fried or steamed. Like the hard-shelled clams, they should only be collected from unpolluted waters.



SOFT-SHELLED CLAM


HARD-SHELLED CLAM


AMERICAN OYSTER


BAY SCALLOP

American Oyster (*Crassostrea virginica*): Oysters differ from other bivalves in that they are *nonmotile* and that the two shells are unlike, with the bottom one varying in shape according to the shape of the substrate to which the oyster cements itself. The shells are *thick* and *rough, whitish* in color, and even the top shell is very *variable in shape*. They may measure up to 15 cm or more in length but are generally smaller. Oysters grow on any hard substrate such as rocks or shells or pilings. They can tolerate waters of low salinity but cannot tolerate exposure to extreme temperatures. For the latter reason they are generally found in subtidal areas. Oysters were once very abundant in Long Island Sound but the numbers of this commercially important species have been greatly reduced by over-fishing and by predators such as starfish. Siltation, which smothers the oysters, is probably also responsible for the decline in some areas.

Bay Scallop (*Aequipecten irradians*): The shell of the bay scallop is *fan-shaped*, with a *scalloped margin* and 17-21 *radiating ribs*. It is light gray-brown, with darker markings, and measures approximately 7.5 cm across. Projections of the shell on either side of the hinge resemble ears and are equal in size in this species. The edge of the mantle bears a row of well developed eyes. Scallops can secrete byssal threads and may be found attached to the substrate when young, but adults are free-living and can swim about by rapidly opening and closing the shell valves, forcing jets of water out.

Bay scallops are harvested commercially in many of the shallow bays along Long Island Sound and southward. Only the muscle which connects the two shell valves is eaten, and it is considered a delicacy. The abundance of bay scallops varies a great deal from year to year, for reasons which are not completely understood. It does appear that an adequate oxygen supply in the water is an important factor and that very dense stands of eelgrass, in which these shellfish are usually found, can cause a drop in population size by impeding water circulation. Old time shellfishermen say that when the clam population is large the scallop population is small, and *vice versa*.

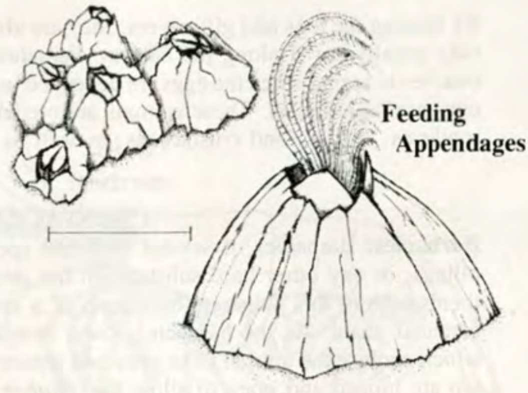
ARTHROPODS

Animals with jointed appendages make up the phylum Arthropoda. Also characteristic of arthropods is a thick and generally inflexible exoskeleton which is more or less impermeable to water. This phylum contains a larger number of species than any other.

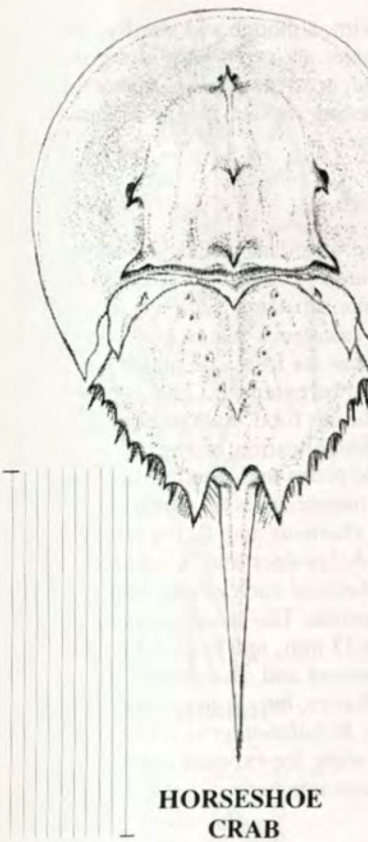
Arthropod classes which include marine species found here are the Xiphosurida (horseshoe crabs) and Crustacea (including barnacles, isopods, amphipods, shrimp, and crabs).

HORSESHOE CRAB

Horseshoe Crab (*Limulus polyphemus*): This familiar animal with the *leathery, olive-brown, horseshoe-shaped shell* and *long-thin tail* is not a true crab but belongs to the same subphylum as the spiders and mites. Fossils of horseshoe crabs identical to those found alive today date back to the Triassic period, more than 200 million years ago, and for this reason today's animals are often referred to as "living fossils". There are four eyes; a pair of large, compound eyes situated far apart about midway on the dorsal surface, and a pair of small, simple eyes near the center of the forward margin. The length of the females may be 50 cm or longer; males are smaller. Horseshoe crabs are common on sandy or muddy bottoms in shallow, brackish water.

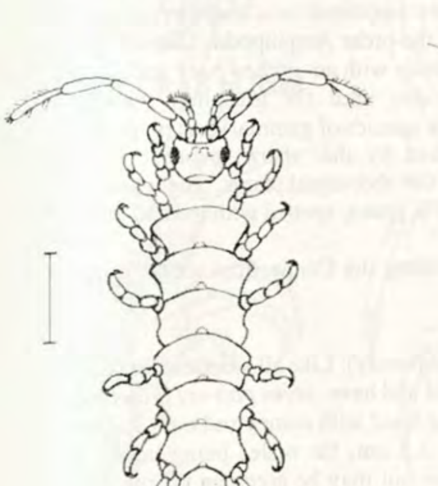


BARNACLES

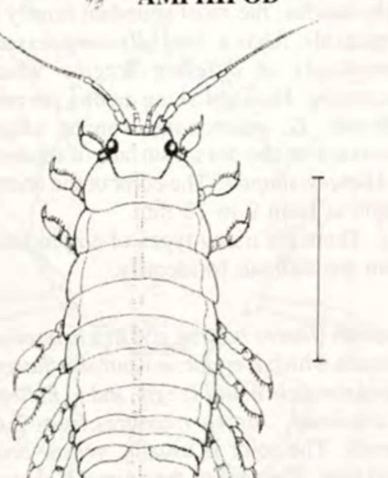


HORSESHOE CRAB

AMPHIPOD



Erichsonella



Idotea

ISOPODS

By beating the legs and gill covers, they are able to swim, although awkwardly, but they usually crawl along the bottom. Females and males are often seen along the beaches in spring when the eggs are deposited in the sand, or on the marshes where the eggs are laid in mud. These animals are predators, feeding on such things as small molluscs, worms, and crustaceans, as well as on algae.

CRUSTACEANS

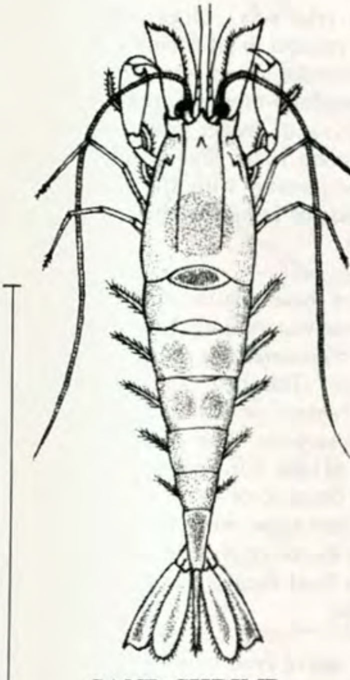
Barnacles: Barnacles of several different species are abundant on rocks, shells, pilings, or any other hard substrate in the intertidal area. Young barnacles attach themselves to this substrate by means of a cement-like substance secreted by the antennal gland. As the barnacle grows, overlapping calcareous plates are formed which enclose the animal. The eyes and sensory antennae are lost. The plates at the top are hinged and open to allow the *feather limbs* to be extended. The constant motion of these limbs creates the water current which brings food, such as copepods and other zooplankton, and oxygen to the animal. Identification of the different species of barnacles depends on the arrangement of the plates and whether the base with which the animal is attached to the substrate is membranous or calcareous.

Four abundant barnacles in our area are: *Balanus eburneus* and *B. improvisus*, in both of which the bases are *calcareous*, and *B. balanoides* and *Chthamalus fragilis*, in which the bases are *membranous*. The shells of each of the *Balanus* species are whitish; that of *Chthamalus* is gray or brown. The basal diameter of *Chthamalus* is 10 mm, that of *B. improvisus* is about 13 mm, and that of both *B. eburneus* and *B. balanoides* is about 25 mm. *B. eburneus* and *B. improvisus* are generally found in the protected waters of the upper estuaries, but *B. improvisus* can tolerate waters of lower salinity than can *B. eburneus*. *B. balanoides* is widespread throughout the intertidal zone of the lower estuaries or along the exposed coast but is not found in waters of low salinity. *Chthamalus* is a common barnacle of the upper intertidal zone along Long Island Sound.

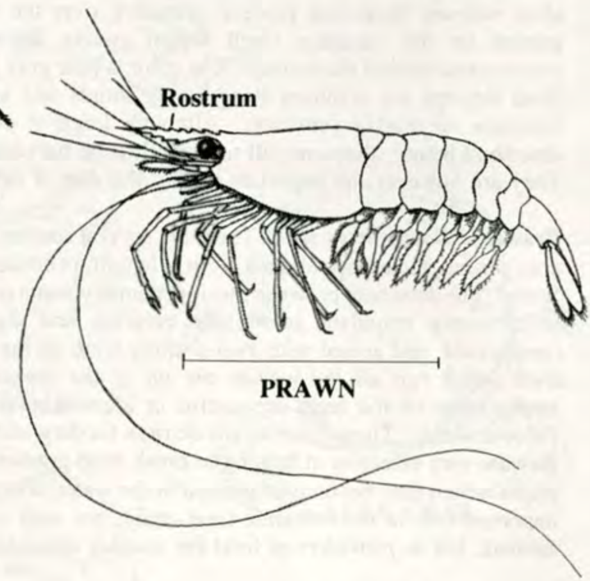
Amphipod (*Gammarus mucronatus*): This amphipod is a member of the family Gammaridae, the most abundant family in the order Amphipoda. Like all gammarid amphipods, it has a *laterally compressed body* with an *arched back* and *13 pairs of appendages of differing lengths* which are used for grasping, walking, and swimming. Distinguishing among the many species of gammarid amphipods is often difficult. *G. mucronatus* can be identified by the *sharp, posteriorly directed processes* on the dorsal surface of three of the abdominal plates. The *eyes are large and kidney-shaped*. The color of the animal is green, spotted with red and brown. The length is from 9 to 13 mm.

There are many types of amphipods along the Connecticut shore, but many of them are difficult to identify.

Isopods (*Idotea baltica* and *Erichsonella filiformis*): Like all isopods, these are small animals which are *dorso-ventrally flattened* and have *seven pairs of crawling legs of approximately equal length* and a *flattened head* with compound eyes and two pairs of antennae. *Idotea* measures from 2 to 3.5 cm, the males being larger than the female. The color is usually *yellow-brown* but may be green or yellow with black markings. The rear of the animal is *bracket-shaped*, coming to a point in the center. *Erichsonella* is a *smaller, more slender, brownish-green* isopod which measures from 0.8 to 1.5 cm. The rear of the animal is *tapered*, not bracket-shaped. Both isopods are abundant in eelgrass, either submerged or exposed at low tide, and both feed on algae and detritus.

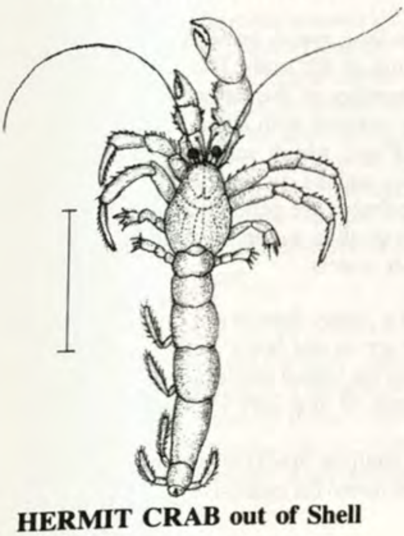


SAND SHRIMP

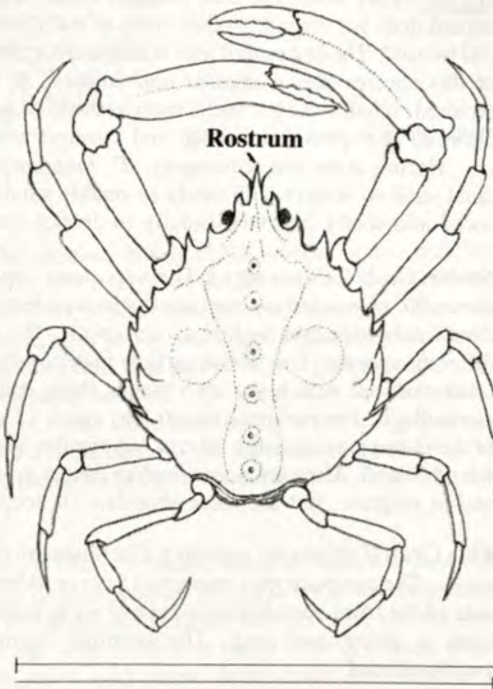


PRAWN

HERMIT CRAB in Shell



HERMIT CRAB out of Shell



SPIDER CRAB

Sand Shrimp (*Crangon septemspinosa*): This is a relatively *large* shrimp, measuring up to 5.5 cm in length, with *long antennae*, present in all shrimp, and a *short rostrum* (beak-like process extending over the mouth). A *dorsal spine* is present on the carapace (shell which covers the cephalo-thoracic region of crustaceans) behind the rostrum. The color is pale gray in sand, deeper gray in mud. Sand shrimps are common along sandy shores and among rocks and algae, less common on muddy substrates. Although large in comparison with the prawns described below, they are still too small to be harvested for human consumption. They are however, an important part of the diet of fish.

Prawns (*Palaemonetes* spp.): There are several species of these smaller, *translucent gray* shrimp, measuring about 3.5 cm in length, in estuarine waters along Long Island Sound. The dominant prawn in the upper embayments is *Palaemonetes pugio*, which is extremely abundant among the eelgrass and algae. The rostrum is *long, compressed*, and armed with *two or three teeth on the ventral surface* and *several teeth which run all the way to the tip of the dorsal surface*. The number and arrangement of the teeth are useful in identification of the different species of *Palaemometes*. These prawns are detritus feeders and because of their abundance they are very effective in helping to break dead grasses and algae down into smaller pieces which then become suspended in the water. They therefore play an extremely important role in the estuarine food chain, not only as food themselves for larger animals, but as providers of food for smaller organisms.

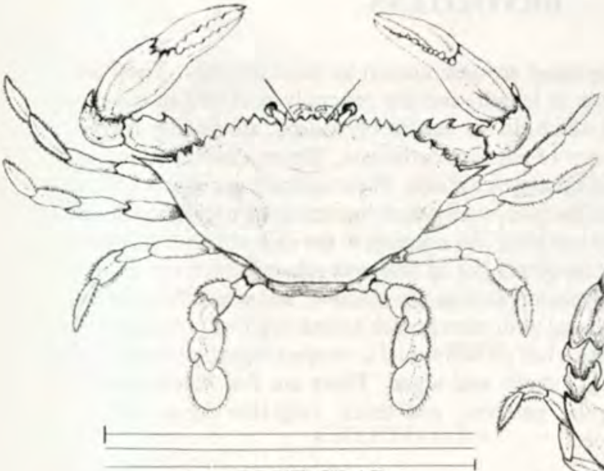
Hermit Crab (*Pagurus longicarpus*): This is a small, active crab which *inhabits empty snail shells*, the largest generally being the shells of the common periwinkle and the oyster drill. The crab changes shells as it grows. Seen outside the shell, the animal does not resemble other crabs in body form. The abdomen is elongated, soft, and twisted. The last pair of legs is adapted for clinging to the shell. The pincing claws of this species are *elongated and smooth*. A larger species, *P. pollicaris*, (not pictured) inhabits larger shells such as those of whelks and moon shells. The pincing claws in this species are broad and covered with tubercles (small protuberances).

Hermit crabs are scavengers. *P. longicarpus* is common in rock pools and in quiet shallow waters with sandy or muddy sand bottoms. *P. pollicaris* is found on rocky and shelly bottoms, usually in deeper water.

Spider Crab (*Libinia* spp.): The very *long, thin legs, rough brown carapace*, and *somewhat elongated rostrum* are distinctive features of this crab. The carapace bears *dorsal tubercles* and *medial dorsal spines*, the number of the latter identifying the different species. The dorsal surface is generally covered with algae, hydroids, and other material which the crab places there itself and which serve as an effective camouflage. The carapace length may reach 13 cm and the distance between the tips of the claws may measure 30 cm, but smaller specimens are generally found in Long Island Sound. They are occasional to common in shallow waters on muddy surfaces and in eelgrass, but are more abundant in deeper waters.

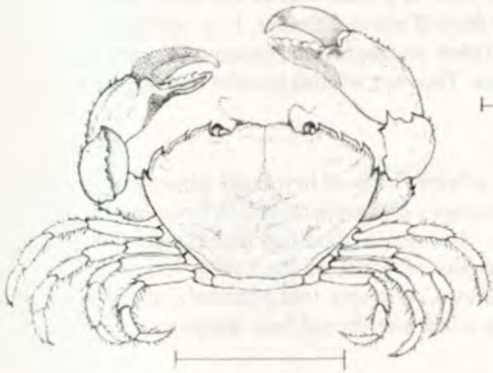
Blue Crab (*Callinectes sapidus*): The blue crab is a *large, dark green* crab with *blue claws*. The carapace may measure 15 cm or more across and bears *nine teeth* on each side of the front edge between the eye sockets and the lateral angles. The *outermost tooth is sharp and long*. The terminal segment of the last legs is broad and paddle-shaped.

These voracious predators are common in shallow brackish waters during the summer and, since their meat is delicious, they are fished for extensively. They winter offshore.



BLUE CRAB

GREEN CRAB



MUD CRAB

Detail of Claw of *Eurypanopeus*

Green Crab (*Carcinus maenas*): The carapace of this crab is *almost square* and from 5.0 to 7.5 cm in width. There are *five sharp teeth* on the anterior carapace between each eye socket and lateral angle, and *three low teeth* between the eyes. The color varies from dark green to orange-green, with yellow markings. Although classified as a swimming crab, the terminal segment of the last pair of legs is pointed rather than paddle-shaped as in the blue crab, and better adapted for walking than for swimming.

Green crabs are common crabs of rocky shores, estuaries, and the edges of tidal marshes. They are omnivorous, with a large part of their diet consisting of bivalves, and are thought to be destructive of the soft-shelled clam population. They are used extensively as bait.

Mud Crab (*Eurypanopeus depressus*): This is a *small, sluggish, heavy-bodied* crab with a relatively *flat carapace* which measures about 2.3 cm in width and bears teeth along the front margin. The ends of the grasping claws are *dark* in color and the inner surfaces of the tips of these claws are *depressed and spoon-like,* a feature which distinguishes *Eurypanopeus* from other mud crabs. Mud crabs are common in muddy areas in waters of low salinity, often associated with oysters, and are predators and scavengers.

BRYOZOANS

Bryozoans (phylum Bryozoa) are also known as moss animals. They are very small (usually less than 5 mm in length) and are generally enclosed in cases which they secrete themselves and which, in the marine bryozoans, are usually formed of a layer of chitin overlying a layer of calcium carbonate. The external skeleton and the contained animal together are known as a zooid. These animals are characterized by a lophophore, a circular fold of the body wall which encircles the mouth, bears ciliated tentacles, and serves for food catching. An opening in the case allows the lophophore to be extended, and in most cases there is a lid (the operculum) which closes when the lophophore is withdrawn. Bryozoans are usually colonial, and while the walls of their cases are in contact with or shared with others, each animal is entirely separate (unlike the polyps of hydroids) and each has an individual U-shaped digestive tract. Colonies are attached to rocks, pilings, shells and algae. There are flat, encrusting forms, which often appear in regular patterns, and erect, twig-like forms which may resemble hydroids or seaweed.

Cryptosula (*Cryptosula pallasiana*): This is a *flat, encrusting* form with colonies which are *rusty orange* in color and about 2 cm in diameter. It is common on floats, rocks, shells, algae, and eelgrass. Other encrusting bryozoans, *Electra* spp. (not pictured), are also common in this area. They are whitish in color and have a lace-like appearance.

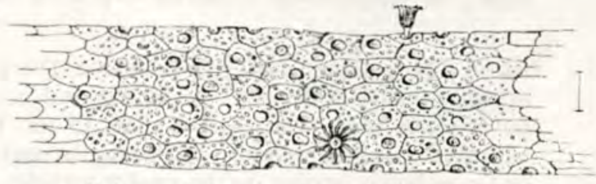
Bugula (*Bugula simplex*): *Bugula* is an erect form of bryozoan whose colonies may reach 2.5 cm in height. The *yellow-orange* cases are arranged in rows and bear short, stout spines at the upper outer margin. *Avicularia* (modified zooids resembling birds' heads) are present on the outer margins of some of the cases. Other bryozoans frequently found in the shallow estuaries, *Crisia* spp. (not pictured), also form erect, bushy colonies. These are whitish in color and do not bear avicularia.

ECHINODERMS

One of the basic characteristics of the phylum Echinodermata is the division of the body into five parts around a central axis. Echinoderms also possess a water-vascular system of fluid-filled vessels, usually ending in tube feet which are used for locomotion, food-getting, respiration, and sensory functions. The phylum includes the classes Asteroidea (starfish), Ophiuroidea (brittle stars), Echinoidea (sea urchins and sand dollars), Holothuroidea (sea cucumbers), and Crinoidea (feather stars). Echinoderms are bottom dwellers; most do not tolerate waters of low salinity and therefore are not common in estuaries. The two groups most apt to be found in the estuaries of eastern Long Island Sound are the starfish and sea cucumbers.

Common Starfish (*Asterias forbesi*): The *five arms* of the common starfish are *blunt* and *firm* and the surface is *rough*. The arms can be regenerated if lost; occasional specimens have arms numbering other than five. The color is *beige* or *orange-brown*, with an *orange madreporite* (a round, stony plate on the central upper surface through which water enters the water-vascular system). The undersurface is lighter in

Zooids of Cryptosula (enlarged)

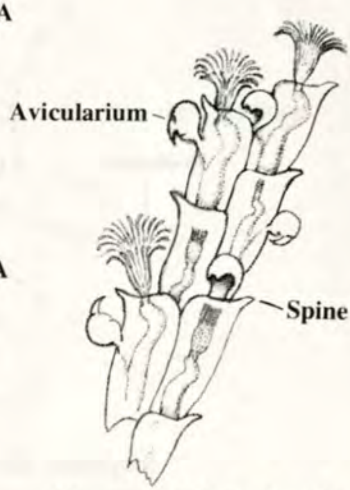


Colony of Cryptosula on Eelgrass

CRYPTOSULA

BUGULA

Bugula Colony



Bugula Zooids (enlarged)

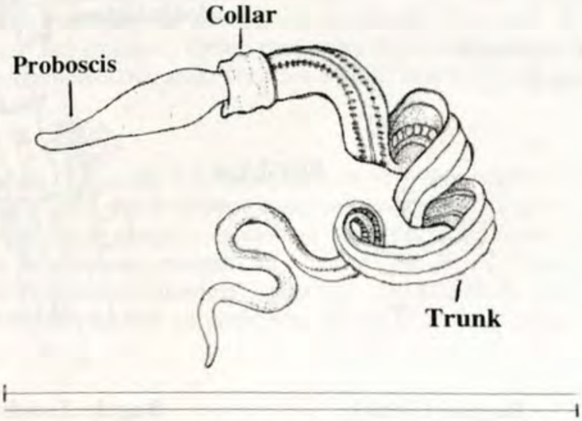
color, with *four rows of tube feet* on each arm. The distance between the tips of the arms may measure 13 cm. These starfish are usually found in tide pools along rocky shores and in deeper water, but they are occasionally common on sandy or muddy bottoms in estuaries. They are carnivorous and feed chiefly on bivalves and small crustaceans such as barnacles. They are very destructive to many commercially important shellfish such as oysters and clams. In feeding, the starfish pulls the shells of the bivalve apart with its tube feet, inserts its everted stomach through the resulting crack in the shell, and digests the tissue of its prey.

Sea Cucumber (*Leptosynapta tenuis*): This species has the usual cylindrical form of all sea cucumbers but is *grayish-white* in color, up to 15 cm in length, and more *worm-like* in appearance than the others. Tube feet are *absent* in this species but *five longitudinal muscle strands* are visible on the body. A ring of *branching tentacles* is present around the mouth. Sea cucumbers are found buried in sand or mud. They ingest the bottom sediments and digest the nutritive materials found therein.

HEMICHORDATES

Most members of the small phylum Hemichordata are worm-like and exclusively marine. The body is divided into three parts: the proboscis, the collar, and the trunk. One hemichordate is reported from Long Island Sound:

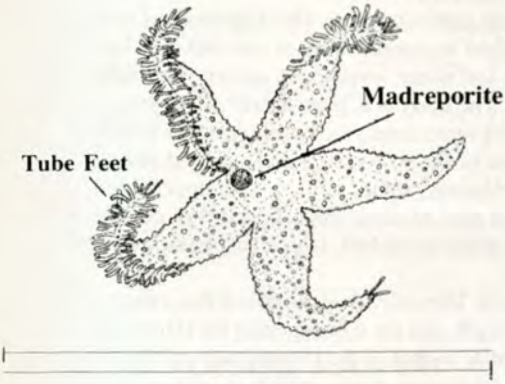
Acorn Worm (*Saccoglossus kowalewski*): The acorn worm is a very *fragile, wormlike* animals with a *white* or *pinkish proboscis, orange collar,* and *brown or yellow-brown* trunk. The length is about 15 cm. The animals live in mucus-lined burrows and are detritus feeders, collecting the sand or mud adjacent to their burrows on the proboscis, sorting out the smaller particles, and ejecting the larger ones as castings.



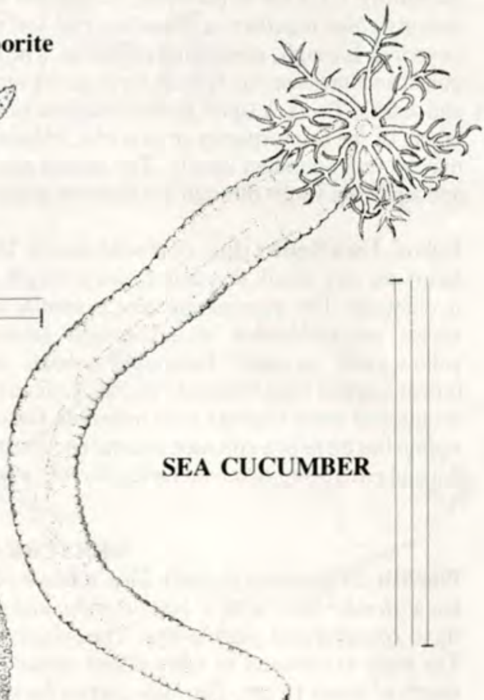
ACORN WORM

CHORDATES

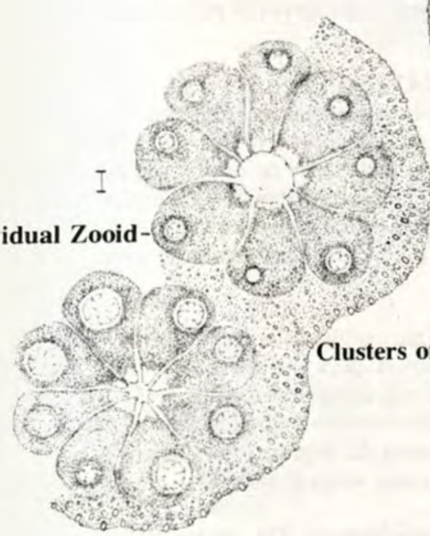
The phylum Chordata is considered the most advanced in the animal kingdom and consists of animals possessing a notochord, a dorsal hollow nerve cord, and paired gill clefts at some point in the life history. The phylum includes the tunicates (or urochordates), the cephalochordates, and the vertebrates. Of the tunicates, the class Ascidiacea (sea squirts) are the only animals found here. Two species of sea squirts, one solitary and the other colonial, will be discussed below. There are no cephalochordates (lancelets) in this area. From among the very numerous marine vertebrates, five species of fishes which are common in shallow estuaries will be described. Many other fish found in Long Island Sound also spend a part of their life cycle in these estuaries.



STARFISH

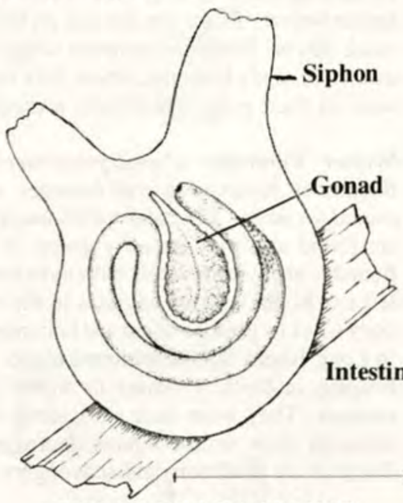


SEA CUCUMBER



COLONIAL SEA SQUIRTS
(Botryllus schlosseri)

Colony of Colonial Sea Squirts on Eelgrass



SOLITARY SEA SQUIRT
(Molgula manhattensis)

SEA SQUIRTS

Solitary Sea Squirt, Sea Grape (*Molgula manhattensis*): This bag-shaped tunicate, measuring 3-3.5 cm in diameter, is attached to the substrate at one end and has *two siphons close together* at the other end for water intake and outgo. The tunic, or covering, is rough, containing cellulose. The body is a *translucent olive-green*. The gonad and intestine can be seen through the tunic unless the latter is covered with sand and debris. This sea squirt is characteristic of shallow waters and is found attached to others of the same species or to rocks, eelgrass, algae, pilings, and ship bottoms. It may be very abundant locally. The animal gets its name from the habit of contracting and squirting water through the siphons when disturbed. It is a suspension feeder.

Colonial Sea Squirt (*Botryllus schlosseri*): The individual zooids of this colonial sea squirt are very small, less than 2 mm in length, but the colonies may be 10 cm or more in diameter. The internal structure is similar to that of the solitary sea squirts but the zooids are embedded in a common gelatinous tunic which is olive-green or yellow-green in color. Individual animals are variously colored, often purple or brown marked with white or yellow. A colony may consist of a number of clusters of zooids and these clusters may resemble stars. Each individual has its own inhalant siphon but there is a common central excurrent opening for each cluster. *Botryllus* is flat and encrusting when on rocks, thicker when on the leaves of eelgrass and algae.

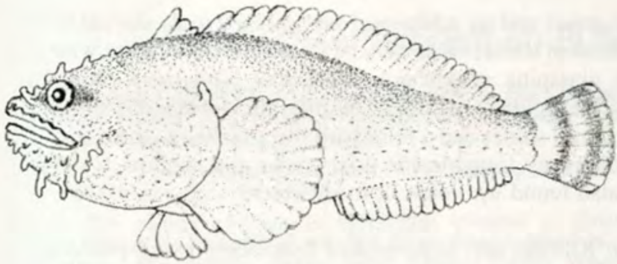
VERTEBRATES

Pipefish (*Syngnathus fuscus*): This relative of the seahorse (pictured on front cover) has a *slender head* with a *tubular snout* and an *elongated, eel-like body*. The caudal fin is *rounded* and *paddle-like*. The color is usually *olive* or *brown,* lighter below. The body is encased in bony plates rather than scales. Pipefish generally reach a length of about 15 cm. The male carries the eggs in a brood pouch situated behind the vent. These fish, which are predators, are very common in both brackish waters and in waters of higher salinity in this area.

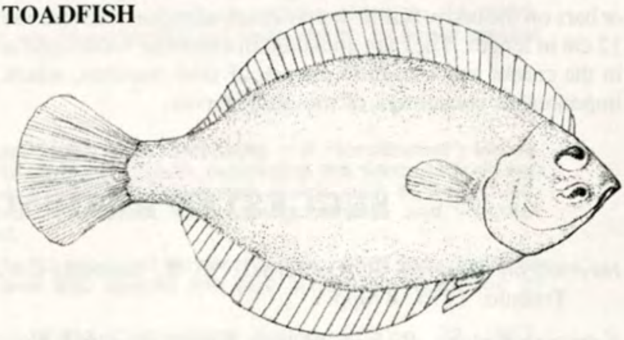
Oyster Toadfish (*Opsanus tau*): The head of the toadfish is large, with a *large mouth* containing many *strong, blunt teeth*. The body is *thick* and the color *brown-green,* lighter below. *Flaps* are present on the head and around the mouth. The length may reach 30 cm. Toadfish are rather sluggish fish which are found in shallow waters, on muddy or sandy bottoms, where they hide among the eelgrass or in shallow holes and wait for their prey. They make a croaking noise when disturbed.

Winter Flounder (*Pseudopleuronectes americanus*): The body of the winter flounder is *flattened* as in all flounder, and *oval* in shape. The *mouth is small* and the *caudal fin large*. The color varies according to the color of the bottom on which they are found and may be *olive-green* or *reddish-brown,* or *dark slate gray*. Young flounder are symmetrical, with eyes on both sides of the body, but as they grow the left eye of this species migrates to the right side of the head and the blind side of the body loses its pigmentation and becomes whitish. The length of winter flounder found in Long Island Sound seldom exceeds 35 cm. They are found on sandy or muddy bottoms in shallow waters in winter and spring but move into deeper waters in summer. They were once sufficiently abundant to be commercially important, and although their numbers have decreased they are still valued as food fish. These flounder are predators and scavengers, and occasionally feed on algae.

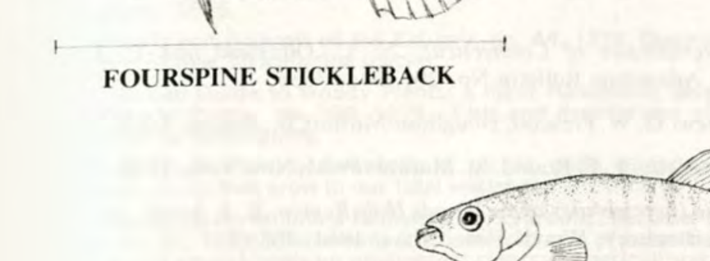
Fourspine Stickleback (*Apeltes quadracus*): This is a small fish, no more than 6 cm in length, which is *brownish* with darker markings above and lighter below. There



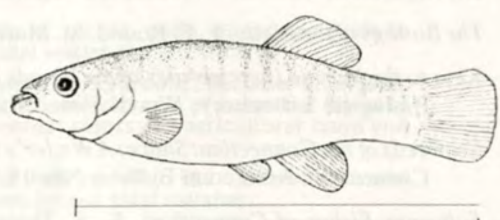
OYSTER TOADFISH



WINTER FLOUNDER



FOURSPINE STICKLEBACK



KILLIFISH

are *two to four free dorsal spines* and an *additional one attached to the dorsal fin* by a membrane. Two other species of sticklebacks may be found in the estuarine waters of eastern Connecticut: the ninespine stickleback (*Pungitius pungitius*), with nine (occasionally seven to twelve) spines, and the threespine stickleback (*Gasterosteus aculeatus*), with two free dorsal spines and a third partially attached to the dorsal fin. These sticklebacks are commonly found in the tidal creeks and shallow waters off tidal marshes. They are also found upstream in fresh water.

Killifish (*Fundulus* spp.): Killifish are *stout-bodied* fish, compressed posteriorly, with *short, blunt heads* and *projecting lower jaws* that protrude slightly beyond the upper jaw. There are no stripes or bars on the body of *Fundulus heteroclitus* (also known as the common mummichog), except during the breeding season. It is a stouter fish than the banded mummichog, *Fundulus majalis,* which does have black stripes or bars on the body. Killifish may reach a length of 15 cm but are generally from 10 to 12 cm in length. They are abundant in estuarine waters and are the most common fish in the creeks and mosquito ditches of tidal marshes, where, as predators, they are important as consumers of mosquito larvae.

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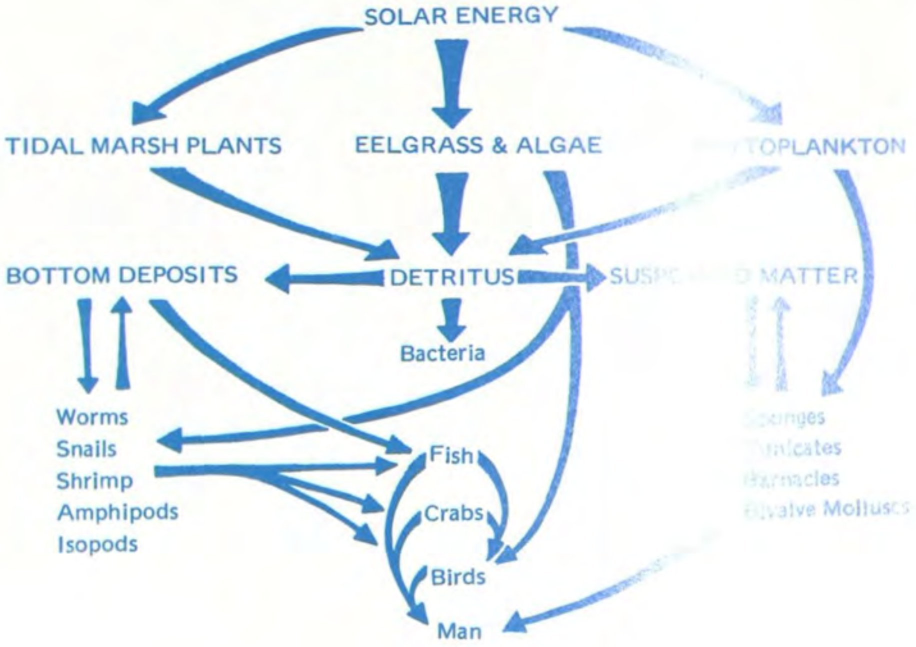
Artistic map of Arboretum Showing Features and Trails.

Available from Connecticut Arboretum, Connecticut College, New London, Connecticut. *Include* .70 postage per publication.



FOOD WEB OF TIDAL MARSH-ESTUARINE ECOSYSTEM