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Long Island Sound: An Atlas of Natural Resources

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Foreword

Throughout the history of Connecticut, our people have prospered from the vast resources of Long Island Sound and the coastal area. These resources are of great economic, recreational and environmental value.

Each year, thousands of our citizens from all over Connecticut fish in the Sound, swim at its beaches and take advantage of the numerous products shipped through its ports. Understanding our coastal resources and their interrelationships is vital to assure their preservation and protection for our own benefit and that of future generations.

To increase this comprehension and to provide fundamental information about Long Island Sound and the Connecticut shorelands, the Coastal Area Management Program has prepared the **Long Island Sound Natural Resource Atlas.** Written in a clear, non-technical style, the **Resource Atlas** serves as a basic guide which citizens can use to understand and enjoy these resources.

The **Resource Atlas** is divided into chapters on the various components and processes of the Long Island Sound system. It discusses the physical oceanography of Long Island Sound; shoreline features and the forces that create and influence them; and the numerous plant and animal species found in and along the Sound.

The **Resource Atlas** is not merely an inventory of coastal resources and processes. It also stresses the natural systems and the interrelationships between all parts of this complex ecosystem.

I urge educational organizations, government agencies and all our citizens to make use of the **Resource Atlas.** Hopefully, increased understanding of our valuable and fragile coastal resources will lead to greater appreciation of them and greater realization of the need to plan for their future.

Ella Grasso

ELLA GRASSO
Governor

The **Resource Atlas** is not intended to be a technical publication, but rather a basic source of information which will be interesting and understandable to all citizens, including those without a background in the natural sciences. With this in mind, three informational aids are included in the **Atlas** and are described below.

1. For those who would like additional or more detailed information, there is a suggested reading list at the end of each chapter.
2. Terms which may not be familiar to readers are italicized and explained in the Glossary (Appendix II).
3. Appendix I is a list of the scientific names of all the plant and animal species mentioned in the **Atlas.**

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1. Glacial History

Approximately 18,000 years ago coastal Connecticut and Long Island Sound were covered by a thick sheet of ice. It is estimated to have been as much as 1000 meters thick in the interior and 400-500 meters thick along its southern margin. This ice sheet was part of the Late Wisconsin Glacier, which covered much of northern North America at the time. It was the most recent of a series of *glaciations* to have spread from the polar regions across the continent in the past 10 million years.

Exactly why climatic changes allowed vast layers of ice to repeatedly cover North America is not well understood. Some think that sunspot activity or cosmic dust were responsible, while others feel that variation in the Earth's motion, movements of the Earth's crust, or changes in the atmosphere may have been the cause. No single hypothesis has yet achieved widespread acceptance, and it is possible that several different phenomena were involved.

Impact of the Glacier on Southern New England

Among the most dramatic changes brought about by glaciation were changes in sea level. At the peak, or maximum size, of the Late Wisconsin Glacier, sea level stood about 100 meters lower than it does today. As a result, large areas of land once above sea level are now submerged. The great weight of the advancing glacier also depressed the land masses in interior areas by as much as one-third the thickness of the ice.

The ice masses scoured vast quantities of rock and soil from the land as they moved south. It is believed that the Late Wisconsin Glacier eroded an average of 20 meters of surface materials from the preglacial New England landscape. The estimate is based on the quantity of all sediments deposited as a result of glacial activity that are found on- and offshore in the New England region. Such glacial sediments are collectively known as *drift*.

Moraines

18,000 years ago, the ice sheet was at its maximum size, extending across the present Long Island Sound basin to southern Long Island. The southern margin of the glacier remained there for a time in an "equilibrium" position, as the movement of the ice southward was offset by the melting of the ice front due to a regional warming trend. At this time, a large quantity of drift was deposited, known as a *terminal moraine*. The southernmost deposit is called the Ronkonkoma Moraine. A somewhat later, more northern equilibrium position resulted in the formation of the Harbor Hill Moraine (see Figure 1).

Evidence indicates that no moraines were formed in the central basin of Long Island Sound, which suggests that the glacier receded across that area without establishing any equilibrium positions. Apparently there are no moraines between Harbor Hill on the south side of the basin and a group of moraines near the Connecticut coastline on the north. The Connecticut moraines, which are located both on- and offshore, are discontinuous and considerably smaller than the Long Island moraines (see Figure 2). They occur in a zone which is less than 10 kilometers wide in most places. The smaller size and discontinuous nature of these moraines is due to minimal deposits, presumably resulting from the relatively short-term equilibrium position of the ice front in that area.

There are two principle areas at which lines of terminal moraines intersect the Connecticut shoreline: the Norwalk area and the Madison-Old Saybrook area. In these areas, relatively greater quantities of drift have led to the formation of sandy plains and beaches. East of these areas the drift thins and there are more numerous *bedrock* exposures. Where the drift cover is thinnest, rocky headlands backed by marshes predominate.

Within a 10 kilometer strip of the Connecticut coast, numerous islands and shoals are found. Some, like the Captain Islands near Greenwich, the Norwalk Islands, and Falkner Island off Guilford, are segments of a terminal moraine. Other islands, like the Thimbles off Branford, are principally exposed bedrock with a thin, discontinuous cover of drift. Still other shoals and islands fall somewhere between these two extremes and appear to be bedrock with a more substantial mantle of drift. Also offshore are several sandy deltas, including those in Bridgeport and New Haven. These deltas were formed by materials deposited by melting glaciers.

The Long Island Sound Basin

The basin of Long Island Sound, which predates glaciation and is probably a stream-carved feature, received a relatively thick cover of sand and gravel as the ice front receded. Such materials, deposited by glacial meltwater streams, are termed *outwash*.

The basin is bounded on the west by a ridge about 20 meters below present sea level and on the east by another ridge, the Mattatuck Sill. The lowest point of this ridge is approximately 25 meters below sea level. These ridges, together with the lowered sea level during the glacial period, kept Long Island Sound isolated from the open ocean. As a result, glacial meltwater pouring into the Sound formed a freshwater lake (see Figure 1).

The Sound remained a freshwater lake until approximately 8,000 years ago, by which time sea level had risen to 25 meters below its present level. At this point, seawater entered the central basin of Long Island Sound, changing it from a non-tidal, freshwater lake to a tidal, saline arm of the sea.

Continued global warming and the shrinkage of glaciers led to further rises in sea level. Present sea level is probably approaching its maximum for the current inter-glacial period. Studies of marsh sediments on the Connecticut coast indicate that sea level rose at the rate of approximately 1.2 millimeters per year from 8,000 to 3,500 years ago; about 0.8 millimeters per year until 100 years ago; and 2-4 millimeters per year (or about 1-1½ feet per century) since then.

Suggested Reading

Bloom, A. L. and Ellis, C. W., Jr., *Postglacial Stratigraphy and Morphology of Coastal Connecticut.* Connecticut Geological Natural History Survey Guidebook No. 1, 1965.

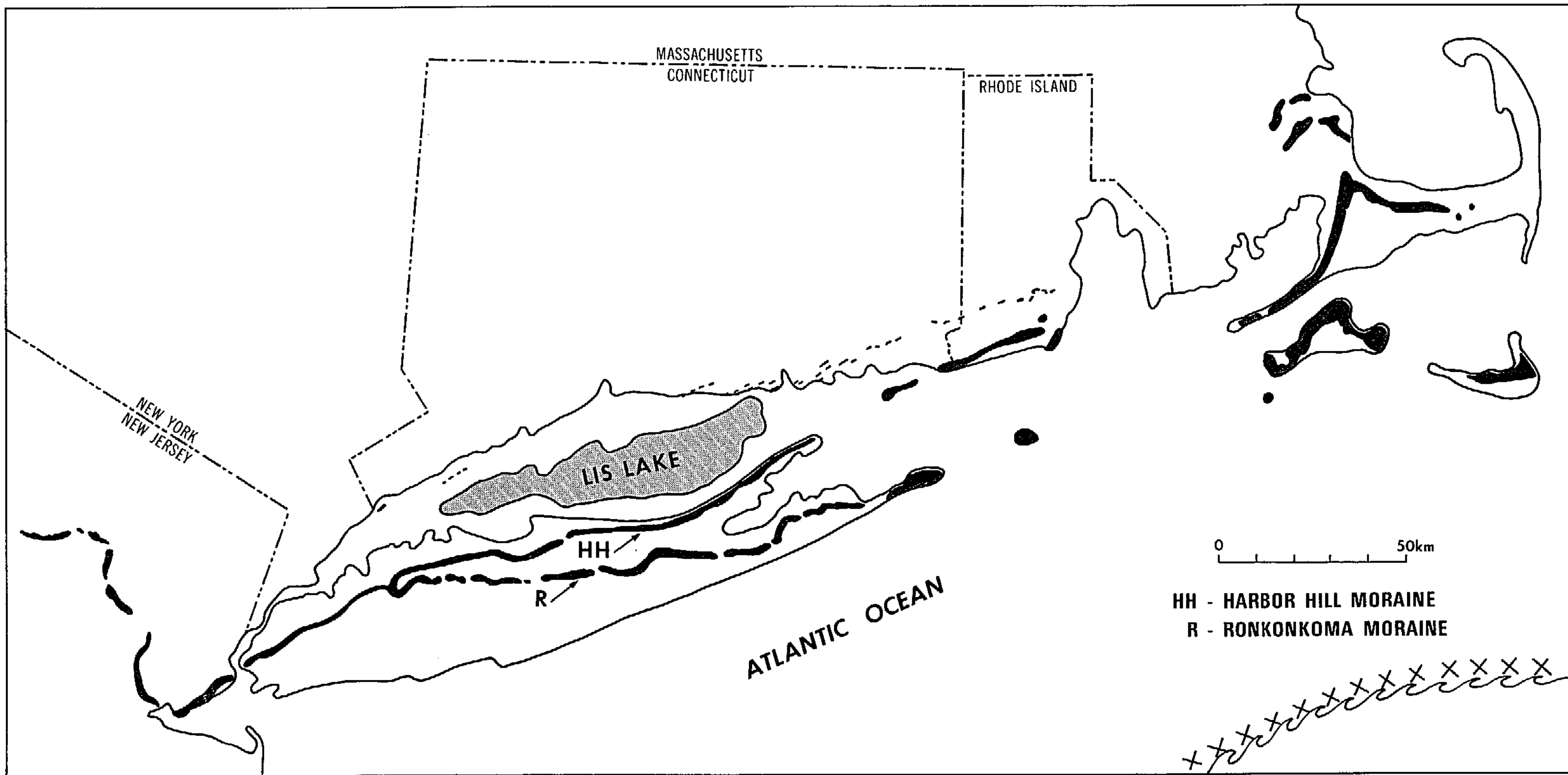


Figure 1. Terminal Moraines in Southern New England

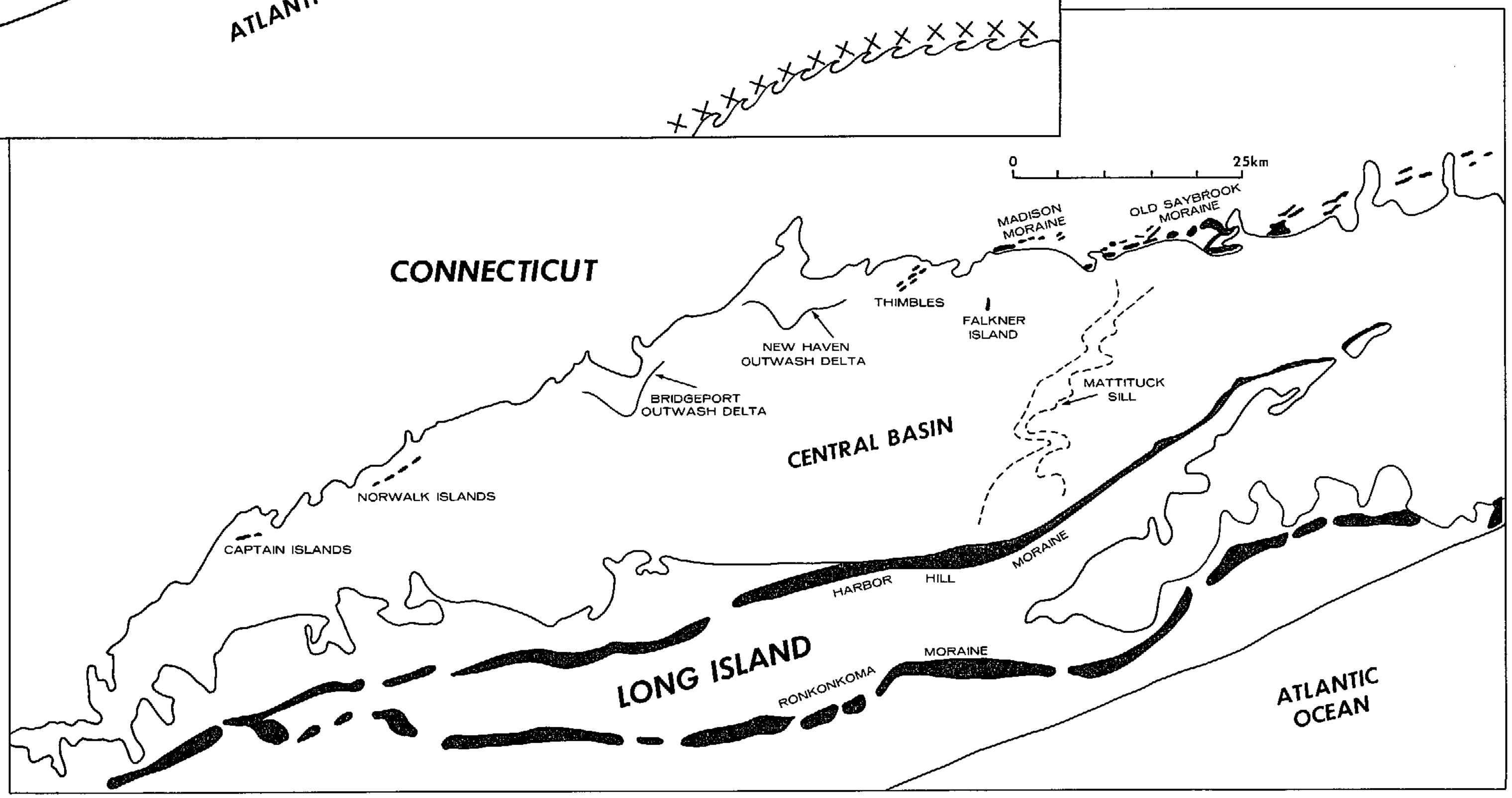
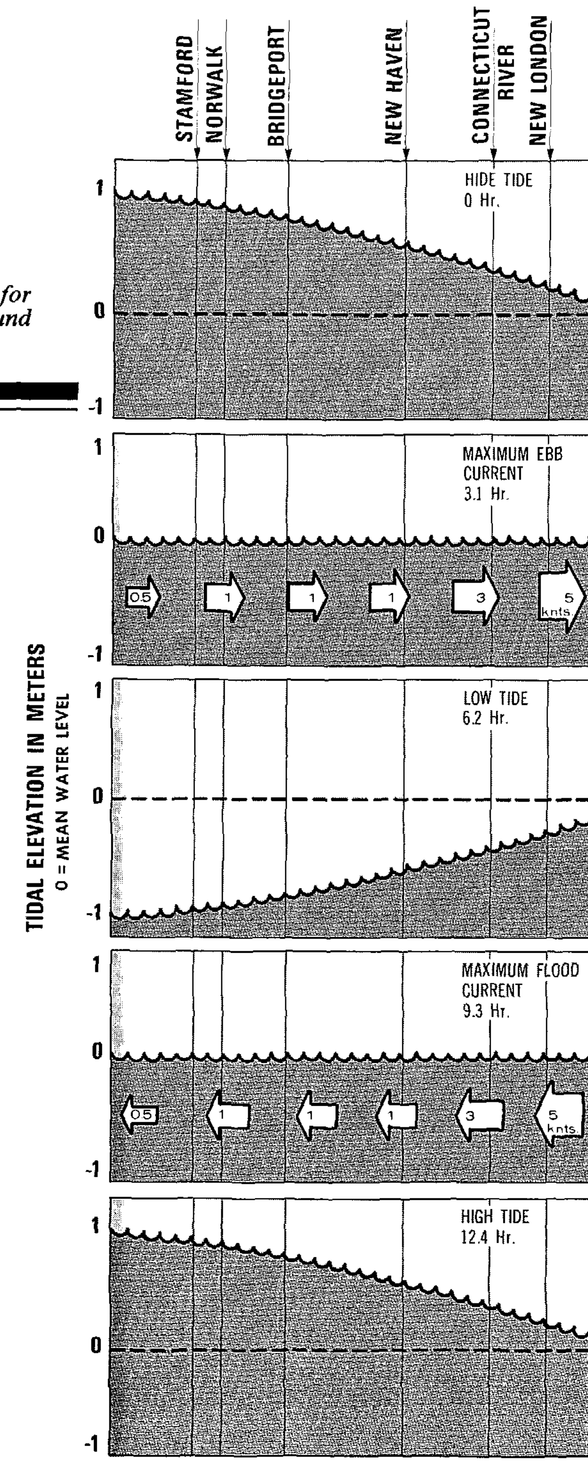


Figure 2. Moraines in Connecticut and Long Island

2. Physical Oceanography

Figure 3. *General Tidal Sequence for Long Island Sound*



Long Island Sound is an *estuary;* a protected coastal body of water with open connections to the sea, in which saline seawater is measurably diluted by fresh water. Ocean water flows in and out of the Sound through the opening in the eastern end, known as the *Race.* Fresh water, from the rivers entering the Sound, dilutes the seawater. Estuarine properties are repeated on a smaller scale in the many harbors and river mouths in the Sound. Thus, Long Island Sound is a large estuary with many smaller estuaries, such as New Haven Harbor and the mouth of the Connecticut River, at its edge.

Tides

On the shores of Long Island Sound, the waters rise and advance, then fall and retreat with a regular rhythm. The tides are produced by the gravitational attraction of the moon and sun on the ocean water. The rotation of the earth causes the tide to be semi-diurnal; in other words, the Sound experiences high tide about twice a day (once every 12 hours and 25 minutes, to be more exact). The difference in the water depth between high and low tide is called the *tidal range.*

The tides in Long Island Sound are driven by the oceanic tide outside the Race. Because of the Sound's size and shape, it is particularly tuned to amplify the oceanic tide. Consequently, the tidal range in the western Sound is larger than the tidal range in the east. At Stamford, for example, the average tidal range is about 2.2 meters (7.2 feet) while at New London the range is only 0.9 meters (3.0 feet).

Associated with the tidal changes in water level are strong tidal currents. Figure 3 shows a generalized tidal sequence for Long Island Sound. As the water level is falling after high tide, water is flowing eastward out of the Sound through the Race. This is the *ebb* (outgoing) tide. When the water level begins to rise again after low tide, the *flood* (incoming) tidal currents are bringing water westward, into the Sound. The tidal currents rush in and out (flood and ebb) with the current speeds at their minimum near times of high and low tides. Figure 4 is a graph of the current flow in the east-west direction measured on November 5 and 6 near the bottom of the central Sound. It also depicts the water depth measured simultaneously at the same location. Notice that high tide occurs when the east-west tidal current speed is almost zero.

The tidal currents reach their greatest speeds in the eastern Sound. The current speeds diminish to the west (see Figure 3). When a 5.0 knot current is running through the Race, for example, the flow past Stamford may only be 0.5 knots. (A "knot" is a unit of speed of one nautical mile per hour, equivalent to 1.15 statute miles.)

Salinity

Long Island Sound is an arm of the sea; however, the saline sea water in it is diluted with fresh water from the rivers of Connecticut. This dilution is increasingly pronounced moving westward, away from the source of salt water, the ocean. The salinity of the surface water at the Race is typically about 30 parts salt per 1000 parts water, or, as it is scientifically expressed, 30 o/oo. The salinity diminishes to about 26 o/oo at Stamford. Salt water has a greater density than fresh water; therefore, fresh water floats on more saline water. Consequently, at any location the surface water is usually less saline than the water near the bottom by one or

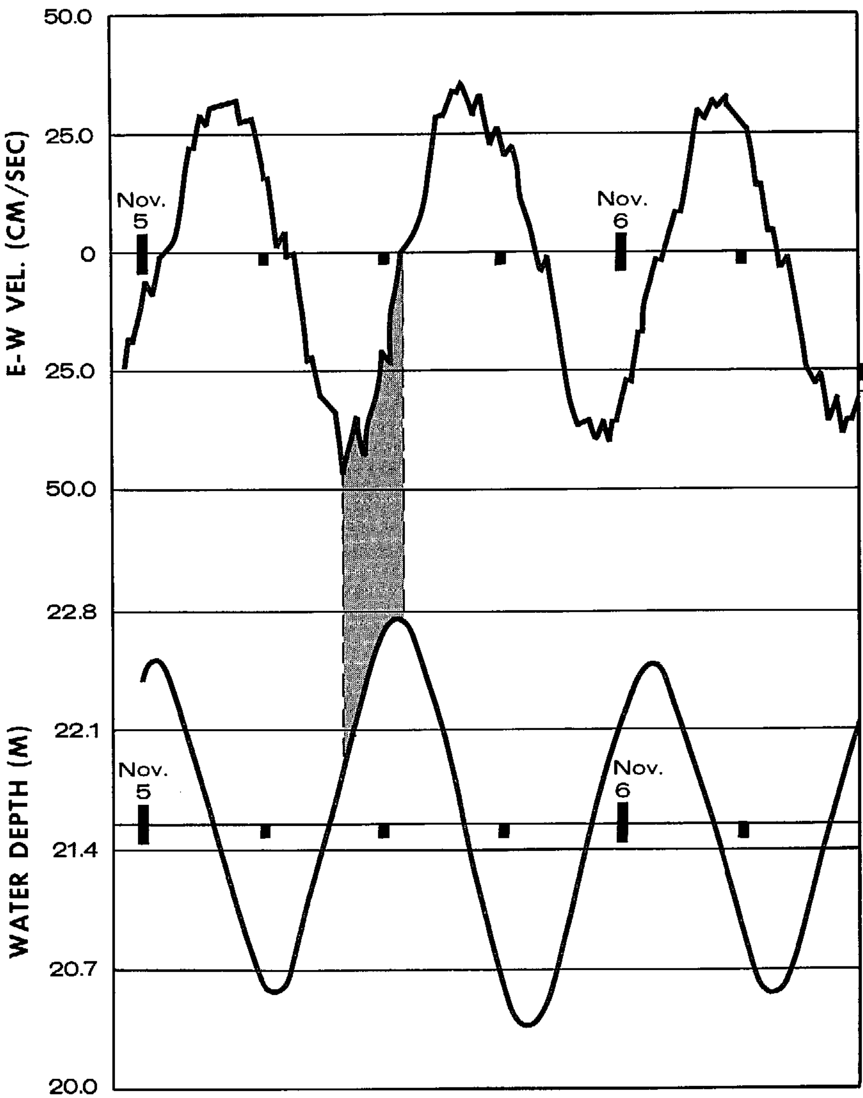


Figure 4. Current Flow Compared to Water Depth

two parts per thousand.

The distribution of salinity at any particular time depends on many factors, such as the magnitude of river discharge and rate of evaporation. The salinity distribution shown in Figures 5 and 6 was observed during the summer of 1972. Differences in salinity among different parts of the Sound result from a continuous flow of both fresh water and salt water through the Sound. On the average, some 470 cubic meters (about 120,000 gallons) of fresh water enter the Sound every second. The Connecticut River is the major contributor; this one source accounts for more than 70% of the freshwater supply. Nonetheless, the inflow of seawater greatly exceeds the freshwater supply. An estimated 19,000 cubic meters per second (over 5 million gallons per second) enter the central Sound from the ocean.

Circulation

The horizontal and vertical salinity differences in Long Island Sound are typical of many estuaries, and they produce a characteristic *estuarine circulation* of water. The heavy, saline bottom water sinks and flows under the fresher surface water. Thus, saline bottom water flows westward into the Sound, while less saline surface water flows eastward out of the Sound. Intense mixing of surface and bottom water occurs in the shallow near-shore regions and over reefs and shoals. This general pattern of estuarine circulation is shown in Figure 7.

The estuarine circulation flows all of the time, during both ebb and flood tides. Thus, the current observed in Long Island Sound is the sum of the estuarine circulation and the tidal currents. The estuarine circulation, however, is so slow that it can only be noticed by careful measurements. In the central Sound, the maximum tidal current speed may be 1.0 knot, while the speed of the superimposed estuarine circulation is likely to be less than 0.2 knots. In Figure 8 the speed of the maximum ebb tidal current at the surface is contoured. The arrows in this figure indicate the net, long-term water velocity measured 2 meters (6.6 feet) above the bottom. This is the estuarine circulation. The speed of this flow of bottom water diminishes to the west, and at depths less than about 20 meters (65.6 feet), bottom water flows shoreward into the near-shore mixing zone.

Sediments

The currents sweep the bottom sediments of Long Island Sound. They have worked the sandy bottom of the eastern Sound into large underwater dunes, or sand waves. The estuarine circulation superimposed on the tidal currents produces a net westward transport of sand out of the eastern Sound into the central muddy basin. Figure 9 shows the distribution of bottom sediments in Long Island Sound.

In the central and western basins, a large amount of silt has accumulated. Fine sediment is introduced by the rivers and is carried by the estuarine circulation into the inner Sound. The accumulation of silt is aided by the feeding activity of animals inhabiting the muddy bottom. Fine grains of silt are bound into much larger fecal pellets by bottom-dwelling animals. The muddy central basin is covered with a layer of fecal pellets about 0.5 centimeters (0.2 inches) thick.

Every tidal cycle a layer of sediment one or two millimeters thick (less than a tenth of an inch) is eroded and redistributed within the central basin. Throughout the Sound, the tidal streams resuspend and redeposit more than seven million tons of sediment daily. Despite this activity, fine silt is accumulating in the central and western basins of Long Island Sound at the rate of about a millimeter per year.

Temperature

Long Island Sound is a dynamic environment of strong tidal currents and varied salinity. The water temperature is also extremely variable. In the Sound, the water temperature oscillates from 0° Celsius (32° Fahrenheit) in the winter to about 22° Celsius (71.6° Fahrenheit) in the summer, a range as great as that of any body of water in the world.

Suggested Reading

Riley, G. A. et al., *Oceanography of Long Island Sound.* Bingham Oceanog. Coll. Bull., v. 15, 1956.

Turekian, K. K., *Oceans.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1968.

Figure 5. Surface Salinity

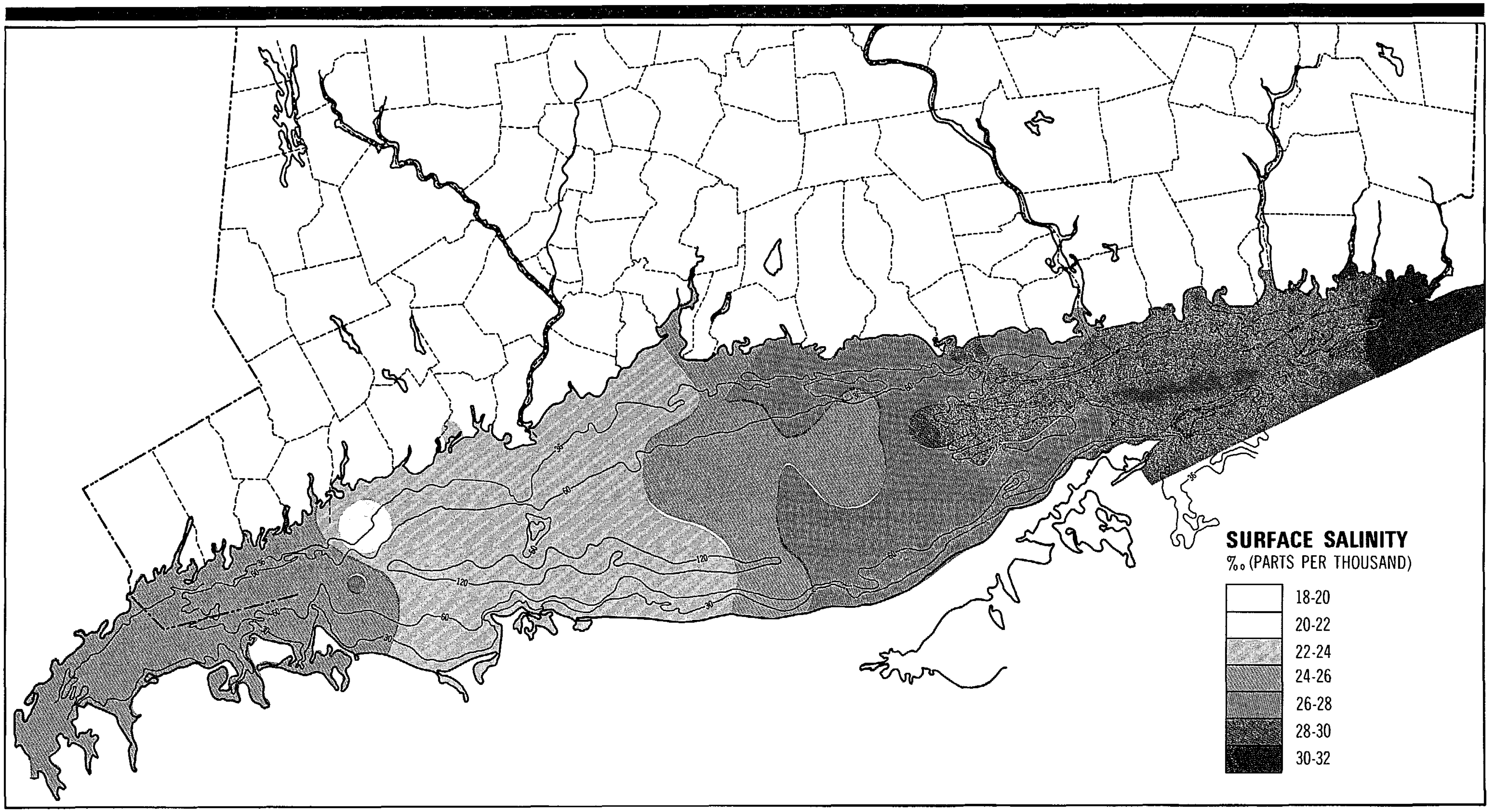
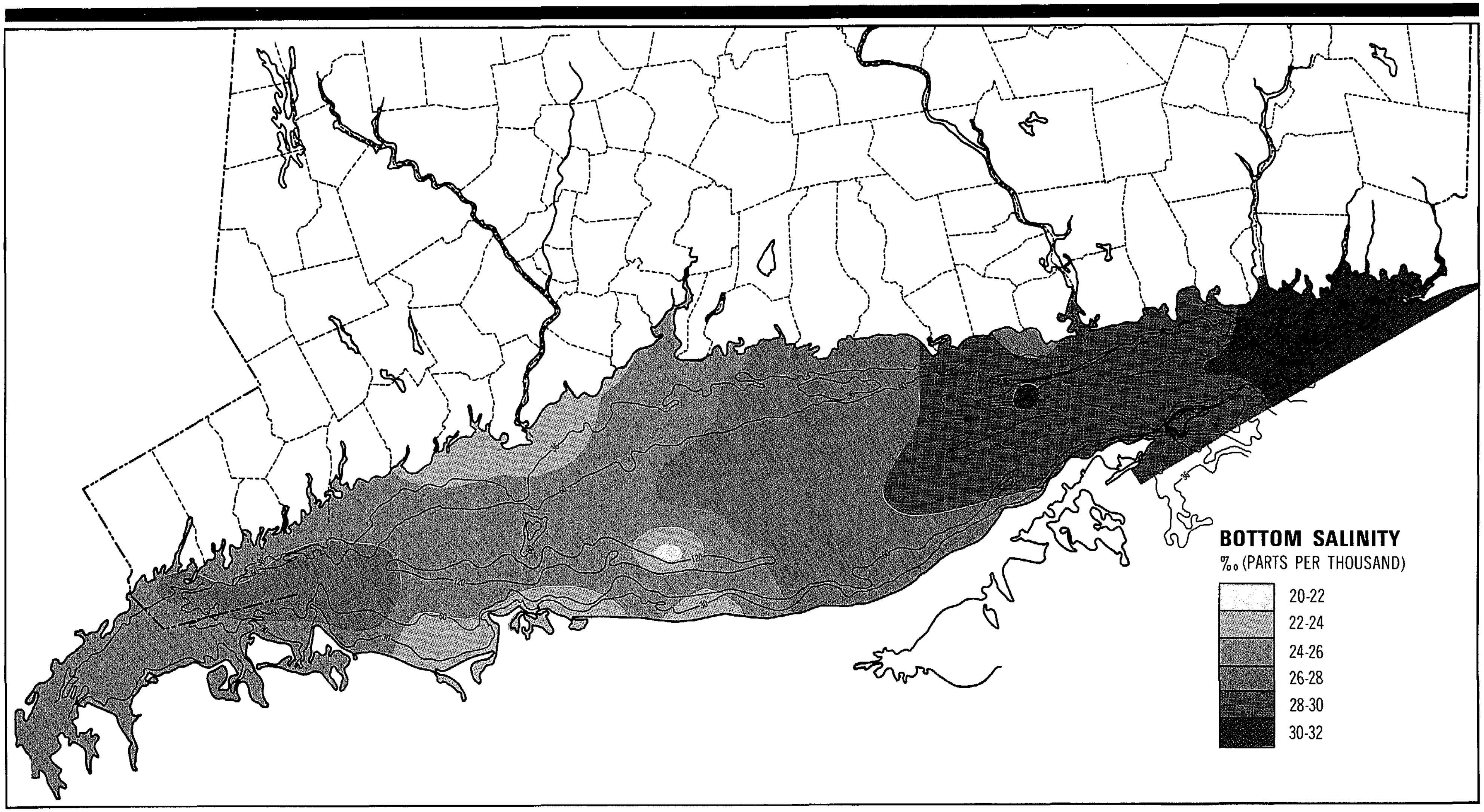


Figure 6. Bottom Salinity



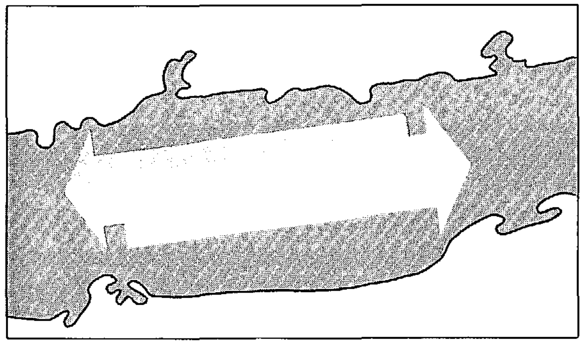


Figure 7. General Pattern of Estuarine Circulation

Figure 8. Maximum Ebb Tide Surface Currents

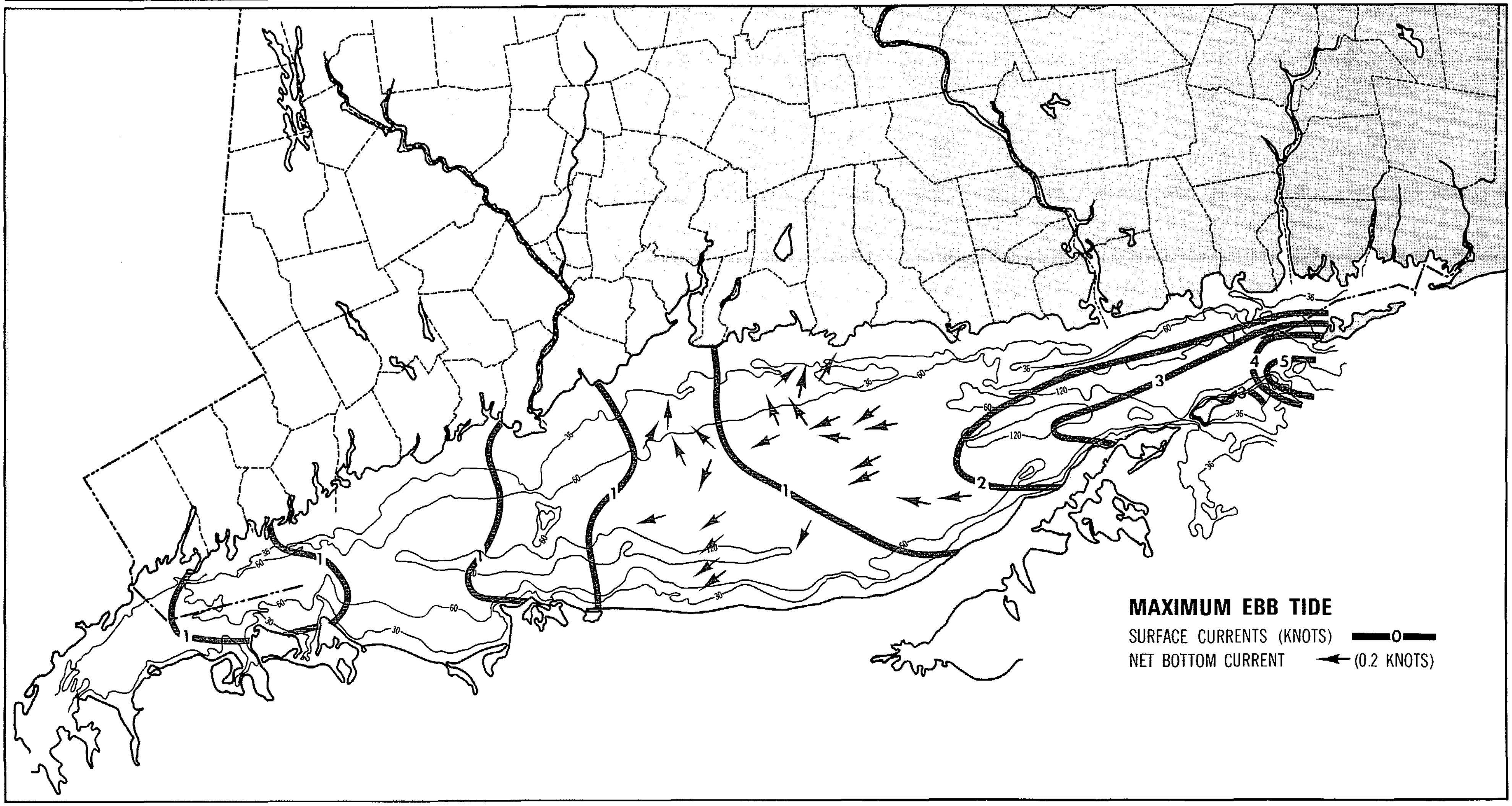
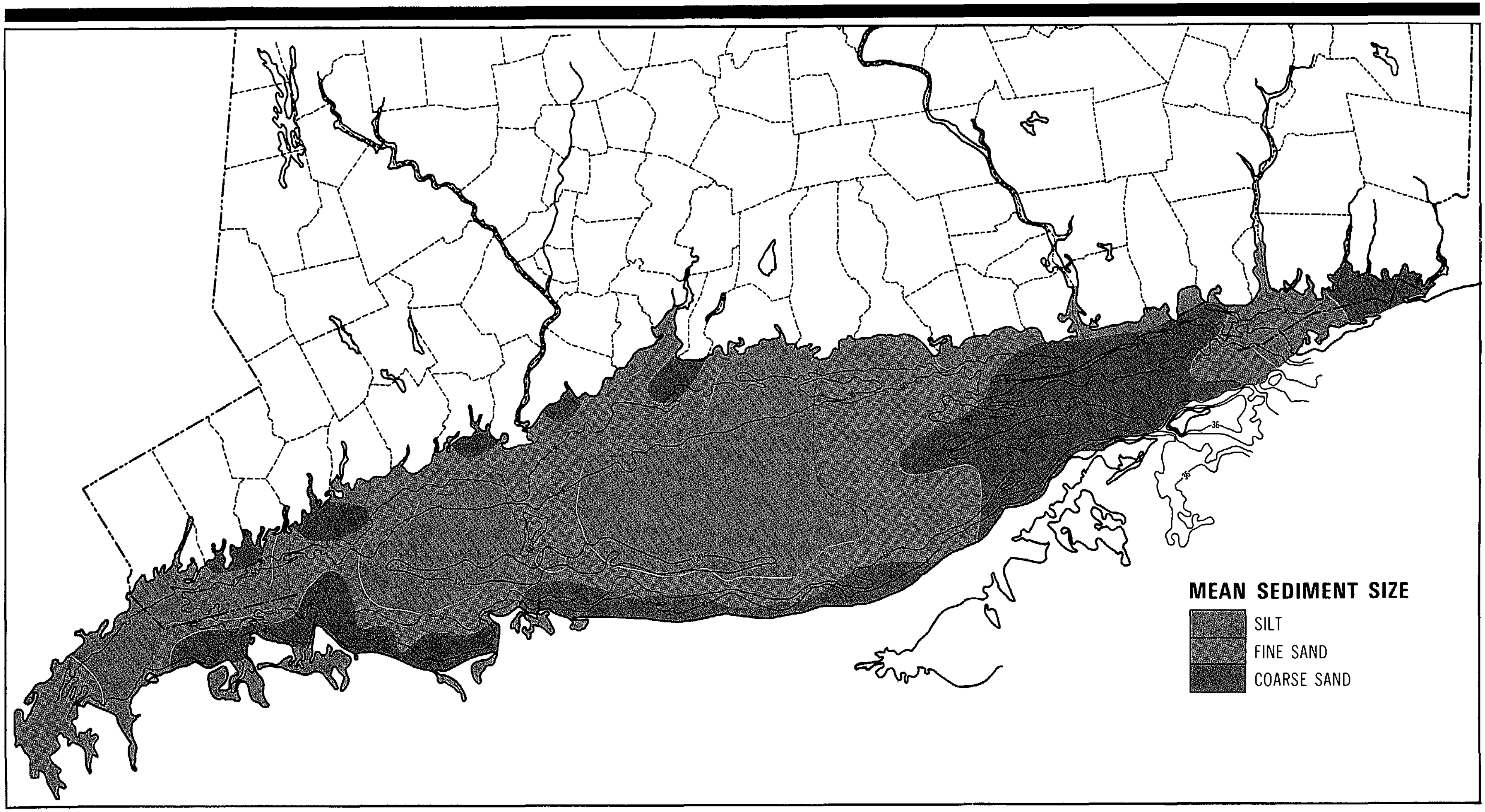


Figure 9. Mean Sediment Size



3. Shoreline Features and Processes

Connecticut's shoreline has a number of distinct land features such as tidal marshes, intertidal flats, bays, islands, headlands and bluffs, and beaches. Figure 10 shows the general distribution of some of the noted landforms along the Connecticut shore. These features are a direct result of a number of physical and geologic factors, including glaciation, changing sea level, waves, tidal currents and wind. Through the processes of erosion, transportation and deposition, these factors created and continue to modify existing landforms.

Processes

Erosion is the wearing away of the earth's surface by the action of natural forces, such as wind and water. Sediments that are eroded from the shoreline are transported by wind and wave energy and tidal currents, and eventually are *deposited* elsewhere. *Tidal marshes and* mudflats are examples of areas resulting from depositional activity.

It is important to bear in mind that any feature under the influence of a number of separate but interrelated factors is dynamic. It must respond to both short and long term trends. Due to the influence of the tides, the zones where wave action affects the shoreline change daily. Changes in sea level, on the other hand, must be viewed as long term trends, causing modification of shoreline configuration over a period of thousands of years. Because of their dynamic nature, no shoreline or shore feature should be considered as strictly erosional, depositional or stable, but rather, each should be viewed as continuously changing.

Rising Sea Level Approximately 8,000 years ago rising sea level first began to influence Long Island Sound, which was previously a freshwater lake (see Chapter 1, "Glacial History"). Since that time, sea level has continued to rise and has "drowned" features which were previously upland, such as river valleys and glacial moraines. Such land forms as small embayments (New Haven Harbor) and some offshore islands (Norwalk Islands) subsequently appeared. In addition, tides and related currents began to affect the Sound.

Wave Dynamics Surface waves are produced by wind blowing over open water. Generally speaking, wave conditions are governed by three factors: *fetch*, or the length of unobstructed water over which the wind blows; duration, or the length of time for which the wind blows at a given speed from a given direction; and the velocity of the wind. As each of these factors is increased, larger waves can be generated. In the Long Island Sound area wind direction varies on a seasonal basis, with winds blowing generally from the south and southwest during spring and summer months and from the north and northwest during the fall and winter. Winds blowing from southerly directions generate the waves which most dominate Connecticut's shoreline.

As waves traveling across Long Island Sound enter water of increasingly shallow depth, they become gradually steeper until their crests fall forward as *breakers*, creating what is commonly known as *surf*. Since the Sound is almost entirely sheltered by Long Island and Fishers Island, fetch is limited and large waves, such as those which break on shores exposed to the open ocean, do not reach Connecticut's coast. Normally, waves breaking on the Connecticut side of Long Island Sound range in height up to 6 feet, although during infrequent storms and hurricanes larger waves can be expected.

As waves approach the shore and break, they release energy. This energy erodes and transports shoreline sediments in three ways. *Longshore currents,* which are created when waves break at an angle to the shore, carry sediments along (parallel to) the shore. Also, waves may transport sediments either on- or offshore, depending upon the nature of the actual "breaker". The steeper "plunging" breakers tend to move material offshore, while the less steep "spilling" breakers tend to move material onshore.

The zones in which waves exert the most influence (where breaking occurs) are changed daily due to rising and falling tides (see Chapter 2).

Tidal Currents Currents created by the action of the tides are also important in the erosion, transportation, and deposition of sediments along our shores, particularly at inlets, bays and river mouths. When tides enter small coves, harbors, and other embayments with inlets (constricted openings), the velocity of the current is significantly higher. The narrower the inlet, the higher the current velocity. At inlets, an equilibrium situation normally exists; that is, there is a balance between the size of the inlet and the volume of the tidal exchange. If an inlet is below a certain equilibrium size (due to the deposition of sediment from storms, etc.), stronger currents will erode the material from the inlet, eventually returning it to equilibrium. If, on the other hand, the size of the inlet is above the equilibrium, currents are slower and may deposit material at the inlet.

In bays and other semi-enclosed quiescent bodies of water along the shore, finer materials carried in by tidal currents are deposited, giving rise to inter-tidal mudflats. At river mouths and, in some instances, at points of land which project seaward, tidal currents can act in conjunction with longshore currents to move material along the shore and modify magnitudes and directions of longshore currents.

Winds Winds, in addition to generating waves, are also capable of moving sediments along the shore above water level. Their influence is most apparent in the formation of sand dunes. As mentioned previously, normal wind direction varies seasonally. Hurricane-force winds are most likely to occur during the late summer and fall. Waves generated by hurricane winds cause significant and sudden changes to our shores, such as breaching barrier beaches or filling inlets.

Biological Processes Biological factors are important in the formation of shoreline features, particularly tidal marshes and dunes. Beach grass and other dune vegetation as well as various salt marsh species encourage the deposition of sediments by acting as physical barriers to the transport of materials and by stabilizing materials with their root systems. The role of vegetation is discussed in greater detail in Chapter 5.

Features

Headlands and Bluffs In Connecticut, *headlands* may be composed of glacial *drift* and/or *bedrock*. Their original formation is a direct result of glacial scouring and deposition. Where these features are composed of glacial drift, which is easily eroded, they provide a

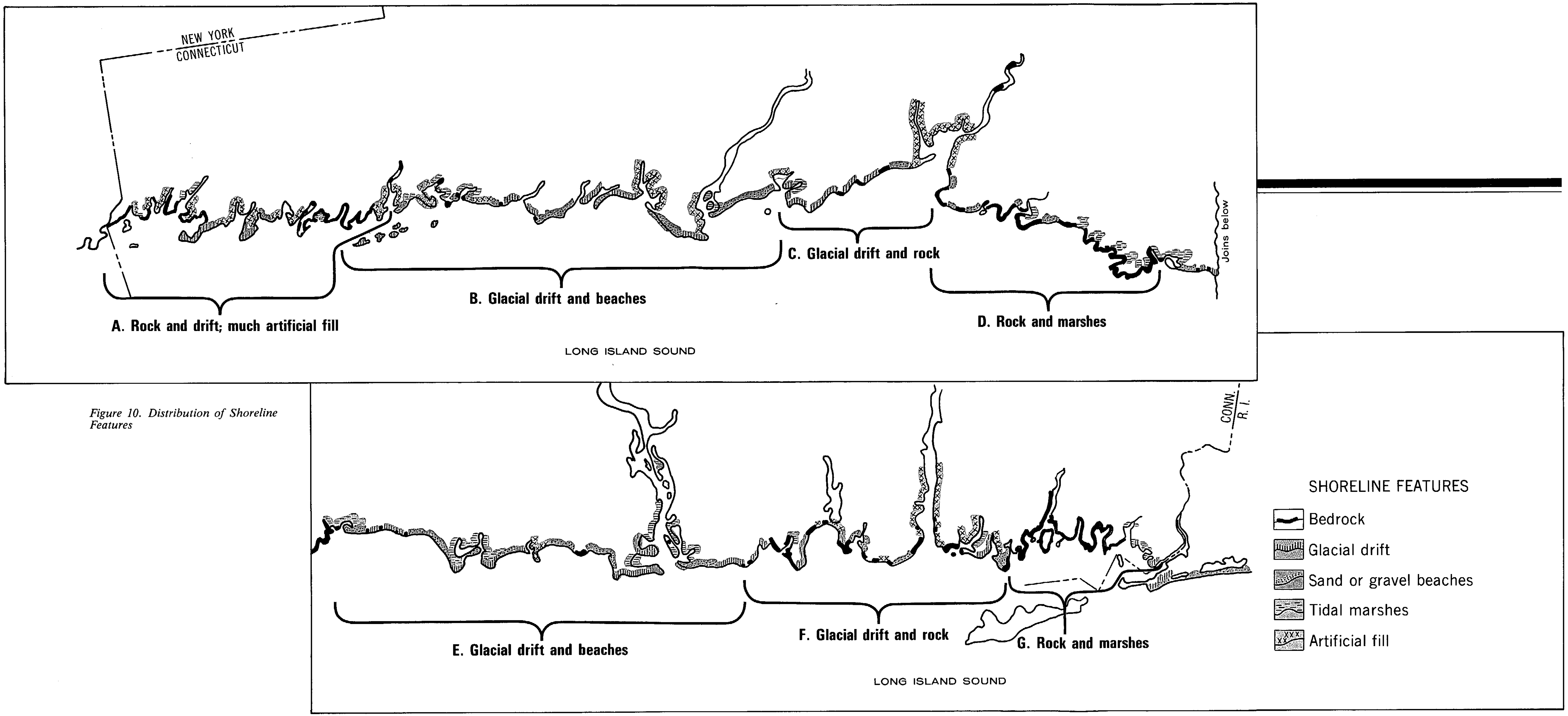


Figure 10. Distribution of Shoreline Features

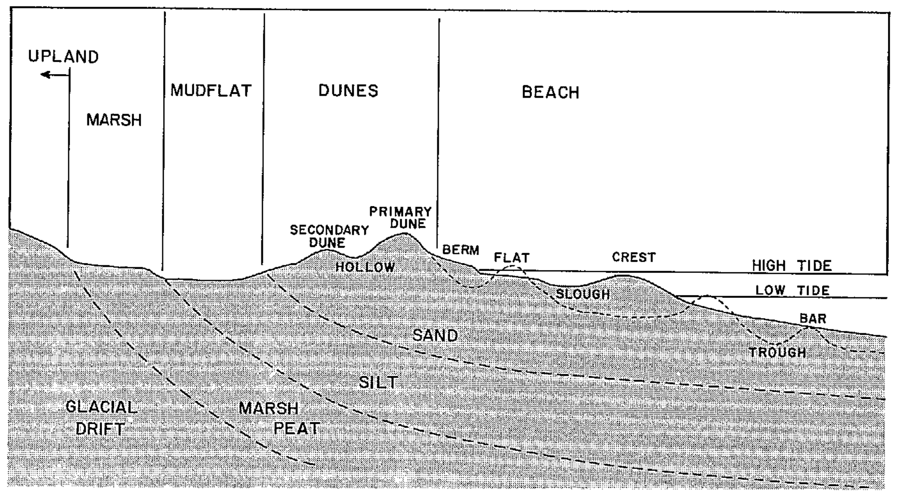


Figure 11. Beach Profile

major source for sediments which are then transported to other sites, forming beaches, marshes and mudflats. In contrast to drift, bedrock is highly resistant to erosion and as a result is only weathered slowly by waves, winds and tidal currents. Headlands are easily recognized as higher hilly forms projecting seaward. Bluff Point is a typical headland which provides a sediment source for Bushy Point Beach.

Beaches Beaches are generally considered to be erosion-prone; however, their initial development is a result of the depositional process. The character of the beach is regulated by the balance between erosional and depositional forces. When these forces are in *dynamic equilibrium,* beach form remains constant. When the equilibrium is altered, the beach may either grow or diminish in size. For example, if the sediment source of the beach is depleted, either as a result of a natural process or through the construction of a man-made feature such as a sea wall, the beach will recede. If, however, additional sediment becomes available and is transported to the beach, it may increase in size.

Another factor affecting beaches is rising sea level. As sea level rises, the beach as a system may retreat in response to changing balances between erosion and deposition. Thus, it may eventually override the land behind it. Such a situation exists at Cedar Island, Clinton, where peat deposits project from the beach face.

Several types of beach are found on the shores of Long Island Sound. Included are: *spits,* or projections of sand attached at one end to an island or the mainland; *tombolos,* or stretches of sand connecting an island and the mainland or two islands; and *pocket beaches,* which occur in small crescent-shaped coves and directly front uplands. Spits and tombolos may be referred to as *barrier beaches* in instances where they extend parallel to the mainland, but are separated from it by a body of water or marsh. Examples of these types of beaches may be seen at Griswold Point in Old Lyme (spit), and on the Norwalk Islands (tombolo).

As illustrated in Figure 11, beaches show characteristic profiles which are related to waves, wind, tides and biological activity. Although the profile shown is for a classic ocean-fronting beach, many of the same features are found on beaches along the Sound. The seaward portion of the profile (the beach proper) changes constantly in response to variations in tidal ranges, weather and surf conditions. Dunes formed by *aeolian* (windblown) sand deposits vary in response to wind and sand supply. Vegetation (such as Beach Grass) growing on the dunes stabilizes them and encourages their growth. Dunes provide an important reservoir of sand which may replenish beaches during times of severe erosion.

Typical beaches in Connecticut are relatively narrow with steep faces composed of coarser sand and some gravel. They generally lack well developed dunes.

Tidal Marshes Tidal marshes develop where finer sediments accumulate. When these sediments build to at least the *mid-tide* level (the water level intermediate between high and low tides), plants may begin to colonize them and to create marsh systems. Plant roots stabilize the sediment and their stems trap additional sediments. Once plants have colonized the sediment, decaying vegetation accumulates, eventually forming peat.

Tidal marshes began forming on the coast several thousand years ago, when sea level was much lower than it is today. As sea level rose, many marshes that had formed in shallow coastal waters were able to accumulate peat and sediment rapidly enough to keep pace with the rise, and therefore are in existence today. Like beaches, marshes have also migrated landward as sea level was rising, overriding the uplands on their landward edge while being eroded and/or overtopped by other sedimentary deposits at their seaward edge (see Figure 11). In numerous places along the coast, marsh peat actually juts from the seaward edge of beaches, evidencing the former position of the marsh.

According to soil scientists, four main classes of tidal marshes are found in Connecticut: deep coastal, shallow coastal, very shallow coastal and estuarine. Deep coastal marshes, present mainly in areas west of the Connecticut River, are characterized by peat deposits averaging 5 meters thick. They represent the State's oldest marshes. Shallow coastal marshes occur primarily east of the Connecticut River and average 2 meters thick. They began forming within the past 3,000 years. Very shallow coastal marshes occur for the most part in Rhode Island, although a few are present in Connecticut. They are generally less than 1 meter thick and contain a great deal of sand mixed in with their peat. They are also affected by erosion much more markedly than the previously mentioned marsh types. Estuarine marshes develop along tidal rivers rather than on the coastline. When river flow is slowed by incoming tides (slack water), muddy sediments accumulate, forming these marshes.

Tidal Mudflats *Tidal mudflats* accumulate in a manner similar to the initial stages of tidal marsh development. The differences are that sediments have not accumulated above the mid-tide level and the mudflats remain unvegetated. Tidal mudflats are exposed at each low tide. The mudflats at Long Wharf in New Haven are a particularly good example of this type of coastal feature.

Although this chapter has discussed each type of shoreline feature separately, no feature should be considered independent and unrelated to other components of the coastal system. Almost invariably, features occur together, forming unique and interacting units. A headland-marsh-spit complex, such as those occuring at the mouths of the Connecticut and Housatonic Rivers (Griswold and Milford Points, respectively), is representative of such a unit. In each case a headland provides sediment for the lateral growth of the spit, while the spit provides shelter from waves and storms for the marsh behind it. The headland is eroding, while the spit and marsh may be alternately eroding or depositional. Each feature responds in a particular way to changing physical conditions, and in turn, influences other features.

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Bascom, W.M., *Waves and Beaches.* Garden City, N.Y.: Anchor Books, 1964.

Bloom, A.L. and Ellis, C.W., Jr., *Postglacial Stratigraphy and Morphology of Coastal Connecticut.* Connecticut Geological Natural History Survey Guidebook No. 1, 1965.

Hill, D.E. and Shearin, A.E., *Tidal Marshes of Connecticut and Rhode Island.* Connecticut Agricultural Experiment Station Bulletin 709: 34 p., 1970.

4. Natural Systems

Along Connecticut's coastline, a number of distinct types of natural geographic features can be observed. These features, or *habitats,* are products of long periods of interaction between the physical and biological environment. Each habitat is characterized by its own particular complex of plants and animals which have adapted to the specific physical conditions of the area. This grouping of plants and animals is termed a *community.*

Communities

The concept of a community may be defined more precisely as a group of plants and animals, interacting with and closely dependent upon one another, that are tied to and strongly affected by their particular physical environment.

The *food web* is an important component of any community. Plants are the *producers* of the food web in that they alone are capable of transforming light energy from the sun into food energy. In the presence of sunlight, green plants can use carbon dioxide, water, minerals and nutrients to manufacture carbohydrates by a process known as photosynthesis. Some of this food energy is utilized by the plant to sustain life, and the rest is stored in various plant parts (such as roots, leaves, seeds, etc.). These plant parts are eaten by *herbivores* (plant-eaters), such as insects, small mammals, songbirds and others. The herbivores are preyed upon by the *carnivores* (meat-eaters), such as foxes or hawks. When members of the food web eliminate wastes or die, the wastes or carcasses are broken down into their component mineral parts by another group of creatures, the *decomposers,* consisting largely of bacteria and fungi. Each of these groups is individually referred to as a *trophic level.*

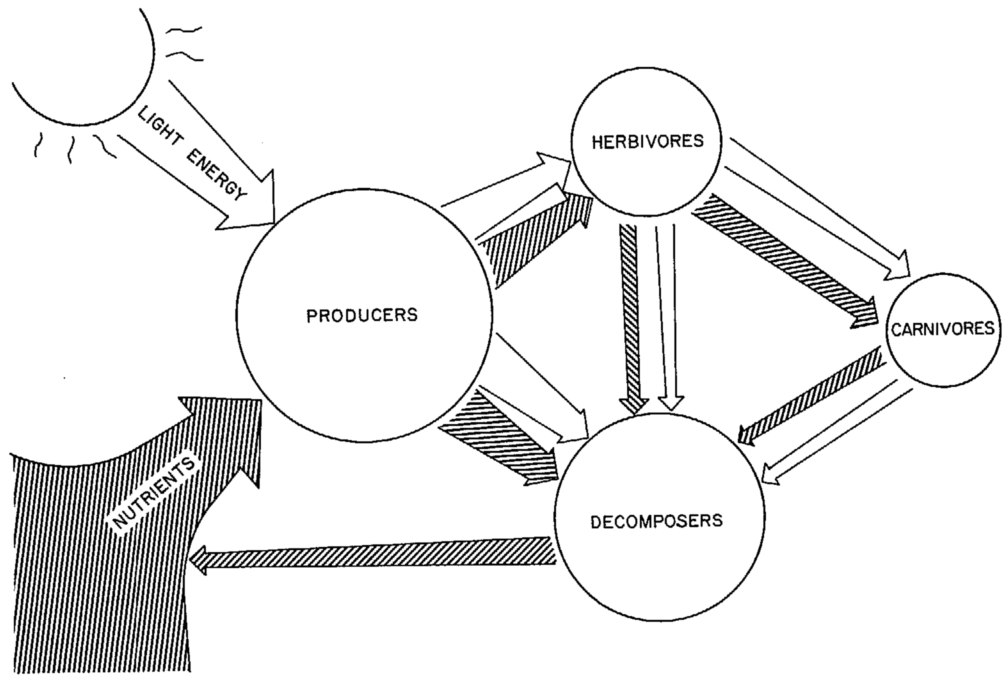
Energy is passed from one trophic level to another. First, energy captured from the sun and incorporated into the tissues of the plants is passed to the herbivores as they graze upon the plants. The energy is then passed to the carnivores as they feed upon the herbivores. Decomposers draw their energy from all trophic levels.

In general, the efficiency of the energy transfer between trophic levels is very low, since each level uses up much of the energy that it consumes through such activities as digestion. As a result, the energy available for each succeeding trophic level is substantially reduced. With the exception of the microscopic decomposers, fewer creatures can be supported at each succeeding trophic level. For example, it has been estimated that it takes 800 kilograms of algae to supply food for 26 kilograms of minnows, and 26 kilograms of minnows for a one-kilogram bass.

Nutrients entering the food web are generally not lost. For the most part, once they have reached the decomposers, they are released back into the soil and air where they can be re-used. Figure 12 illustrates the flow of energy and nutrients through the community.

Another important feature of a community is its *productivity.* Productivity refers to the amount of living material produced in a given area over a specific length of time. Productivity is often related to the amount of food available in an area. Food supply has direct bearing on the area's *carrying capacity* (the amount of wildlife that it can support). As will be shown, habitats present on the coastline vary in their productivity.

Figure 12. Energy and Nutrient Flow Through a Simple Community



Habitats

Communities occur within habitats. On the coast these habitats may be viewed in four broad zones, shown in Figure 13: the *subtidal zone, intertidal zone, water-land interface,* and *upland.*

The **subtidal zone** is characterized by two major habitats: the *benthic* and *pelagic.* The benthic (or seafloor) environment is home for a variety of creatures that live upon or within the seafloor. The type of community present is largely determined by the texture of the sediment surface and the salinity of the overlying water. The pelagic environment consists of the *water column* (the mass of water between the surface and the seafloor) itself. This environment may differ in chemical and physical properties such as salinity, dissolved nutrients, and suspended sediments, especially in areas where fresh water rivers enter. It may also differ in depth, current patterns and seasonal temperature.

The **intertidal zone,** that area which is periodically flooded and uncovered during each tidal cycle, is similar in some respects to the subtidal zone. Both benthic and pelagic habitats exist, but the environment is much more severe. For example, tidal mudflats and sand flats, along with rocky shorelines, are subject to intense heat and drying from the sun at each low tide; at high tide saline water inundates the area. These extreme variations in the physical environment, in combination with sediment type, determine to a large extent the composition and structure of communities inhabiting these areas.

The **water-land interface** is that area above the daily influence of tides which is still strongly affected by oceanic processes. Habitats such as beaches, rocky bluffs and the upland borders of salt marshes generally fall into this category. Although above the normal reach of tides, these habitats may be affected by the extra high *spring tides* which occur twice monthly. The upper reaches of most of Connecticut's salt marshes are, for the most part, flooded only twice monthly, while the lower reaches nearest to the water are flooded twice daily. The community composition of the lower marshes is substantially different from the higher marshes.

Salt spray is an important factor in the development of communities in the water-land interface. Tiny particles of wind-blown salt severely limit the types of plants and animals that can survive here; most terrestrial forms of life are highly intolerant of salt in their environment.

The *substrate* (the type of soil or rocks present) also affects community development. Whether the substrate is being eroded, as in rocky shorelines, or deposited, as in beaches, is another determining factor.

Upland habitats occur beyond the influence of normal and spring tides, and are affected by waves and salt water only during storm tides. The coastal, or "maritime", climate is characterized by more moderate conditions than those occurring inland. The onshore breezes of Long Island Sound cool the coast in summer, while the relatively warm water of the Sound in winter moderates the coastal climate. Salt spray reaches the upland usually only during severe storms, but the effect of even this infrequent salt spray is significant in determining what communities exist there. Again, substrate has a strong effect on community development of upland habitats.

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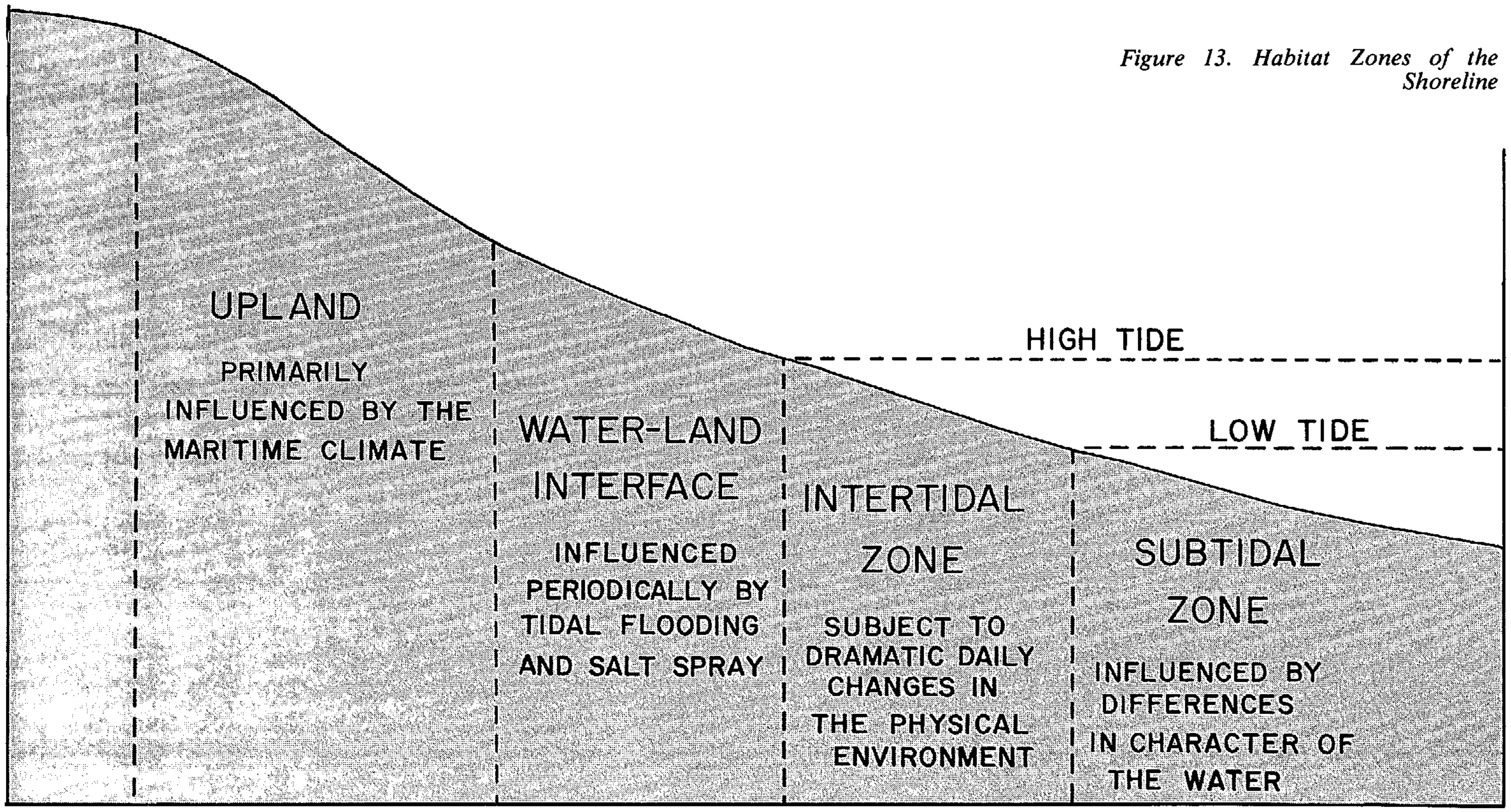
Figure 13. Habitat Zones of the Shoreline



5. Vegetation

Plantlife can be divided into two broad groups: the *non-vascular,* or primitive plants; and the *vascular,* or advanced plants. There are many types of non-vascular plants, such as mosses, liverworts, fungi, algae, and lichens. Vascular plants include most of our large terrestrial forms, such as grasses, trees, and shrubs.

A characteristic and familiar group of non-vascular plants is the algae, which can be divided into two groups. One group consists of the microscopic floating *planktonic* or bottom-dwelling *benthic* forms, which will be discussed in Chapters 6 and 9; the other group includes seaweeds.

The Seaweed Communities

As their name implies, seaweeds live only in seawater. There are three main types of seaweeds: the green algae, the red algae, and the brown algae. Each is characterized by the type of pigment it contains. In the Sound, the greatest abundance of seaweeds is in rocky intertidal areas and on rocks on the sea floor. Sandy and muddy sites are not as suitable for most species of seaweed since the constantly shifting sediments do not permit them to become attached.

In addition to *substrate,* factors such as light, salinity, severity of wave action, water temperature, and duration of exposure above water all affect the distribution of seaweeds. For example, below the intertidal zone, light strongly influences the depth to which seaweeds can occur, particularly in the *turbid* waters of Long Island Sound. The type of light available for the seaweeds changes at increasingly greater water depths. Seaweeds requiring relatively direct sunlight, such as the green algae, occur primarily in shallow water. Brown algae and, particularly, red algae, which can survive in subdued sunlight, extend their ranges into deeper water.

In Connecticut, a number of seaweed species are characteristic of the intertidal and subtidal zones (see Figure 14). In the rocky intertidal zone, the rocks exposed to the air are often covered with heavy growth of two conspicuous brown seaweeds, *Fucus* and *Ascophyllum,* both of which have air bladders. The bladders allow them to float and thus receive direct sunlight as the tide rises and falls. Other seaweeds, such as *Ectocarpus* (a brown alga) and *Polysiphonia* (a red alga), only grow attached to *Fucus* and *Ascophyllum.* The red alga *Porphyra,* recognized by its thin, sheet-like appearance, is also found in the rocky intertidal zone. Another red alga commonly found here, especially in backwash areas, is *Chondrus* (Irish Moss). Its highly branched, shrub-like form is especially distinctive.

In the intertidal zone of estuaries and tidal marshes, which are relatively calm environments in contrast to the rocky intertidal zone, several green algae occur. These include the soft, many-branched *Cladophora* (Mermaid's Hair); the narrow, strap-like tubes of *Enteromorpha*; and the broad blades of *Ulva* (Sea Lettuce). In recent years, another green alga, *Codium,* has become locally abundant. It is easily recognized by its branching form and sponge-like texture.

In water several feet deep at low tide (the subtidal zone), the red alga *Rhodymenia* is found, intermixed with two brown algae, *Laminaria* and *Chorda.* The distinctive, strap-like *Laminaria* (kelp) with its tangled, root-like holdfasts, is often found washed up on the beach. Specimens 1-2 meters in length are not uncommon. *Chorda* is a single, long, round strand which looks like a swollen string, and often reaches a length of 45 centimeters. In the still deeper water of the subtidal zone grow the delicate, finely branched red algae such as *Spermothamnion, Antithamnion,* or *Callithamnion.* They are easily dislodged by wave action and can be found floating freely.

In tidal pools, rocks and mollusk shells are often encrusted by the red or pink colored *Hildebrandtia* or *Phymatolithon.* Green algae such as *Ulothrix, Cladophora,* and *Enteromorpha* also thrive in the same pools, attached to the rocky substrate. These thread-like plants float in the quiet water left behind by the high tides.

It is important to note that seaweed populations fluctuate with the seasons. Some, such as *Monostroma,* reproduce in early spring and die out by late summer. Others, such as the pink *Grinnellia,* appear in August and disappear after four to six weeks.

Tidal Marshes

Comprising about 15,000 acres in Connecticut, tidal marshes are low-lying areas subject to relatively low wave energies and to mixing of fresh and salt water. There are several different plant communities which can occur in tidal marshes, depending upon their proximity to Long Island Sound, elevation above sea level, and duration of tidal flooding.

The most prevalent is the *salt marsh* community, which is comprised of a series of "belts," or zones, progressing from the seaward edge of the marsh to its upland border. A complex set of factors, including tides, salinity, nutrients, oxygen availability and surface elevation all influence the distribution of species in the marsh. The tall form of Salt Water Cordgrass *(Spartina alterniflora)* grows along the ditches and seaward edge of the marsh, where it is inundated daily by the tides. The higher portions of the marshes, often called salt meadows, are inundated less frequently and are usually dominated by the short Salt Meadow Cordgrass *(Spartina patens)* and Spikegrass *(Distichlis spicata).* A short form of Salt Water Cordgrass sometimes grows in depressions *(pannes)* on higher marshes, where evaporation raises the salinity of trapped tidal water to levels higher than sea water. Also occurring in pannes and bare areas are a number of other plant species: Sea Lavender, Salt Marsh Aster, Seaside Gerardia and various species of Glasswort. Forming a belt near the upland border of the marsh is Blackgrass, which is actually not a grass but a rush. At the upland-marsh border, Switchgrass and Reed often occur. Marsh Elder, a shrub which tolerates salt, is frequently associated with Blackgrass or Switchgrass. It usually grows at the level of the highest monthly tides while Switchgrass grows at the level of occasional storm tides. The upland edge of the marsh may often contain the shrubs Bayberry and Groundsel-tree.

In addition to the salt marsh community, other types of vegetation may occur in tidal marshes. These other communities may be observed along the shores of the State's larger estuaries. Further up the Connecticut River, for example, as salt water from the Sound becomes increasingly diluted with fresh water and as the tidal range decreases, the salt marsh vegetation gradually gives way to Cattail marshes; these in turn are replaced by more complex associations of other grasses, sedges, and bulrushes, including Wild Rice.

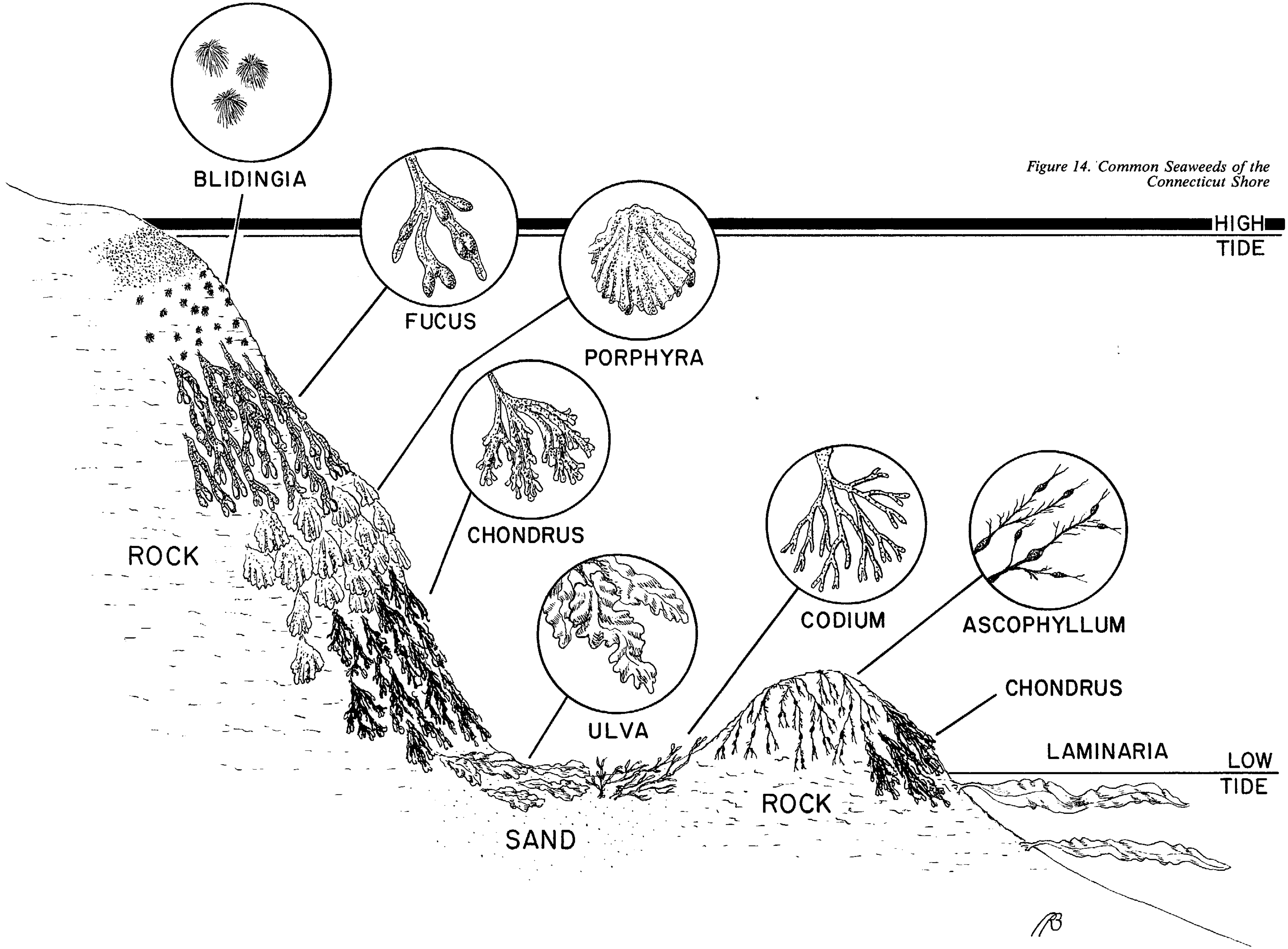


Figure 14. Common Seaweeds of the Connecticut Shore

Tidal marshes, in addition to being botanically specialized, are among the most productive biological systems in the world. In Connecticut, salt marsh production may range from three to seven tons per acre per year. *Productivity* is largely in the form of salt marsh grasses. A substantial part of this production, enriched by the work of the decomposers, is flushed annually into estuarine waters where it becomes a critical part of the aquatic food web. The great finfish and shellfish production of estuarine waters is directly related to tidal marsh vegetation.

Eelgrass Beds

In protected bays, coves and similar areas of brackish water, a unique plant, Eelgrass, may be found. This species is one of the few vascular plants to invade the marine environment. Not actually a grass, it is more closely related to the pondweeds, *Potamogeton.*

Eelgrass grows on muddy sediments primarily below low tide, where it often forms large meadows. The depth to which it exists is, limited by light availability. It can tolerate a wide range of water salinity, from 35 to 25 o/oo (parts per thousand). Minerals necessary for its normal functioning are derived directly from water and sediments.

Reproduction is accomplished in two ways. The plant produces flowers and seeds every two years, but its main method of reproduction is vegetative propagation. This is the sprouting of new plants from *rhizomes* (underground stems) that are sent out by the parent plant. Because vegetative propagation is not a rapid form of reproduction, this species spreads into new areas very slowly.

Eelgrass plays an important ecological role in the subtidal environment. Its roots help to stabilize muddy sediments and its leaves slow currents, thus creating calm environments which provide excellent habitat for numerous species of mollusks and other invertebrates. Eelgrass itself also provides an important food source for waterfowl, particularly Brant (a species of goose).

Although now fairly common along the Connecticut shore, during the 1930's Eelgrass was nearly wiped out throughout much of its range due to a mold infection called Wasting Disease. Much of the mollusk population in the Eelgrass meadows was destroyed, and the Brant population suffered a severe decline. Recolonization of the Eelgrass has been very slow due to its mode of reproduction, and it has still not completely recovered in many areas. There is historical evidence that the disease occurs periodically. It has been documented several times along the Atlantic coasts of North America and Europe.

Vegetation of Beaches and Dunes

Few relatively undisturbed beach and dune systems exist along the Connecticut shore. Where they do occur, the beach environment itself is essentially devoid of vegetation, save for a few specimens of the succulent plant Sea Rocket or an occasional tuft of Dune Grass. On the dunes themselves, the most abundant plant is Dune Grass. Dune vegetation is unique in that it not only tolerates the salt spray and shifting sands characteristic of dunes, but it actually flourishes in this habitat. Plant species living here stabilize their habitat and, in fact, are largely responsible for the establishment and growth of dunes. Sand is held in place by the plant roots and accumulates among the plant stems. Dune Grass is able to grow upward each year because new roots form progressively higher up the stem as sand accumulates.

On the seaward side of the dunes common associates of Dune Grass include Beach Pea, Dusty Miller, and Seaside Goldenrod. Other characteristic beach plants are Orache, Beach Clotbur, Seaside Spurge, and Jimson Weed. On the more protected landward side of the dunes a shrubby cover sometimes develops, dominated by species such as Beach Plum, Bayberry and Beach Rose. Many of the plant species occurring in the latter habitat require the protection of the dunes for their survival. Some beach species, such as Seabeach Knotweed and False Beach Heather, are rare in the State today, partly as a result of the limited amount of beach habitat available.

Upland Vegetation

Plant species growing on upland areas adjacent to the shoreline are not generally subjected to the rigors of the intertidal and dune environment. They are, however, closely influenced by the coastal climate, as seen in the previous chapter. Both the moderate climate and the exposure of the coastline to storms affect, in large part, the observable vegetation patterns. Both the 1938 and 1955 hurricanes had substantial impacts on the vegetation patterns of the coast. The wind and salt spray damage that resulted from Hurricane Belle in 1976 illustrates the effects of storms on the vegetation. Leaves that had been badly salt-burned turned brown and shriveled, and trees downed by the wind left openings in the forest cover. It is probable that even such infrequent storms as these have a significant impact on the long-term composition of upland plant communities.

Mature upland vegetation of the coastal area is comprised primarily of hardwood forest. Dominant tree species include various oaks and hickories, particularly White Oak, Black Oak, Pignut Hickory and Mockernut Hickory. Also important are Sassafras, Black Gum, and Black Cherry. In general, mature trees are somewhat sparse in coastal forests, probably a reflection of their greater exposure to the wind. Consequently, more sunlight reaches the forest floor, stimulating the development of a jungle-like tangle of vines and shrubs. Some important species are Catbriar, Poison Ivy, Bramble and Bittersweet, which are all vines, and Blueberry, Huckleberry, Viburnum and Hazelnut, which are shrubs.

A number of species are limited to the coastal region. These include the Sweetgum, a southern tree occurring only in extreme southwestern Connecticut, and the American Holly, Post Oak and Persimmon, which exist only locally along the shore. It is notable, in fact, that many southern species reach their northern range limits along the Connecticut coast. This is undoubtedly related to the availability of suitable habitat, since many grow typically in sandy soils, and to the milder coastal climate. Further inland, winters are probably too harsh or the growing season too short to allow for the natural colonization of these species.

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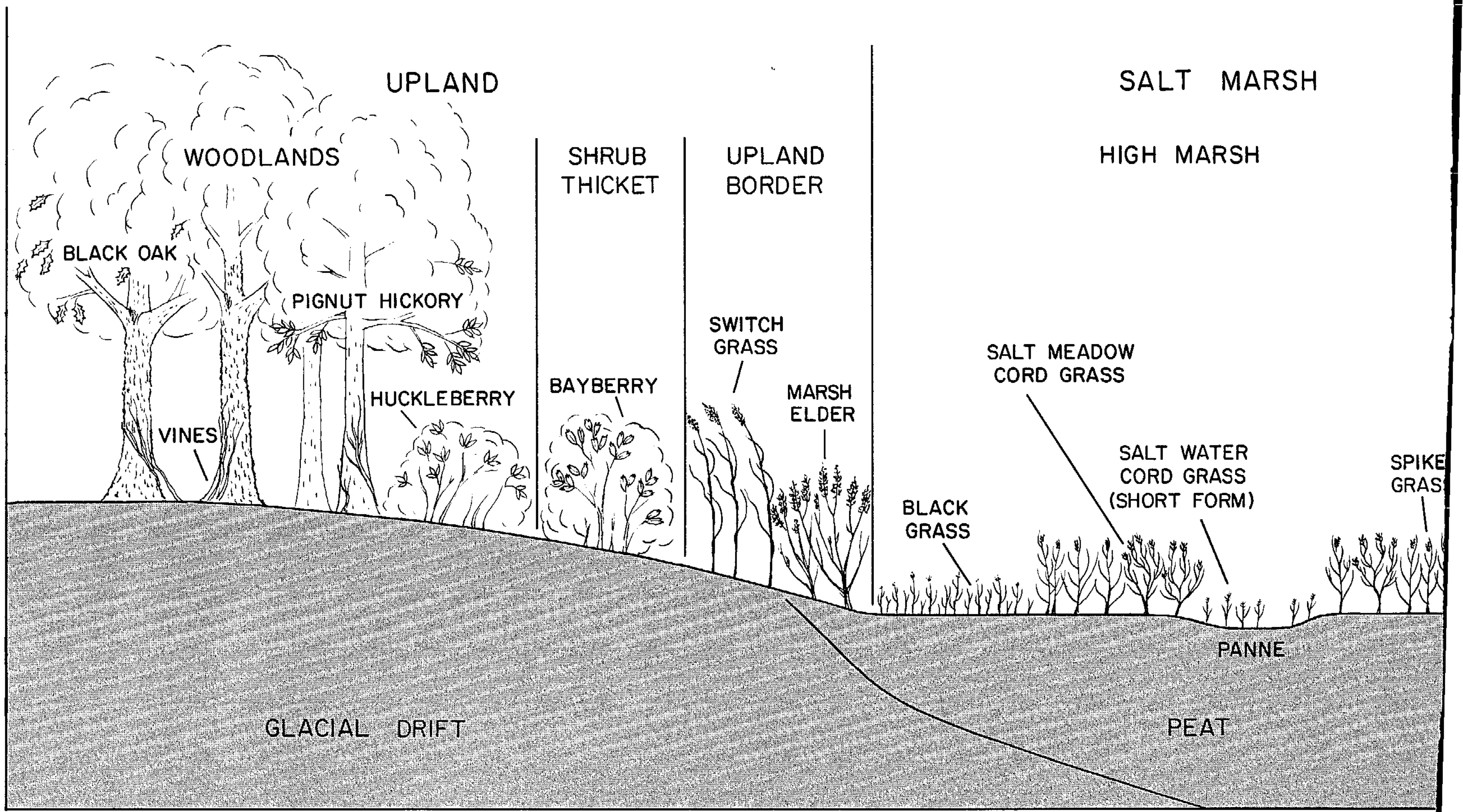
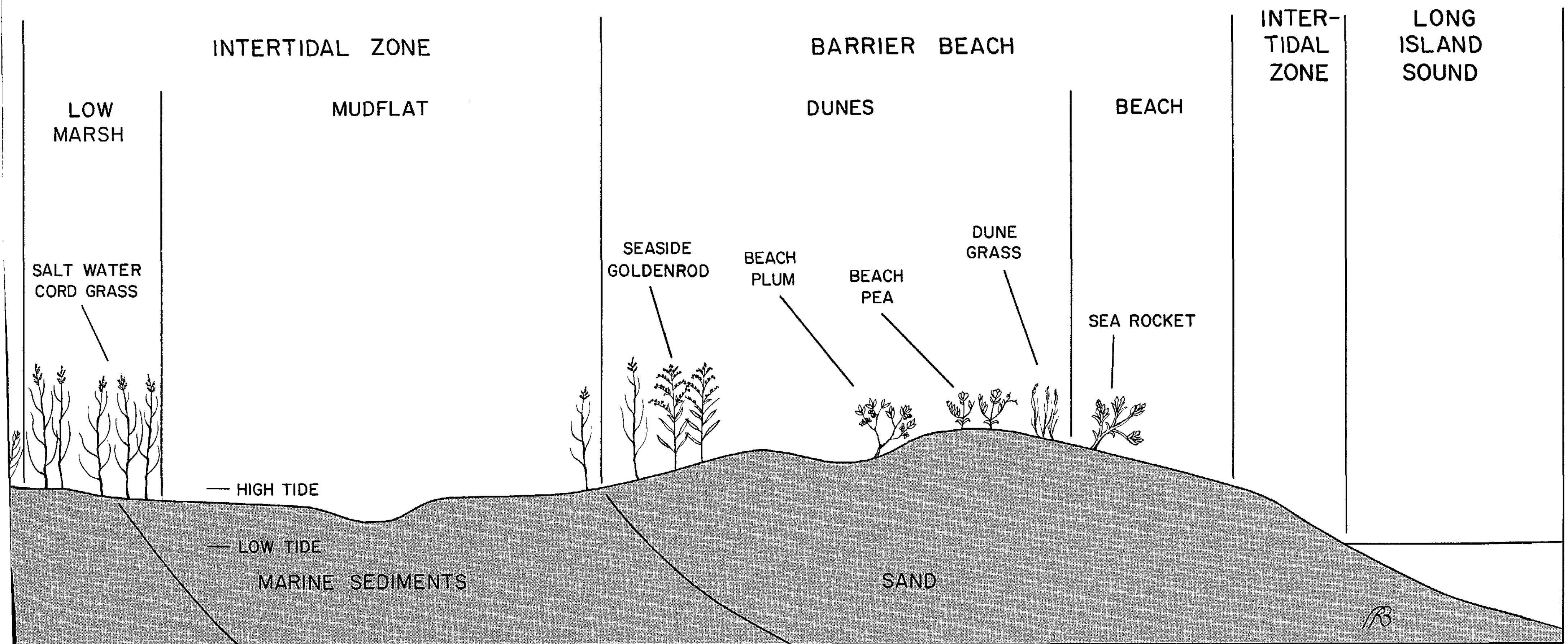



INTERTIDAL ZONE
LOW MARSH
MUDFLAT
BARRIER BEACH
DUNES
BEACH
INTER-TIDAL ZONE
LONG ISLAND SOUND
SALT WATER CORD GRASS
SEASIDE GOLDENROD
BEACH PLUM
BEACH PEA
DUNE GRASS
SEA ROCKET
HIGH TIDE
LOW TIDE
MARINE SEDIMENTS
SAND

6. Benthos

All plants and animals living on or in the seafloor are collectively called the *benthos*, a Greek word for "of the deep." The benthos that live on the seafloor are known as *epibenthos*, with the plants called *epiflora* and the animals called *epifauna*. The benthic plants and animals living below the surface of the sediment are known as *inflora* and *infauna*, respectively.

The Benthic Habitat

The epibenthic habitat includes the sediment surface and the water immediately above it. Organisms living in this habitat include the following types: 1) animals such as mussels, oysters, barnacles and sea anemones, which are cemented or otherwise attached to rocks or other hard surfaces; 2) plants growing on bottom sediments, such as Eelgrass, kelp and other seaweeds; 3) species that are mobile and crawl about on the seafloor, such as crabs, lobsters, starfish and snails; and 4) fish that swim just above the bottom or use the bottom as a temporary refuge from predators, such as the Winter Flounder. Included in categories 1 and 2 are the epifauna that live on top of other plants or animals; these include some species of polychaete worms, snails, diatoms, and bacteria. Figure 16 shows these various epibenthic life forms in their habitats.

Figure 16 also illustrates various infauna and inflora. Most infauna either live in permanent tubes within the sediment or move freely through the bottom. They usually inhabit only muddy or sandy sediments, although a few animals are capable of boring into solid and semi-consolidated materials such as wood, rock, peat and shell. Infauna use the seafloor as a permanent residence or as a refuge from free-swimming predators. In the intertidal zone, organisms burrow deeply into the bottom to escape surface predators. Animals living below the sediment surface may also use the overlying sediment for protection against fluctuations in temperature, salinity, and air exposure during low tide. In addition, the seafloor contains organic matter which provides a food source for many species.

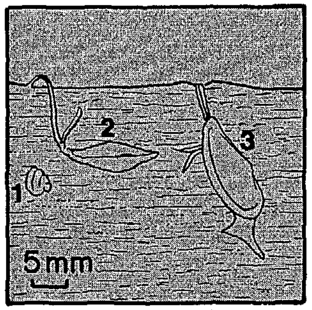
Benthic Organisms

Size Range Benthic organisms can be divided into three classes according to size:

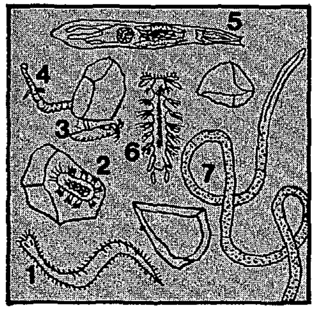
1. Organisms equal to or greater than 1 millimeter in diameter are commonly referred to as *macrobenthos* or *megabenthos*. This group includes all the easily-observed animals, including many that are of direct commercial importance, such as lobsters, crabs and clams.
2. Organisms of intermediate size, smaller than 1 millimeter, but larger than 0.05 millimeters, are called *meiobenthos*. These animals live in the spaces between particles of sand on the beach and among the individual sediment particles on the seafloor. The young (or *larvae*) of the macrobenthos can be temporary members of this size class. The permanent meiofauna, which remain small in adult form, include small crustacea, small polychaete worms, nematodes, and foraminifera. Many of the meiofauna are infaunal, living near the oxygenated surface of the sediment. Other species are epifaunal, living on or above the surface sediment.
3. The smallest creatures, the *microbenthos*, are less than 0.05 millimeters in size and are only visible under a microscope. This group includes bacteria, yeast, fungi, diatoms, and protozoans. The microbenthos are especially numerous in the top layer of the bottom sediments where concentrations of organic matter are highest. They are also found deeper in the sediment as well as on the surfaces of plants, macrofauna and rocks.

Feeding Habits The majority of benthic animals feed in one of the following four ways:

1. *Herbivores* feed on plant material and are most commonly found in intertidal or well-illuminated subtidal areas where marine grasses or algae grow. Animals in this group include grazers such as snails, which scrape minute algae from rock surfaces, and sea urchins, which consume larger algae. Most herbivores are epifaunal.
2. *Carnivores and scavengers* include lobsters, starfish, crabs and bottom-feeding fish that feed on living and/or recently dead organisms. Most of these organisms are highly mobile epifauna.
3. *Suspension feeders* filter or otherwise intercept particles of organic matter (decomposed plant and animal material) suspended in the *water column*. Commercially valuable clams, scallops and oysters feed in this way, using gill structures as food filters. Other suspension feeders (for example, barnacles) have modified mouthparts and legs for filtering food. Some creatures, such as polychaete worms and sea anemones, use tentacles and nets of mucus. Most immobile epifauna and infauna are suspension feeders.
4. *Deposit-feeders* are predominately infaunal and feed on particles of organic matter from

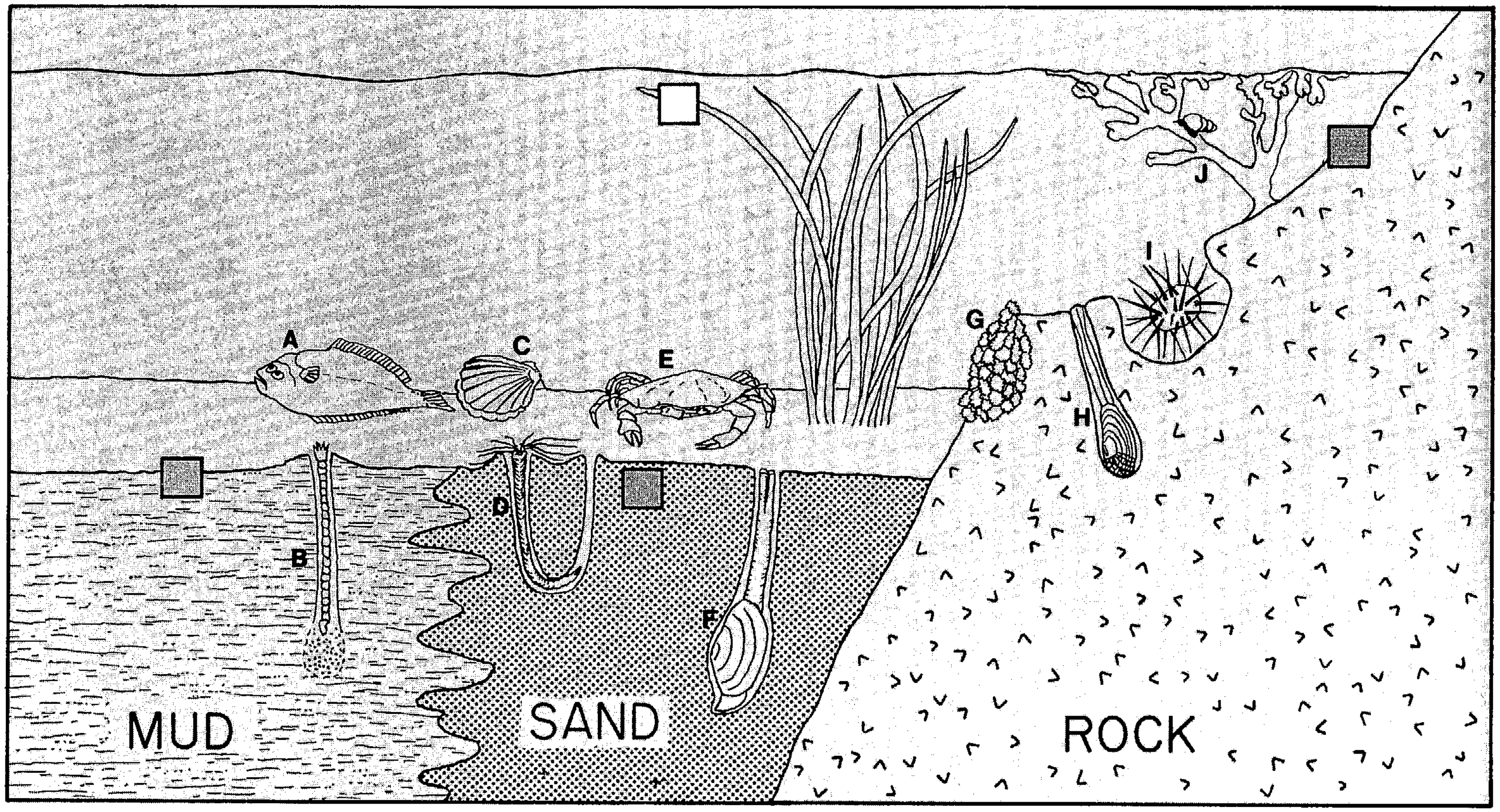


Infauna: Deposit-feeding clams; 1. ***Nucula***, 2. ***Tellina***, 3. ***Yoldia***



Interstitial (living between particles of sediment, in this case, sand) meiofauna: 1. Ciliate, 2. Tardigrade, 3. Ostracod, 4. Hydrazoan, 5. Flatworms, 6. Archiannelid, 7. Nematode

Figure 16. Estuarine Benthic Habitats (The color-coded boxes are spot magnifications of the corresponding sections of the main diagram.)



Granular Sediments (mud and sand)

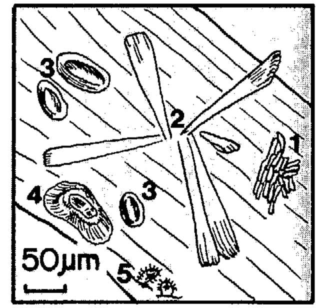
Epifauna: A. Flounder; C. Scallop; E. Crab

Infauna: B. Deep deposit-feeding polychaete worm; D. Surface deposit-feeding polychaete worm; F. Infaunal suspension-feeding clam

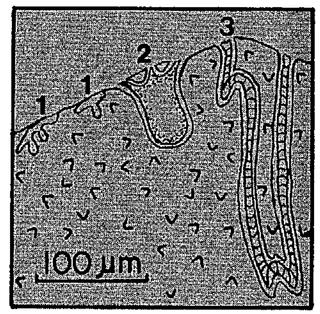
Shallow Rock Bottom

Epibenthos: G. Coral Colony; I. Sea Urchin (living in a groove it bored into the rock); J. ***Fucus*** with a grazing snail

Infauna: H. Boring Clam



Meiofauna and microorganisms living on the surface of plants, in this case, Eelgrass: 1. Rod-shaped bacterial colonies, 2. Stalked diatoms, 3. Pennate diatoms, 4-5. Bryozoans



Endolithic (boring) algae and fungi living in rock: 1-2. Fungi, 3. Algae

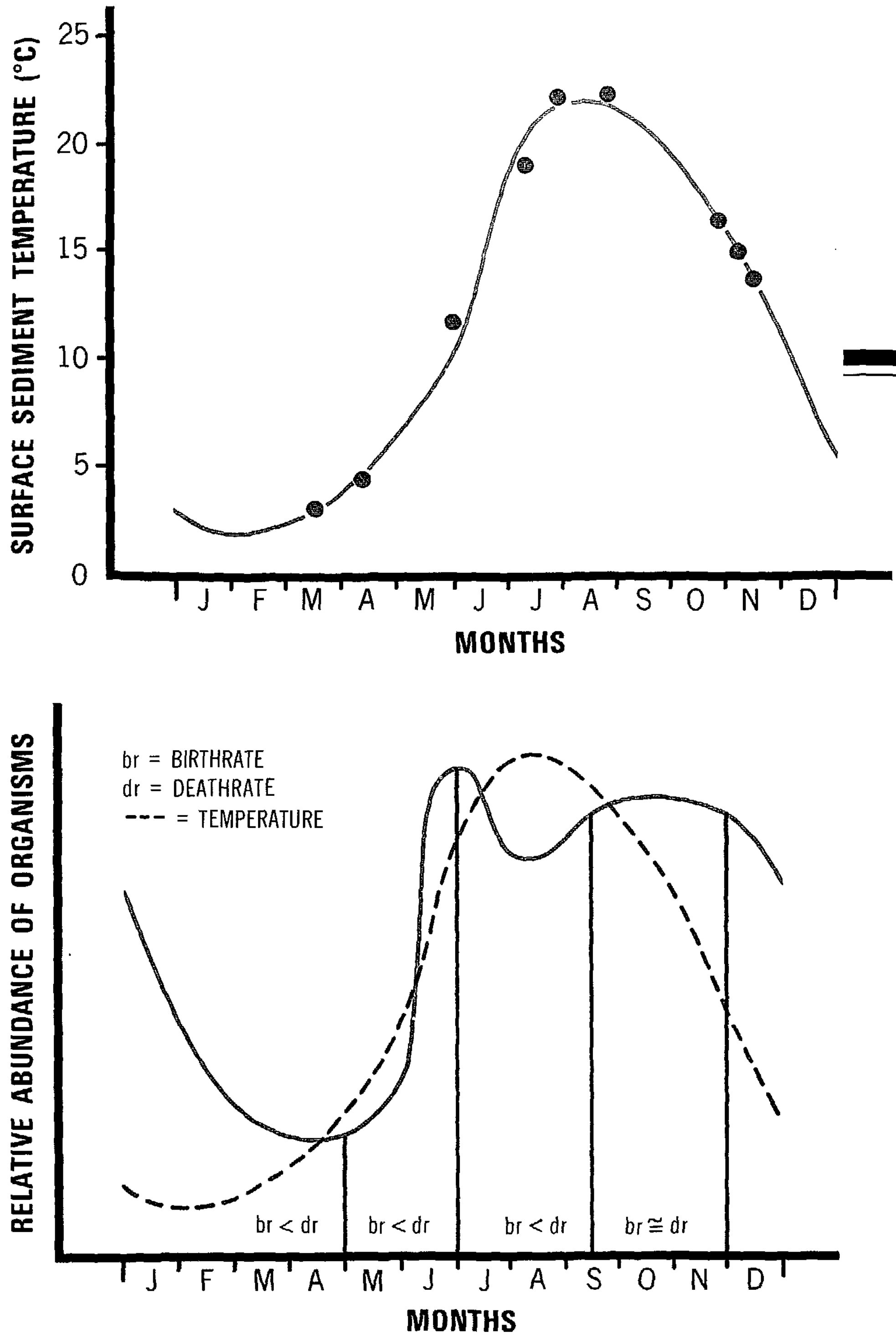


Figure 18. Growth of Benthic Invertebrate Populations Relative to the Seasonal Temperature Cycle

either the sediment surface or deeply within the sediment bottom. Some polychaete worms living in permanent burrows use mucus-covered tentacles to select individual particles from the sediment surface. Some mobile infaunal clams use two long siphons to gather food and reject waste. Many deposit-feeders take in large quantities of sediment from which they digest particles of organic matter. This group includes infaunal polychaete worms and sea cucumbers, which move horizontally through the sediment, ingesting it as they progress.

Distribution The distribution of benthos in Long Island Sound is the result of many factors: the dispersal or concentration of *larvae* (an early juvenile form) by currents; competition between different species and among members of the same species for food and space (known as predator-prey interaction); interactions between organisms and sediment; and small-scale variations in the habitat, including differences in particle size and organic content of the sediment. For example, low numbers of deposit-feeders in clean sandy sediments can be related to low concentrations of organic matter on which they can feed.

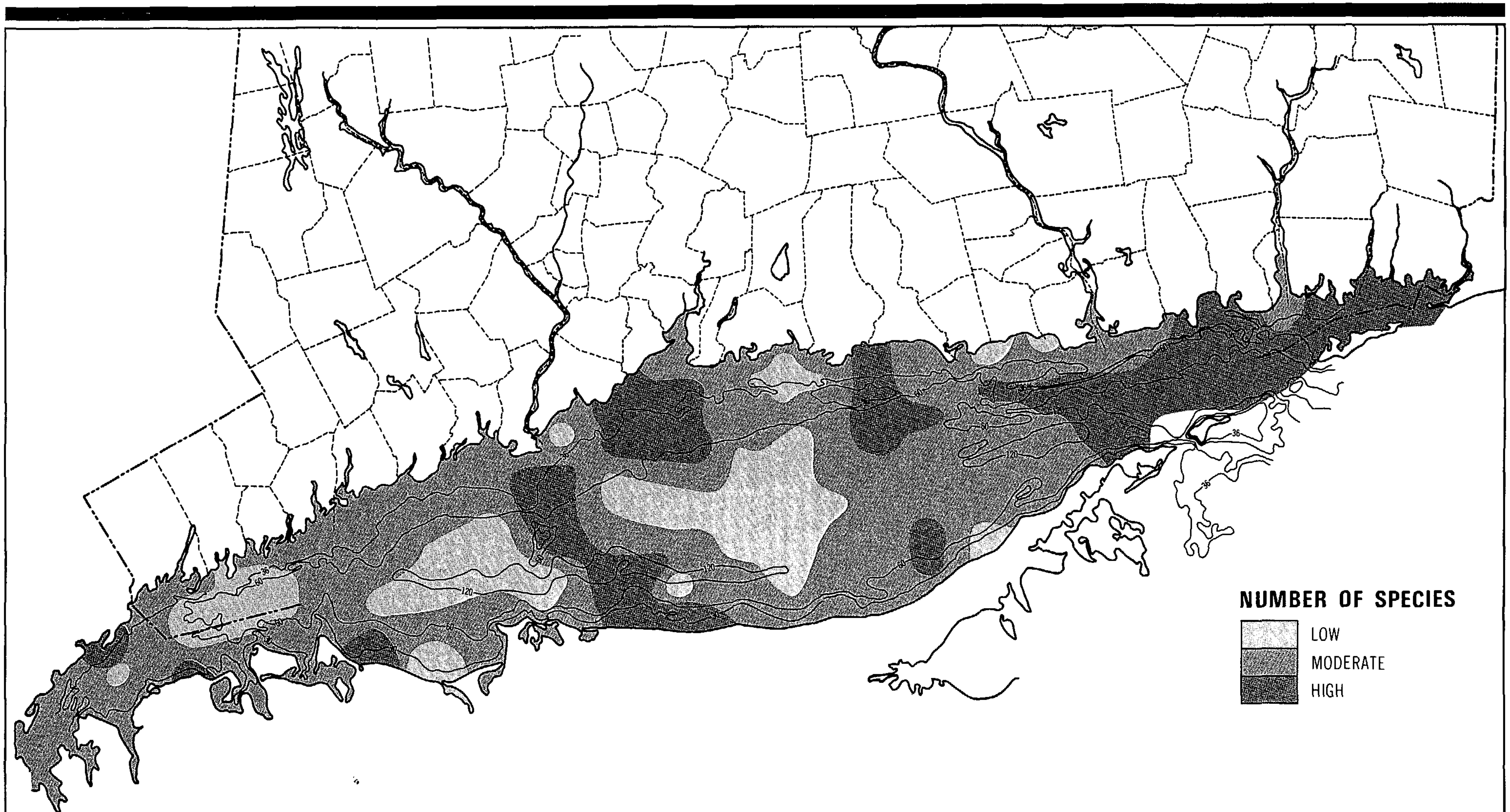
Interactions between organisms and sediment are of major importance in controlling the distribution of benthos. Deposit-feeding and suspension-feeding benthos have been shown to inhabit different areas of the seafloor. Suspension-feeders are characteristic of sandy sediments, while deposit-feeders predominate in muddy sediments. Suspension-feeders are excluded from muddy sediments by the presence of deposit-feeding polychaetes and bivalves, whose feeding activities produce a sediment surface consisting mainly of fecal pellets. This loose, unstable surface is easily resuspended into the overlying water by tidal currents of 0.25 knots or greater. High concentrations of these suspended particles can clog or foul the filtering structures of suspension-feeders. As particles settle, they may bury newly-settled larvae, or deny certain epifauna a firm surface for attachment. A comparison of the distribution of muddy and sandy sediments in Long Island Sound (Figure 9) with the distribution of benthic organisms (Figure 17) shows that areas of fine sand sediments support the greatest numbers of species, while unstable muddy bottoms tend to support the lowest numbers of species.

The benthos respond to the seasonal fluctuations in water temperature in Long Island Sound (see Figure 18). The temperature of the bottom water fluctuates seasonally from 2° Celsius in February and March to 22° Celsius in July and August. The numbers of all benthos increase in the spring and early summer, when the water temperature rises. This period of increased abundance (season of birth) is followed by a period of decline; the majority of benthic animals are unable to survive the lower water temperatures in the fall.

Suggested Reading

Thorson, G., *Life in the Sea.* New York: McGraw Hill, Inc., 1971.

Figure 17. Relative Number of Benthic Species



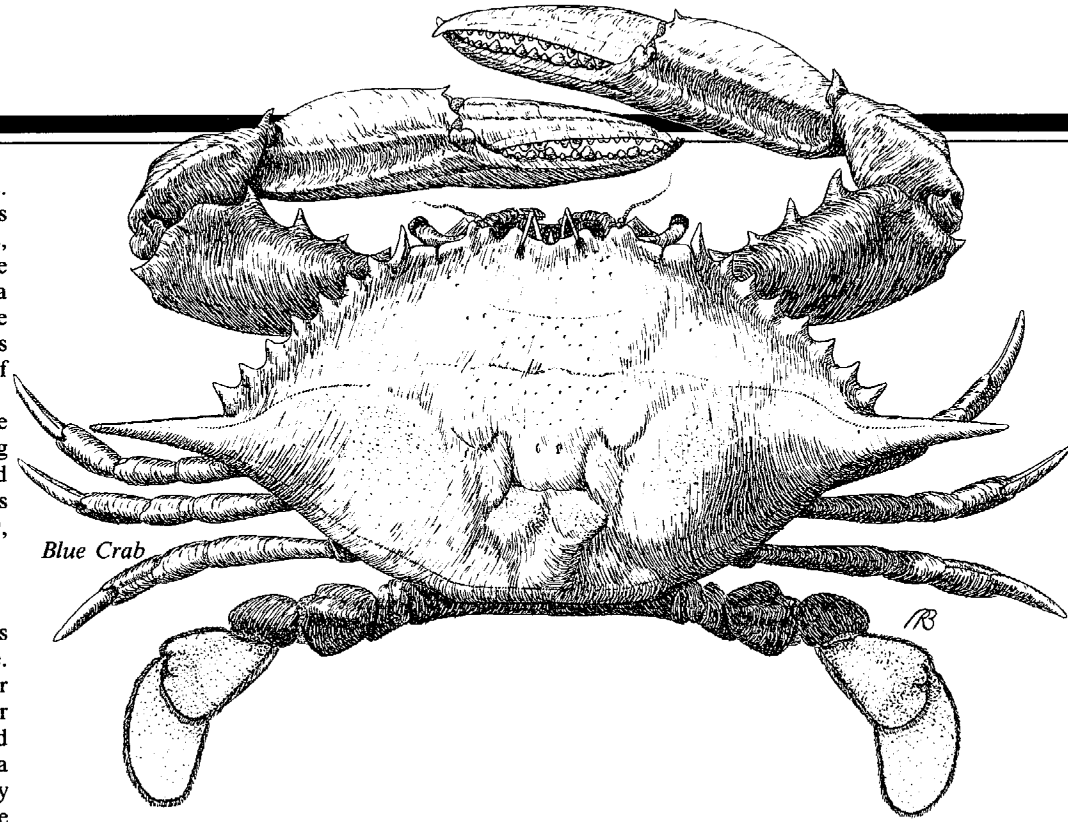
7. Crustacea

The crustacea are a group of primitive animals. Many crustacea are mobile, with adaptations for an active existence, such as specialized legs, eyes and other features. They exist in both the *benthic* environment (that is, on or in the sea floor) and the *water column.* Many of the economically important forms (such as lobsters) are *epibenthos,* living on the surface of the sea floor.

This section will deal with several of the more prominent groups of crustacea, including the true crabs, the hermit crabs, the shrimp and the lobsters. Other crustacea, such as copepods and barnacles, will be discussed in Chapter 9, "Plankton."

Crabs

There are a number of species of crabs commonly found along the Connecticut shore. Most of these are not commercially or recreationally important, and details of their distribution and life histories in Long Island Sound are not well known. However, there are a few species which are caught recreationally and, to a small extent, commercially (see Figure 19).



Blue Crab

Blue Crab This species, the best known of Connecticut's crabs, ranges from Nova Scotia to the northern shores of South America. Although not numerous enough in Long Island Sound to support a commercial fishery, they are of considerable recreational importance. The body is dark green while the legs are marked with bright blue and sometimes scarlet. The upper shell is armed with a strong and sharp spine on both sides.

The Blue Crab is both a scavenger and a predator. Its diet includes fish, crabs, shrimp, whelks, snails and mussels that are either dead or alive. It also feeds upon roots of marsh vegetation and upon young clams and oysters.

In Long Island Sound the river mouths, shallow bays, and salt marsh creeks are the preferred habitat of the Blue Crab. Although its preferred medium is salt water, it will survive in waters ranging from ocean salinity to almost fresh water in upstream reaches of tidal rivers. From May to October, significant numbers can be found in such places as the salt marshes of the Connecticut River, Mystic River, Branford Harbor and Barn Island.

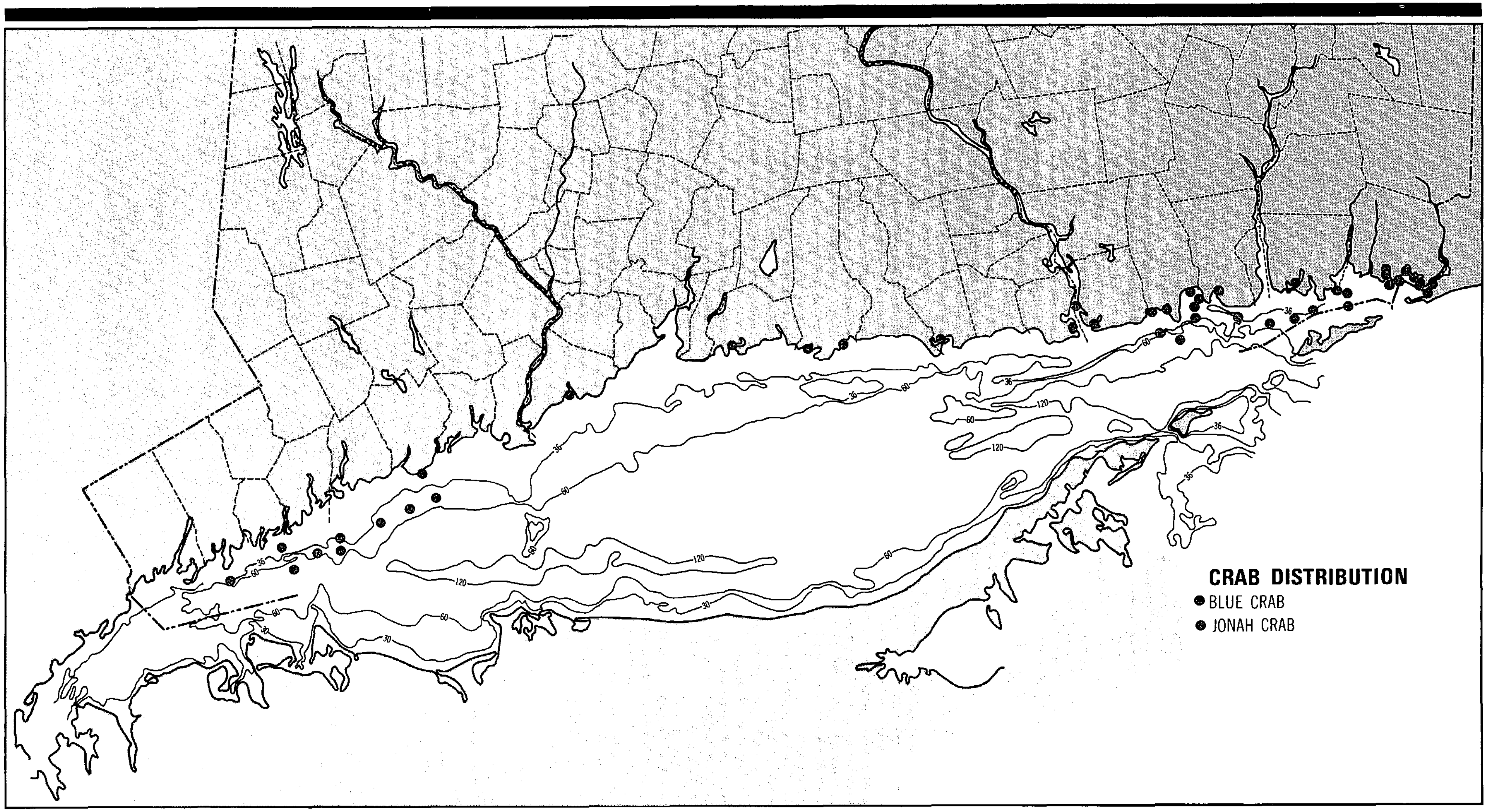
In Connecticut the Blue Crab mates in brackish water between June and October. Females are able to store sperm for at least a year so that sperm will be available as often as the female *spawns* (lays eggs). Spawning may occur as many as two to three times between May and September.

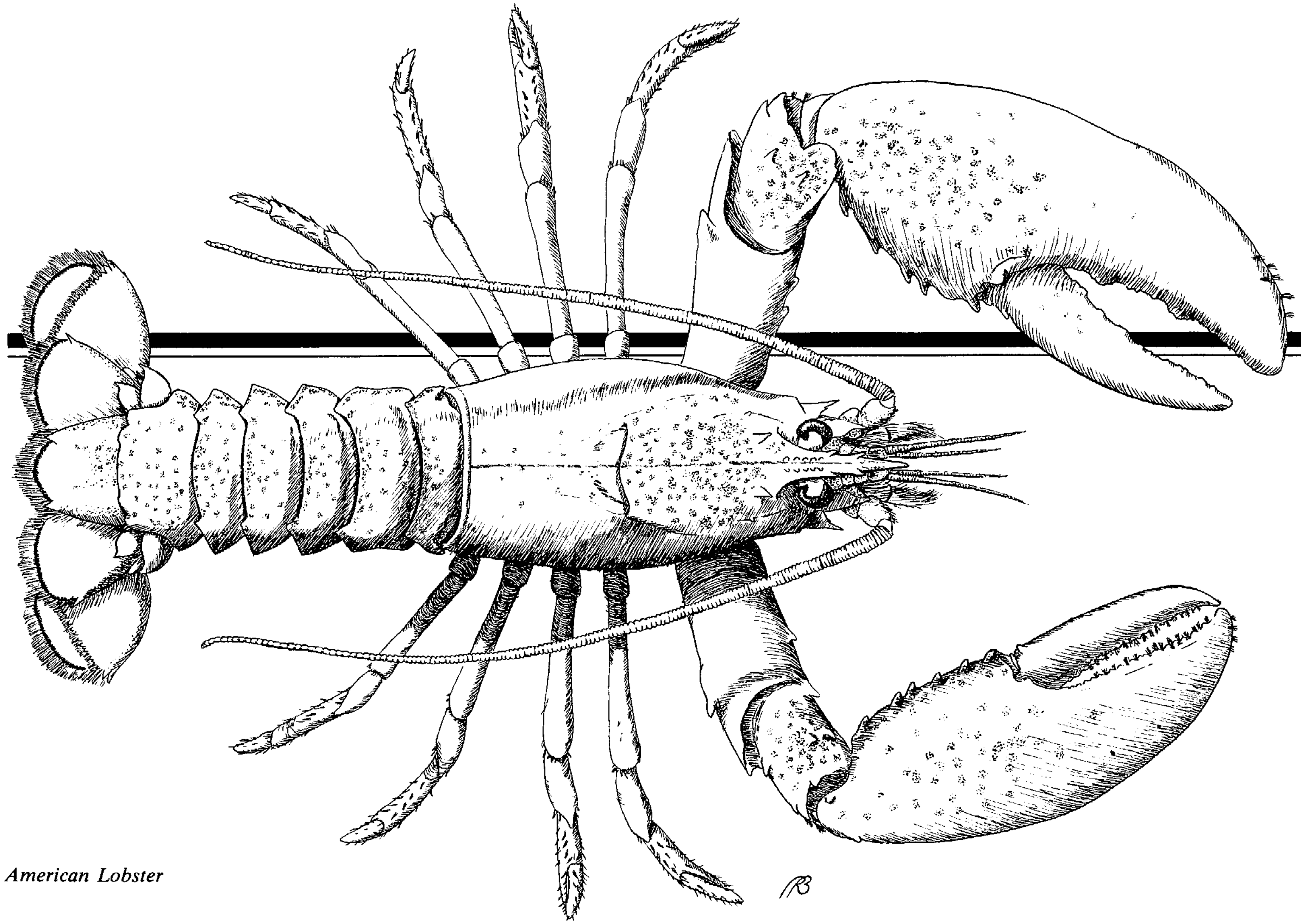
When the young first hatch from the eggs they are called *zoea.* They are free-floating and do not resemble the adults either in appearance or life style. Because they are suspended in the water column, at the mercy of currents and water quality, this is the most critical stage in the crab's life cycle. Zoea *metamorphose* (change) into *megalopa,* and within a short time the megalopa transform into juvenile crabs. Less than one percent of the eggs that hatch will survive to become juveniles. Consequently, from 700,000 to 2 million eggs are produced during each spawning to ensure the species' survival.

The Blue Crab is most important for recreational crabbing. The flaky white meat is delicious and is considered a delicacy by some people. Rich in calcium, magnesium, phosphorous, iron and copper, it is highly nutritious. From July to September it is much sought after in the bays, coves, tidal marshes and creeks of Long Island Sound. Anyone handling the Blue Crab should beware: its quick pincer movements have inflicted many a painful pinch.

Red Crab Two species of red crab, Jonah and Rock Crabs, are found in Long Island Sound. Both are edible; the larger Jonah Crab, which is caught occasionally by lobstermen, is sometimes sold commercially. Rarely encountered along the shore, the Jonah inhabits deepwater areas, where it constructs mud burrows on the sea floor. Many such burrows are found in the mud substrate of Long Island

Figure 19. Distribution of Recreationally Important Crabs





American Lobster

Sound west of Bridgeport. Reproduction occurs in early winter, and its entire life cycle is spent offshore.

The more commonly encountered red crab is the Rock Crab. During the cooler months large numbers settle along rocky shores. Many inhabit the areas around Millstone Point, Niantic Bay and Fishers Island Sound. The Rock Crab rarely occurs very far up estuaries. Reproduction takes place in spring. This species is currently of little economic or recreational importance.

Green Crab The most common crab found along Connecticut's shore is the Green Crab, which inhabits rocky shorelines, tidal mudflats, salt marshes and estuaries. Not native to the United States, it was accidentally brought to North America on the bottoms of ships from European waters. It was first reported in the Boston area around the turn of the century.

The Green Crab is occasionally sold commercially as bait for Blackfish. Its main significance for Connecticut, however, is that it preys upon Eastern Oysters and Soft-shelled Clams.

Spider Crab Two different species of spider crab inhabit Long Island Sound. Both have small bodies from which long slender legs radiate. *Libinia emarginata* has nine spines down the midline of the upper shell *(carapace)*, while the other species, *Libinia dubia*, has six spines down the midline. *Molted* shells of *libinia dubia*, which is the more common species in Connecticut, are frequently found along the shore.

Both species are slow-moving scavenger crabs that inhabit soft muddy bottoms. During the late fall many hundreds come together to form a mound of crabs. Each mound (or *pod*) may cover several square feet of the sea floor. The reasons for this behavior or the conditions that stimulate it are presently unknown.

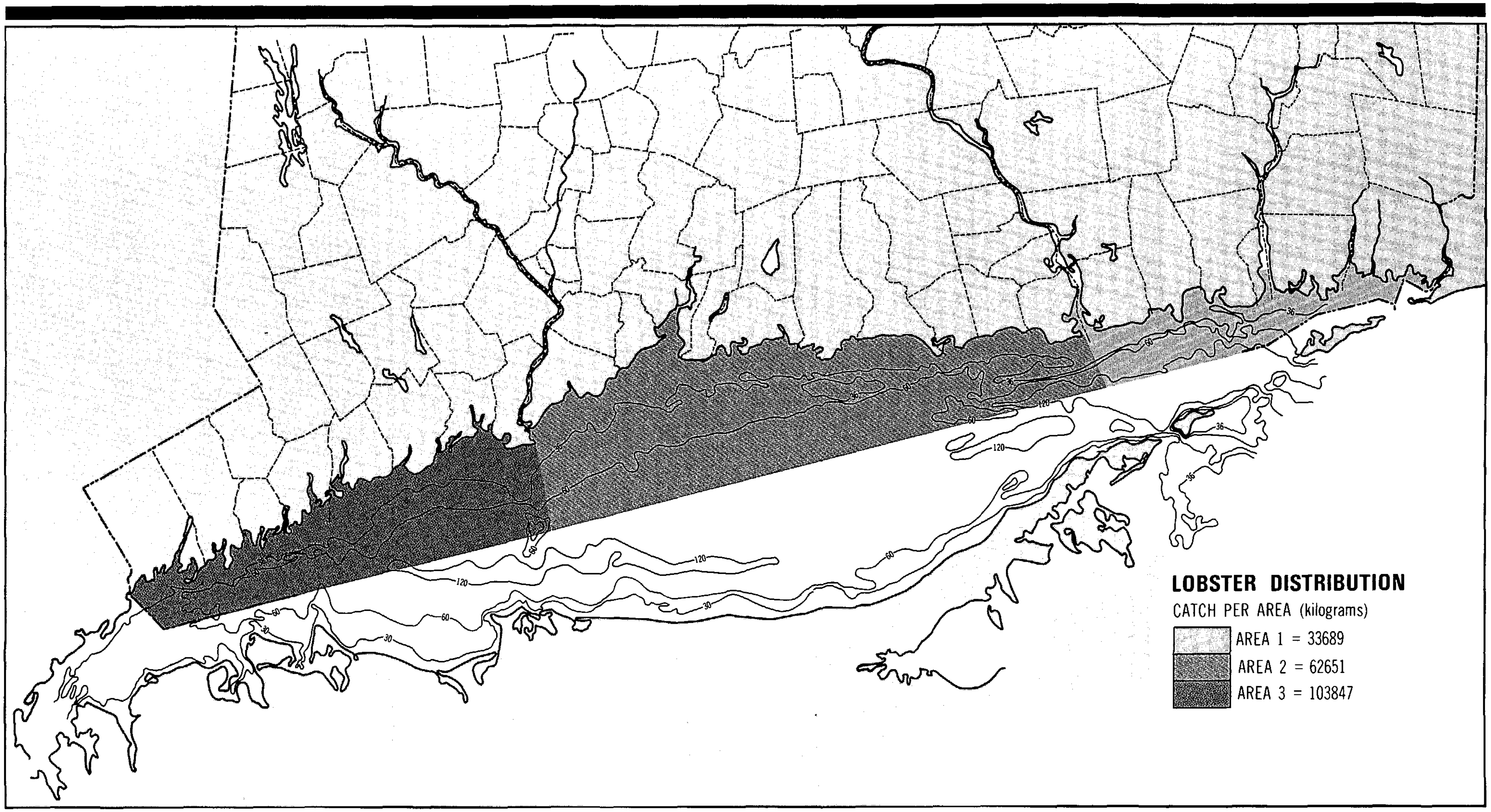
Mole Crab The surf line of sandy beaches is inhabited by the egg-shaped Mole Crab. Common to beaches west of the Connecticut River, it emerges from the sand when a wave breaks on the beach. As the wave recedes it rapidly burrows back into the sand. Migrating up and down the beach with the tide, the Mole Crab feeds upon the material tossed on the beach by the waves. It is occasionally used as fish bait.

Lady Crab This species is found at the *subtidal* level of sandy beaches. A pink-purple color, the Lady Crab is related to the Blue Crab and shares its aggressive nature. Although it appears to be uncommon along much of the Connecticut shore, it may be found in larger numbers off the beaches at Rocky Neck and Hammonasset State Park.

Hermit Crab Sandy bottoms of shallow, quiet lagoons and tidal pools are inhabited by a small hermit crab, *Pagurus longicarpus*. Its relative, the larger *Pagurus pollicaris*, lives in deeper offshore waters. They both feed on algae and other tiny organisms.

Both species of hermit crab use snail shells as a protective housing for their soft bodies. *Pagurus longicarpus* inhabits periwinkle and mud snail shells, while *Pagurus pollicaris* makes

Figure 20. Lobster Distribution



its home in either a whelk shell or a moon snail shell.

Fiddler Crab These small crabs live on the mud banks of salt marshes and estuaries at the high tide line. The common name is derived from the oversized front claw that the males are constantly waving or tucking across the front of their body. Despite its ferocious appearance, the large claw is used only for courtship or aggressive displays. The claws of the females are both the same size.

Fiddler Crabs are most heavily concentrated in areas around the Connecticut River and westward along the Connecticut shore. There are three species: *Uca pugnax, Uca pugilator,* and *Uca minax.* The habitats of the three species overlap, but *Uca pugnax* tends to inhabit mud banks, while *Uca pugilator* is more common on drier sandy banks and in Glasswort beds. *Uca minax,* the largest fiddler crab, is a southern species. Although rare, it does occur in Connecticut, especially in areas where water salinity is low.

Shrimp

The Sand Shrimp and two species of grass shrimp are very common along the shores of Connecticut, especially in late summer and fall. Although economically unimportant, these shrimp are a vital link in the food web of the sea. Many species of fish prey upon them for food.

Sand Shrimp are encountered off beaches and at the mouths of estuaries. They are an offshore species that use estuaries as nursery grounds. Both species of grass shrimp are found in salt marshes; one in the water with the lowest salinity and the other in the seaward marshes, bays, and coves.

American Lobster

The American Lobster closely resembles the Crayfish and, in fact, belongs to the same group of crustaceans. It ranges from Labrador to North Carolina and can be found within Long Island Sound. A seafood favorite, this species is of great commercial and recreational value.

The lobster possesses a hard external skeleton, called an *exoskeleton.* It has a well developed snout, long antennae, a somewhat cylindrical body and large front claws. Lobsters are naturally dark green on their backs and yellow-orange beneath, but occasionally one will have bright blue or red markings.

Lobsters live in a variety of habitats on the sea floor. They will often burrow under rocks or ledges and under colonies of the Sulfur Sponge. They also inhabit kelp beds and areas where there are extensive beds of Blue Mussels, or dig in fine sand and silt, which seem to be their preferred habitat.

Young lobsters hatch from eggs as shrimp-like free-swimming creatures that inhabit the *water column.* As they grow, their skeleton is periodically shed and replaced by a new one in a process called *molting.* After the eighth molt, they become bottom-dwelling juveniles. The lobsters continue to grow and molt; at each molt they increase roughly 15 percent in weight. The newly-molted lobster is soft and must remain hidden for about 6 to 8 weeks to escape predators while the new exoskeleton hardens. The young of the species molt much more frequently than the older ones. The adults (other than females carrying eggs) only molt about once per year.

Reproduction begins in late winter or early spring when mating takes place. The females mate when their exoskeletons are still soft. The sperm is stored, and the eggs are fertilized in the fall after the skeleton has hardened. The females incubate the eggs on the underside of their tails throughout the winter and they hatch the eggs the following spring. Females carrying eggs are often referred to as *berried* females.

Lobsters are omnivorous feeders, eating both plant and animal matter. They do a good deal of scavenging, but are also capable of preying upon animals such as crabs, mollusks, and fish. Cannibalism is not uncommon. They tend to be active and feed at night, but in western Long Island Sound and other areas where visibility is limited by *turbid* waters they also move about during daylight hours. Lobsters are both predators and prey; they are occasionally preyed upon by other creatures, including the voracious codfish.

The large front claws play an important role in the lobster's feeding. Of the two claws, one is a narrow, sharp pincher, which seizes the prey, and the other a heavy blunt claw which crushes it. Lobsters may be right- or left-handed. When a claw is lost through some accident, lobsters are able to grow a new one; the old claw may be replaced after as little as one molt. Other damaged or lost body parts, particularly legs, may also be replaced.

Lobsters are not uniformly distributed throughout Long Island Sound. As commercial catches indicate, a greater number may be found in the western Sound (see Figure 20). In addition, adults generally move inshore and offshore with seasonal changes in water temperature, moving offshore during fall and winter and inshore with the onset of summer.

Lobsters have been known to travel over long distances. Some tagged in Rhode Island waters have moved as far as Virginia, and from Connecticut they have traveled as far as Massachusetts. From the same areas they have moved farther offshore than the *Continental Slope.*

Lobsters are generally fished in shallow waters, 5 to 50 fathoms deep. They are trapped in lobster pots — rectangular frames, often made of wooden slats, with net funnels which permit entrance but no escape. Oily fish, either salted or partially decomposed, is the best bait.

The average total length of the adult lobster captured for market is 10 inches; specimens of this size weigh approximately 1½ to 2 pounds. It takes about 5 years for one to reach this size. The longest lobster ever recorded was 34 inches, and the heaviest 45 pounds.

Lobster meat is relatively rich in protein, having almost 62 percent the nutritional value of beef. An important industry along the New England coast, lobstering constitutes a multi-million dollar business in the United States, where more than 30 million pounds are caught annually and marketed fresh, frozen, and canned.

Suggested Reading

Arnold, Augusta F., *The Sea-Beach at Ebb Tide.* New York: Dover Publications, Inc., 1968.

Miner, Roy W., *Field Book of Seashore Life.* New York: G. P. Putnam's Sons, 1950.

8. Mollusks

The mollusks are a large and varied group of animals. The most common types have a soft body enclosed in a hard shell composed largely of calcium. Along the Connecticut shore most mollusks belong to one of two major groups: the *bivalves,* which live between two shells held together by a flexible hinge; and the *univalves,* which live in a single, usually spiral shell. Although there are over 50 species of mollusks in Long Island Sound, only those species which are important economically or are likely to be seen by the shoreline visitor will be discussed.

Habitats

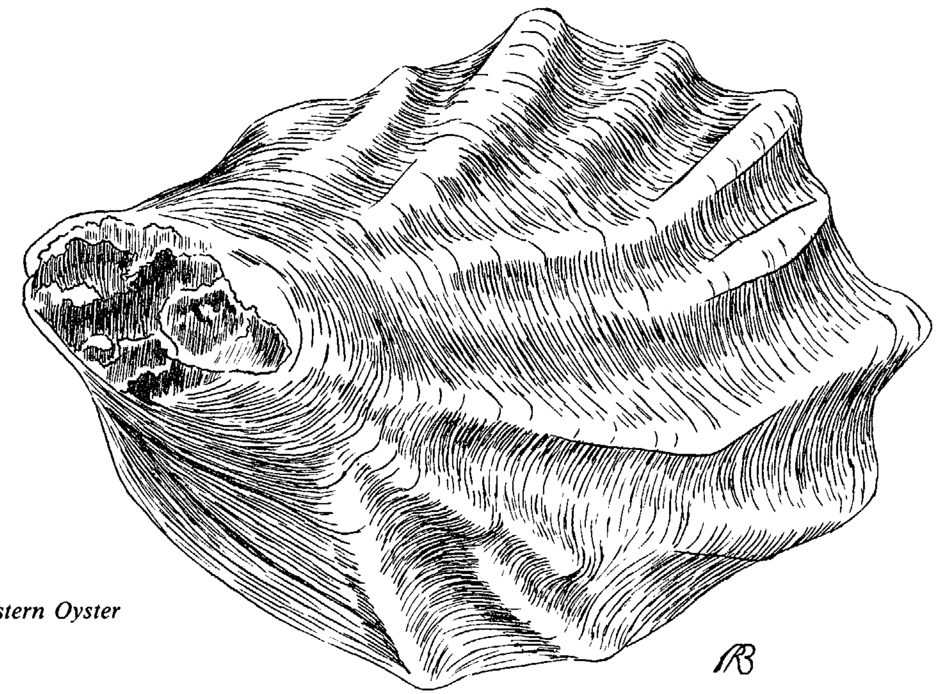
Mollusks are most visible along the rocky shores, especially in the areas exposed during low tide. Animals living in this intertidal zone must be specially adapted to withstand the pounding of waves, extreme temperatures and the drying action of sun and wind at low tide. The periwinkles are the most frequent species in this habitat. The three common species of these algae-eating snails avoid competition for food among themselves by living at different levels. The hardy Rough Periwinkle lives near the high tide line, where it has the longest exposure to the air during each tidal cycle; the European Periwinkle is the most abundant species in the middle intertidal zone; and the Northern Yellow Periwinkle lives under the brown algae in the lowest zones. The Blue Mussel, a popular edible species, attaches itself to the rocks with strong threads called *byssus.* It is found in the mid-tide and low tide zones and may almost cover the *substrate* in some areas.

Some mollusk species need a hard substrate for attachment but are unable to tolerate the rigors of the rocky shore and must seek quieter waters. One of the best known of these species is the edible Eastern Oyster, which is so dependent on a hard substrate for attachment that commercial oystermen spread empty oyster shells on the ocean floor to increase the numbers in commercial beds. Another such species, often found washed up on beaches, is a boat-shaped univalve called the Atlantic Slipper Shell. This species begins life as a male and transforms into a female as it gets larger. These large females frequently serve as a substrate for others of the species, and one can often find large clusters of various sized individuals.

Three bivalve species which are popular food items live in quiet areas with a sandy or muddy substrate. The Hard-shell Clam (also known as the Quahog, Little Neck, or Cherrystone Clam) moves its hard, rounded shell close to the substrate surface by means of a muscular foot. In contrast, the Steamer, or Soft-shell Clam, lives a nearly immobile life buried deep in the mud. It has only a tiny foot but has a long muscular siphon tube, which reaches the surface and draws in water and food particles. The Atlantic Bay Scallop resides in areas where Eelgrass grows. It can propel itself through the water by opening and closing its shell with a large muscle. This muscle is the part of the body that is commonly eaten by man.

The Mud Snail, or Eastern Mud Nassa, inhabits tidal mudflats. It leaves an intricate network of trails in the mud while it feeds. The species is very abundant and at low tide thousands of these dark brown snails can be seen on the damp flats.

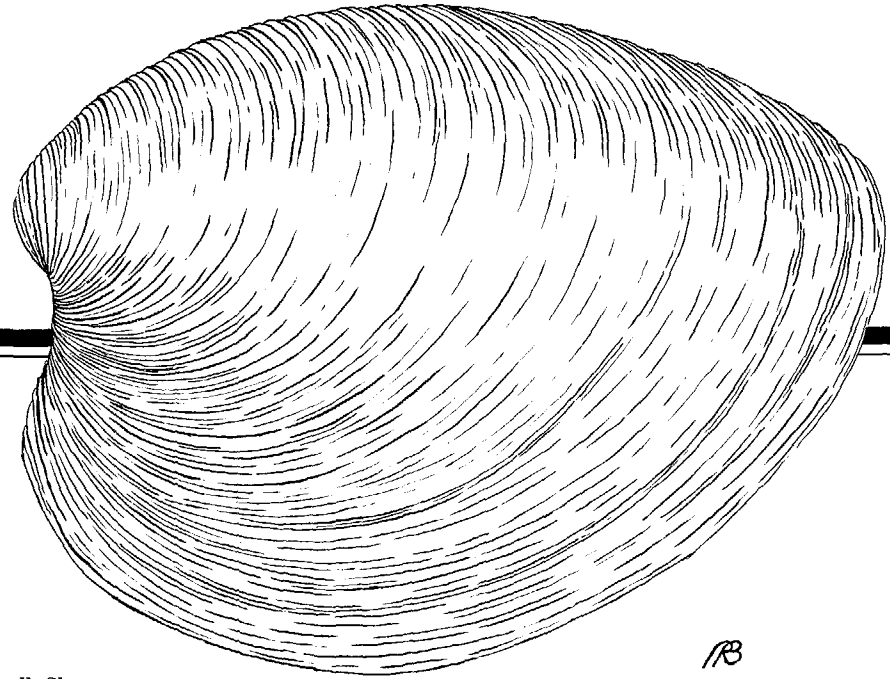
The salt marsh has its own characteristic mollusks. The Ribbed Mussel lies buried in the peat along mosquito ditches and tidal creeks, anchored there by root-like byssal threads similar to those of the closely related Blue Mussel. The tiny Salt Marsh Snail, or Coffee Bean Snail, can be found near the high tide line. It is the only local marine snail with a lung instead of gills for breathing.



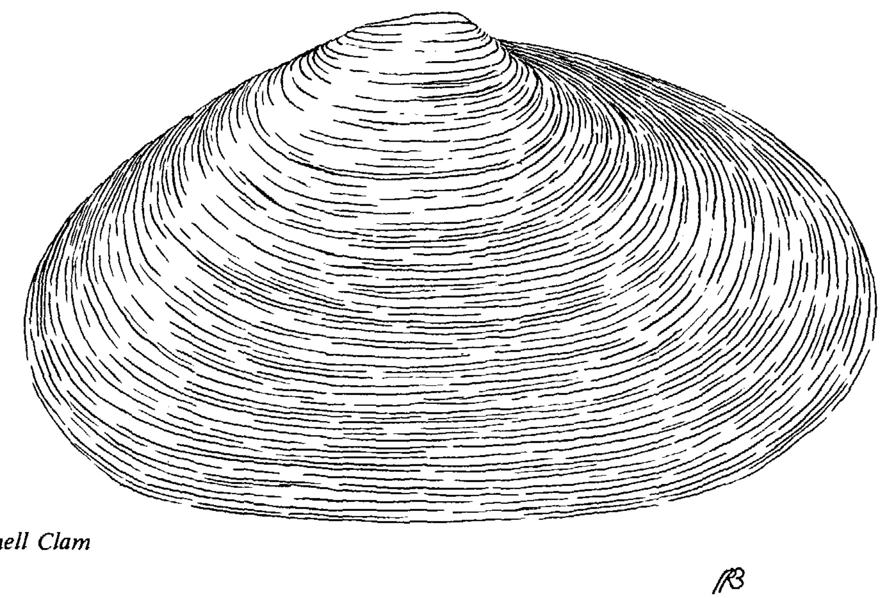
Eastern Oyster

Feeding

All of the above-mentioned species feed on either algae or dead and decaying matter found on the substrate or suspended in the water. However, the mollusk group does include some



Hard-shell Clam



Soft-shell Clam

meat-eating species; indeed, some of the major predators on the bivalves are certain species of univalves. The most notorious is the Atlantic Oyster Drill, which uses a file-like tongue, or *radula,* to drill a round hole in the shell of its prey. It then feeds on the soft inner parts and thus is a major enemy of commercial shell-fishermen. The Northern Moon Snail and the Atlantic Moon Snail also drill into their prey's shell, but the Channeled Whelk and Knobbed Whelk each use a strong foot to pull their prey's shells apart. While the Atlantic Oyster Drill prefers rocky or gravel substrate, the round moon snails and large whelks search for their prey in soft substrates.

Economic Importance

Mollusks have been of economic significance throughout Connecticut's history. For coastal Indians, they were an easily collected food source and their shells were used as tools and containers. Especially important were the Hard-shell Clam and the Blue Mussel, for the Indians used their shells to make wampum beads that served in ceremonial functions and as a medium of exchange.

Prior to World War II, Long Island Sound supported a major oyster industry, which produced about three million bushels annually. Soft-shell Clams, Hard-shell Clams, Atlantic Bay Scallops, Blue Mussels, and whelks were also harvested for local consumption in the early 1900's.

At present there are about 40,000 acres of State-owned shellfish grounds with another 20,000 acres under town control. Unfortunately, much of the coast, especially bays and harbor areas, has been closed to recreational shellfishing because of domestic pollution. Commercial oystering is still practiced, but in 1970 production was reduced to only about 16,000 bushels.

Hard-shell Clams and whelks are still harvested commercially as a food source. In Connecticut, 23,000 bushels of Hard-shell Clams and 10,000 bushels of whelks were taken in 1970. The Atlantic Bay Scallop and Soft-shell Clam harvest is presently very small.

Work is currently underway to improve the Connecticut oyster supply by spawning oysters in hatcheries and raising the juveniles under controlled conditions. In addition, adult oysters in the Sound are moved from polluted waters to cleaner sites off Long Island where they remain for a minimum of two weeks. In cleaner waters, the oyster can flush itself clean of pollutants to the degree that is required by present health standards. They may then be sold commercially (see Figure 21).

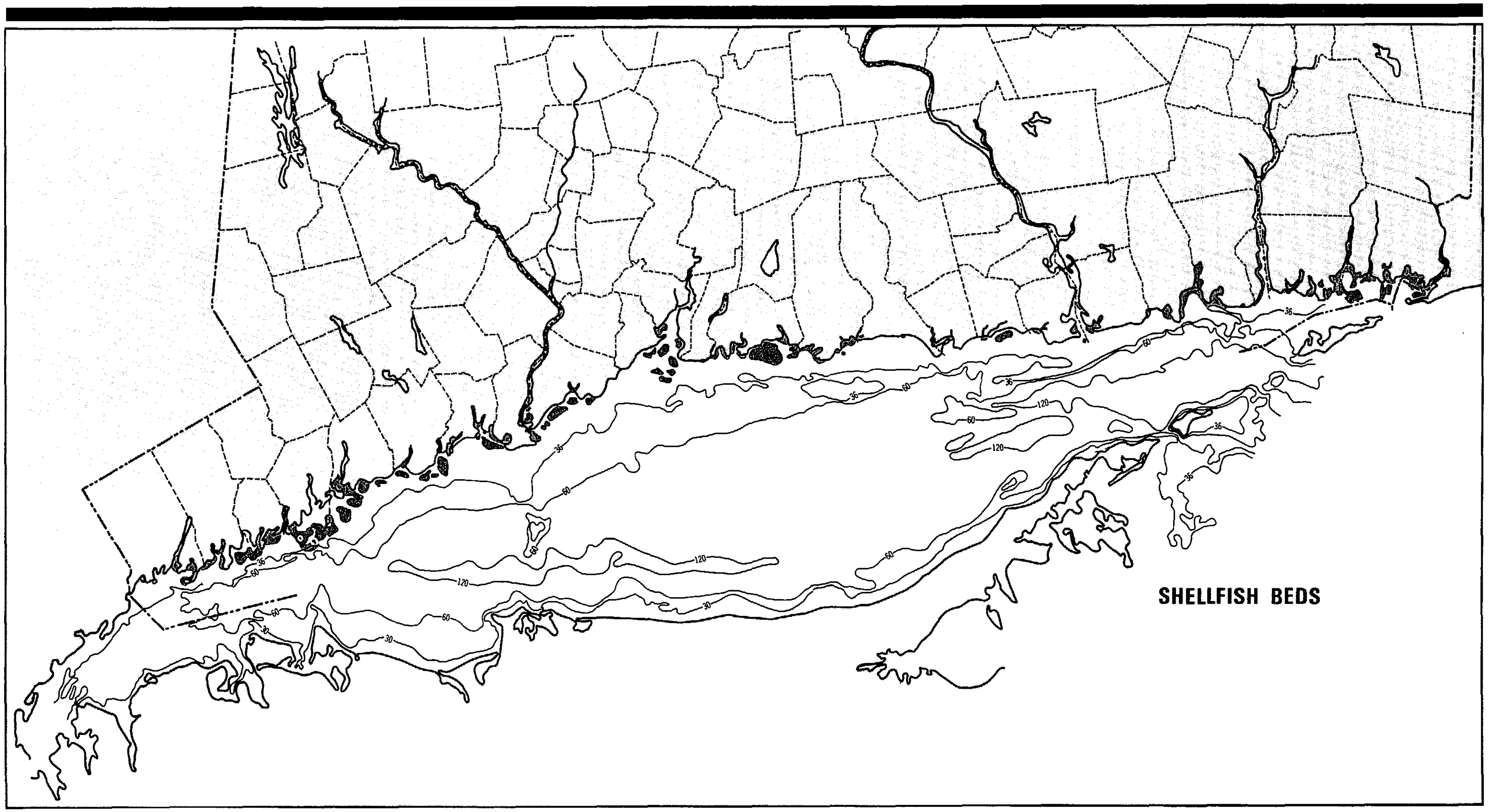
Suggested Reading

Carson, R., *The Edge of the Sea.* Boston: Houghton Mifflin Co., 1955.

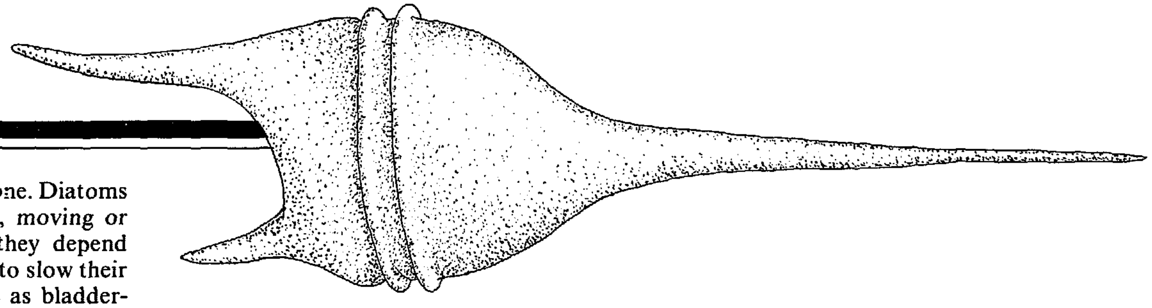
Jacobson, M.K. and Emerson, W.K., *Shells from Cape Cod to Cape May.* New York: Dover Publications, Inc., 1971.

Morris, Percy A., *A Field Guide to the Shells of our Atlantic and Gulf Coasts.* Boston: Houghton Mifflin Co., Inc., 1947.

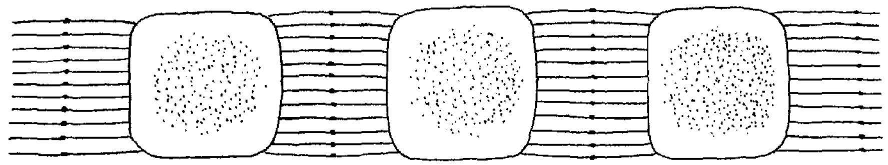
Figure 21. Commercial Shellfish Beds



9. Plankton



Ceratium lineatum



Skeletonema costatum

Plankton are tiny organisms that either swim or drift in oceanic and fresh waters. They include animals, or *zooplankton,* and plants, or *phytoplankton.* In contrast to fresh water plankton, a considerable portion of oceanic plankton is temporary; that is, some organisms spend only a part of their life cycle in planktonic form. For example, fish are planktonic only in the *larval* stage. Temporary plankton are collectively known as *meroplankton.*

Plankton are an extremely important part of the biological communities of the marine environment. Phytoplankton are the *producers* of the marine food web. By converting light, energy, water, nutrients, and carbon dioxide into living material, phytoplankton produce a vast abundance of food for various forms of animal life, including zooplankton and larger herbivorous species (see Chapter 4). Those phytoplankton that are not eaten eventually die and are either decomposed by bacteria as they sink or are eaten by *benthic* organisms when they reach the sea floor.

During their lifetime, zooplankton excrete large amounts of waste materials. These wastes and the remains of some dead zooplankton are broken down directly by decomposers, allowing the return of nutrients to the system. Zooplankton are preyed upon by larger organisms, and dead zooplankton are also fed upon by scavengers.

Phytoplankton

Two major groups of phytoplankton are the microscopic diatoms and dinoflagellates. A diatom is composed of two shells which fit together in a box-like arrangement. Reproduction occurs when the two shells separate and each produces a new one. Diatoms have no active means of floating, moving or adjusting their depth in water; they depend mainly on their physical structure to slow their rate of sinking. Such adaptations as bladder-like shapes, needle shapes and projections branching from the shells serve this purpose. Some species also produce a low-density sap to reduce their weight. Diatoms are an important food for many herbivores. Typical of the diatoms in Long Island Sound are *Skeletonema costatum, Thalassionema spp.* and *Paralia dulcata.*

Unlike diatoms, many dinoflagellates are able to swim by means of whiplike appendages called *flagella,* and thus are able to adjust their position in the water. Their shells contain external features such as spines, which are used for flotation and for protection against predators. They are capable of surviving low levels of light and nutrients. Dinoflagellates are less important in the food web than diatoms because many organisms are unable to digest their shells. In Long Island Sound, dinoflagellates are represented by species such as *Ceratium lineatum.*

Zooplankton

Zooplankton include many forms, such as copepods and the young, or larvae, of benthic organisms and larger swimming animals. Copepods are small shrimp-like creatures with long antennae and numerous legs. They are generally capable of locomotion through the water column. Copepods are extremely important as prey for many marine organisms. Examples of copepods occurring commonly in the Sound are *Acartia spp., Temora longicornus* and *Pseudocalanus minutus.*

A major group of zooplankton includes the larvae of many organisms such as barnacles, shrimp, crabs, polychaete worms, mollusks, starfish and fish. These larval forms, which are plankton only during the juvenile stage of their life cycle, are collectively called *meroplankton.* They too are important prey for larger animals.

Distribution

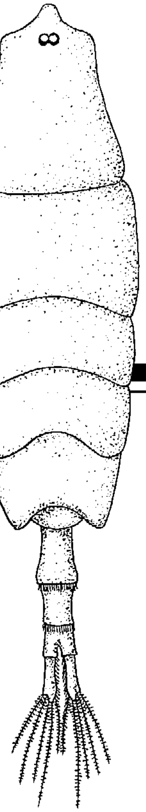
Plankton are found throughout the open waters of the Sound, in coves, salt ponds, and saline areas of the major rivers. The phytoplankton are more abundant in the western end of the Sound than at the eastern end. In the central Sound area they are found in greater numbers inshore than offshore. In all areas they can occur far down the water column, yet during their most prolific period, greater concentrations appear nearer the surface than the bottom.

Zooplankton distributions are similar to those of phytoplankton. The greatest numbers of zooplankton occur at the western end of the Sound and in the shallow waters along the Connecticut shore. They inhabit all levels of the water column, from just beneath the surface to the bottom. Some species move up and down in the water column depending on the time of day or the season.

Seasonal Cycles

The seasonal distribution of plankton depends upon the interaction of many factors, including biological interrelationships, light levels, water temperature and the supply of nutrients. In Long Island Sound, the cycles are generally characteristic of temperate waters; yet there are some major differences.

Experiments have shown that phytoplankton growth in the Sound is limited by the amount of the nutrient nitrate, rather than phosphate, present in the water. In fresh water systems in Connecticut, phosphate tends to be the limiting factor to phytoplankton growth. Another difference is that the great increase, or *bloom,* in phytoplankton abund-



Acartia

ance takes place during winter when the water temperature is at a minimum, rather than in the spring when the temperature levels start to increase.

During October and November, the population levels of plankton are low; as a result, the water is less turbid and greater amounts of light can penetrate. At the same time, nutrient rich water enters Long Island Sound along the bottom through the Race and becomes mixed throughout the water column by the action of strong winds. Thus, nitrates and phosphates are present in their annual maximums in the surface water during early winter. Because of the increased amount of light and nutrients, diatoms, which can withstand low temperatures, suddenly bloom into huge populations. This usually occurs in February. The zooplankton, which feed on the phytoplankton (particularly diatoms), start to increase in abundance during March and April.

During the spring, water temperature rises and there is a slight increase in the amount of phosphate (probably from fresh water runoff), while nitrate levels remain low. Because of the low nitrate levels, the phytoplankton population begins to decrease, yet the zooplankton continue to increase to a peak in summer. By September and October, zooplankton begin to decrease in number, although some remain and continue to feed on the phytoplankton. The feeding, combined with the effect of decreasing daylight, causes the phytoplankton population to reach an annual low level during November and December (see figures 22 and 23.)

Within the zooplankton population, copepods are numerous throughout the year with peaks of abundance in May-June. These peak numbers gradually decrease to a low level which remains stable from December to February. Larvae of benthos are almost non-existent from November to April, with the exception of barnacle larvae, which are often very abundant from January through March. In May there is a general increase in numbers and species of larvae of the benthos. Clam, snail, polychaete worm and crustacean larvae peak in numbers in early July. They disappear rapidly from the water column as they settle to the bottom.

The total population of fish eggs and larvae shows a similar cycle. Much less abundant than the invertebrates, they peak in number and variety in May, June and July, when most fish species of temperate waters spawn.

Suggested Reading

Wood, R. D. and Lutes, J., *Guide to the Phytoplankton of Narragansett Bay, Rhode Island.* Dept. of Botany, University of Rhode Island, 1967.

ANNUAL DISTRIBUTION, BY MONTH

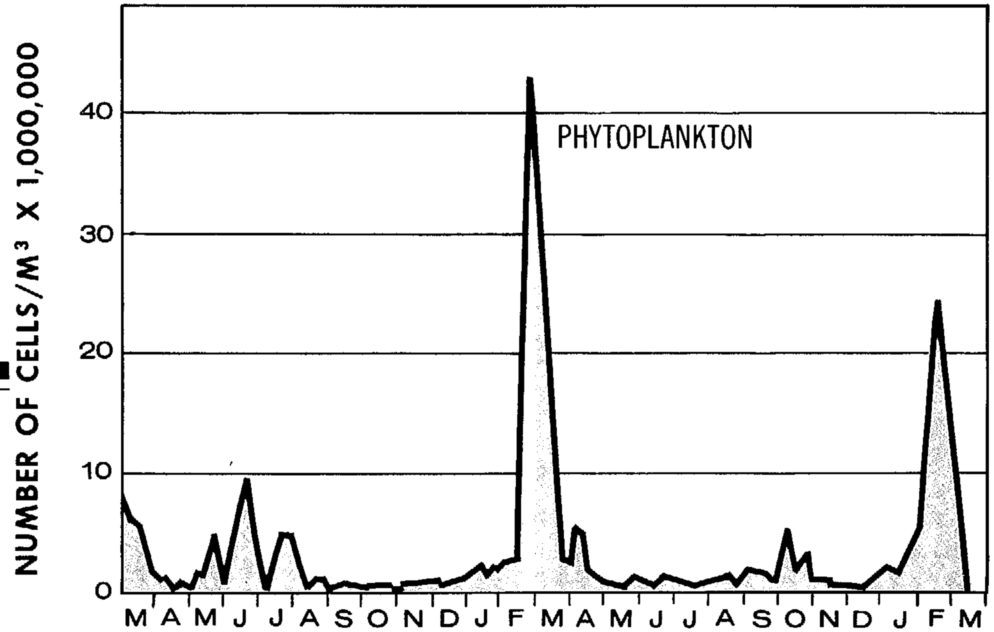
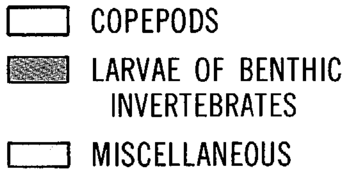


Figure 22. Phytoplankton Population Cycle



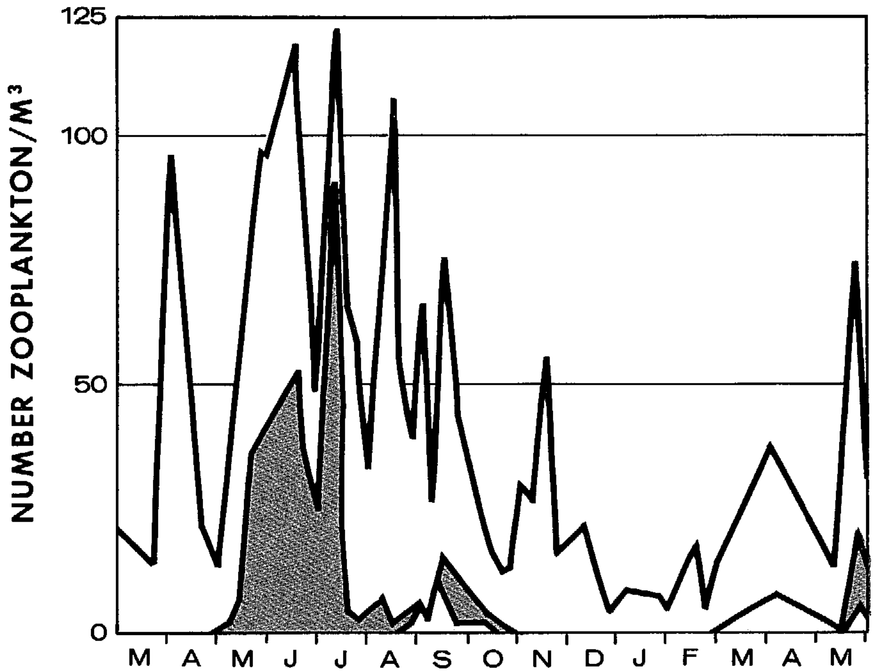
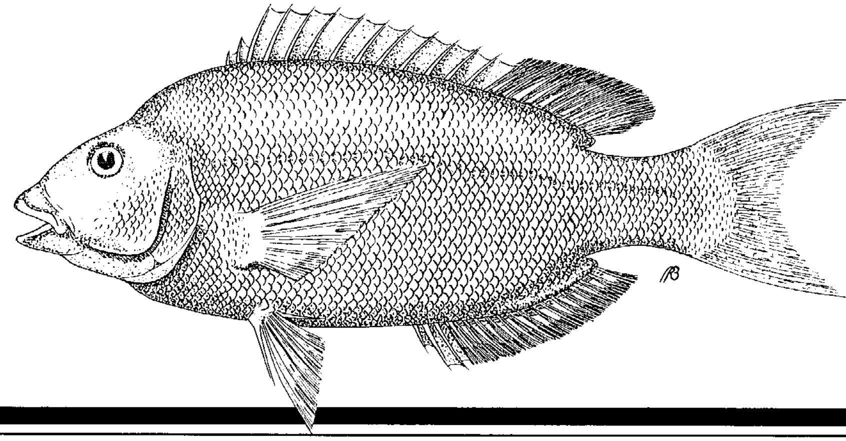


Figure 23. Zooplankton Population Cycle

10. Fishes



Scup

Marine Fishes

Scup The Scup, or "Porgy," is a slender fish about half as deep as it is long. Its scales are large and thick, its eyes high on the side of the head, its tail forked, and its *dorsal fin* single and long with sharp spines. Its irridescence and silver color make it strikingly pretty. On its sides and back are 12 to 15 distinct stripes, flecked with light blue. The general range of the Scup is along the east coast from North Carolina to Cape Cod.

Scup, which are apt to swim in schools, prefer smooth or rocky bottoms. They feed on crustaceans, worms, young squid, and other invertebrates. A small fish, most adults do not exceed 30 to 35 centimeters in length and .5-1 kilogram in weight. They appear near the shore along southern New England in early May and usually withdraw from the coast in late October. They apparently prefer water no colder than 7° Celsius; this factor seems to determine how far offshore they move during the winter. This species is so sensitive to low temperature that large numbers have been known to perish during sudden cold spells in shallow water.

In Long Island Sound, spawning takes place in June. The young are 5 to 8 centimeters long by September and are up to 10 centimeters long by November. Apparently, little growth occurs during the winter months, since 10 centimeter fish are abundant in the spring.

The species has had frequent population peaks since about 1879. The cause of these fluctuations is unknown, but some have suggested that they are due to overfishing.

Scup are important to the commercial trawl and net fishery along the east coast. They are equally important to sport fishermen. Their abundance and food value make them one of the more popular saltwater "panfish." They are easily caught, biting eagerly on sandworms and clams. In 1970, the *Salt Water Angler Survey,* conducted by the National Marine Fisheries Service, reported that anglers from New Jersey to Cape Cod caught over 1.8 million kilograms.

Winter Flounder The Winter or Blackback Flounder, which is a member of the flatfish family, ranges from Labrador to North Carolina. It is one of the most abundant species in New England and New York waters. From Maine to Long Island, there is no bay, harbor, inter-island passage, or stretch of open coast where it is not caught.

The Winter Flounder is small-mouthed and right-handed, meaning that when the fish is viewed from the upper side, the abdomen is on the right. This feature easily distinguishes it from the Windowpane, Four-spotted, and Summer (Fluke) Flounders, which are all left-handed. Flounders have a unique adaptation which enables them to blend with their surroundings. Over light sandy bottoms, the flounder becomes light in color and burrows slightly in the sand, thus becoming well camouflaged. Over darker areas, the flounder's skin color darkens to match its background. This characteristic aids the flounder in escaping predation.

In New England, spawning occurs from January to May. They spawn at night on sandy bottoms in water ranging from 2 to 72 meters in depth and from 0° to 4° Celsius in temperature. On the average, a female produces about 500,000 eggs annually. Incubation lasts from 15 to 18 days. The fish are born with an eye on each side of the head. *Metamorphosis,* during which one of the eyes migrates to the upper side of the head, commences at hatching and is complete within 10 to 12 weeks. At that time the young permanently settle to the bottom. Young fish remain in shallow waters for their first year of life.

As adults, Winter Flounders migrate into shoal waters in late autumn when water temperatures fall, and back into deep water in the spring when water temperatures rise. A sexually mature fish is 2 to 3 years old and about 15 to 25 centimeters long.

The Winter Flounder is highly dependent on estuarine areas for spawning, feeding and nursery areas. The dredging and filling of wetlands and estuaries, as well as pesticides and industrial and domestic pollution, have had adverse impacts on this species.

The Winter Flounder is important to the commercial trawl fishery. Also, flounder fishing is an important recreational activity along the entire New England coast. This thick and meaty flatfish is prized by anglers as one of the tastiest of all fish. The *Salt Water Angling Survey* estimated that in 1970 over 10.9 million kilograms of flounder were caught by sport fishermen in New England.

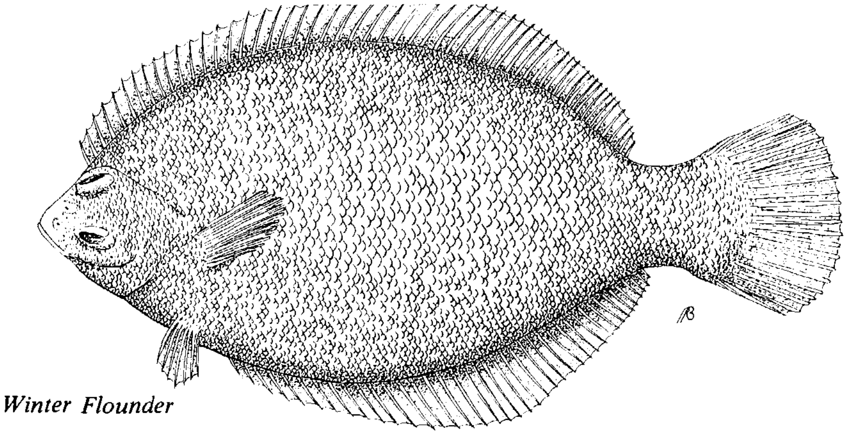
Blackfish The Blackfish, or Tautog, is gray, green, brown or black, with darker blotches of the same color on the sides. It ranges along the Atlantic coast from Nova Scotia to South Carolina, and is most abundant from the tip of Cape Cod to Long Island.

Blackfish feed on mussels, clams, barnacles and crabs. They will even feed on lobster, swallowing the smaller ones whole and cracking the larger ones with their crushing teeth. In the spring they move into shallow waters and in the winter they move out to slightly deeper water, where they spend the cold season with little movement or feeding. Their favorite haunts are along rocky shores, around breakwaters, submerged wrecks, piers and docks, over boulder-strewn bottoms and on mussel beds.

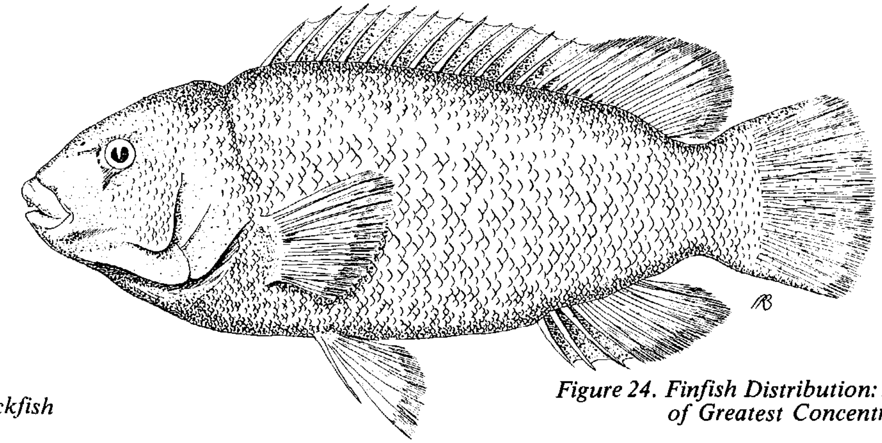
Spawning takes place in late spring and early summer. The eggs hatch in 2 to 3 days, depending upon the water temperature. The young fish move into the very shallow shore area and estuaries, where they spend the summer.

Although the Blackfish is not of commercial significance, it is one of the most popular game fish in Long Island Sound and is considered by anglers to be one of the best table fish. The experienced fisherman seeks this species in the spring and fall, when it is found near rocky, underwater reefs. The most popular baits are Fiddler Crabs, Green Crabs, Hermit Crabs, Sandworms and clams. They resist so strongly when hooked that a stout rod is needed to land them. Blackfish taken in Connecticut usually range in weight from 1 to 4 kilograms.

Bluefish The Bluefish, sometimes called Snapper or Chopper, is found throughout much of the world and abounds in Long Island Sound. It is sea-green and silver in color. Little is known of the age and size of either males or

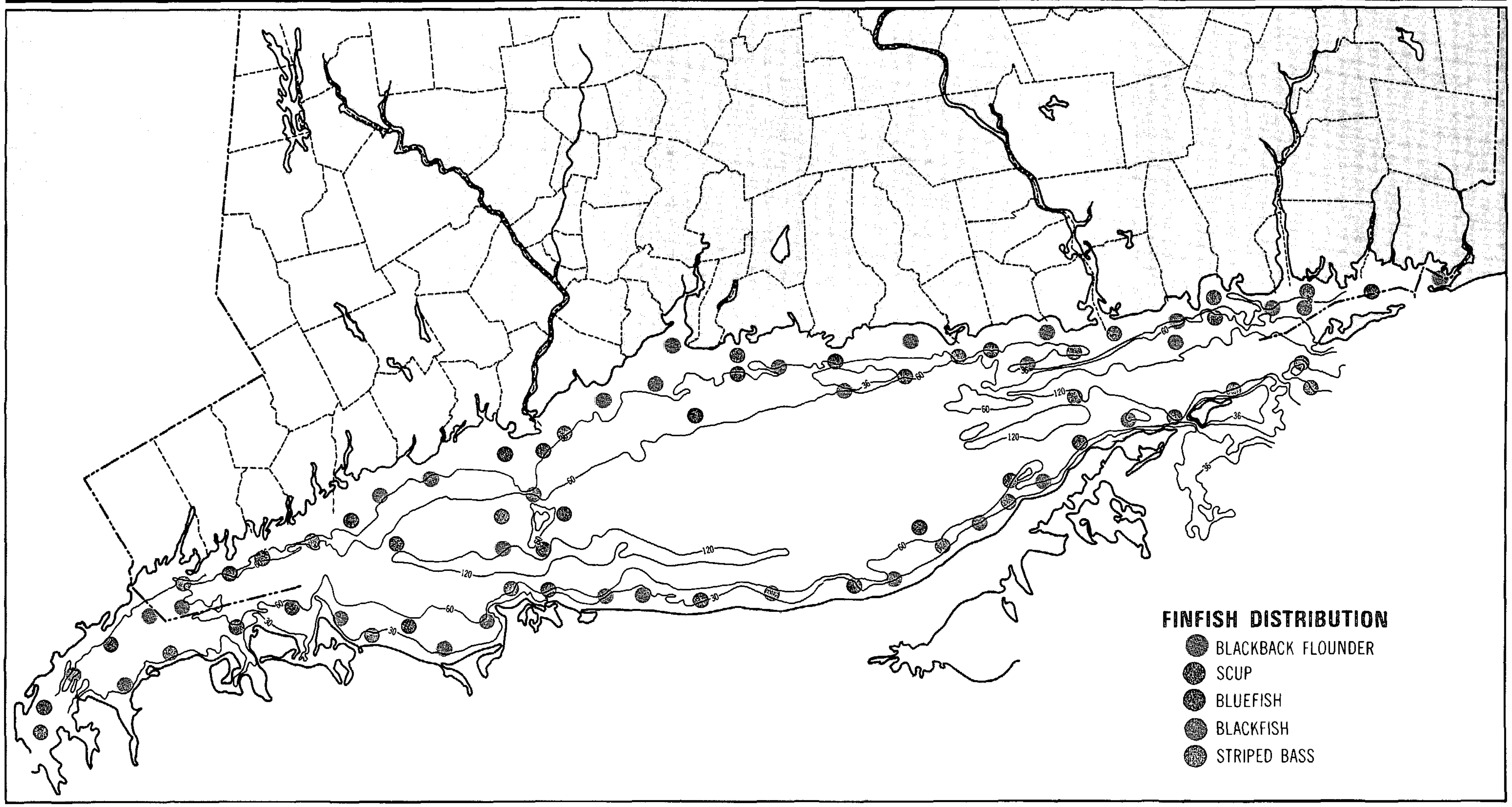


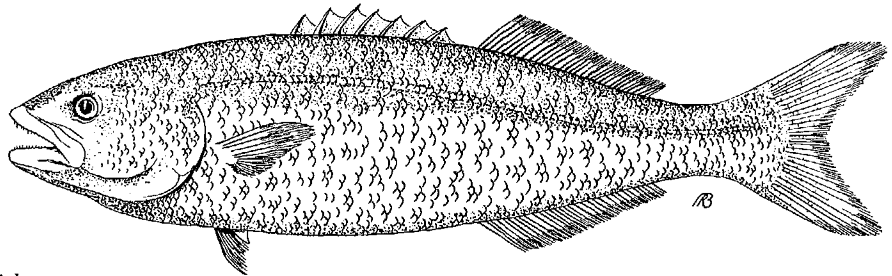
Winter Flounder



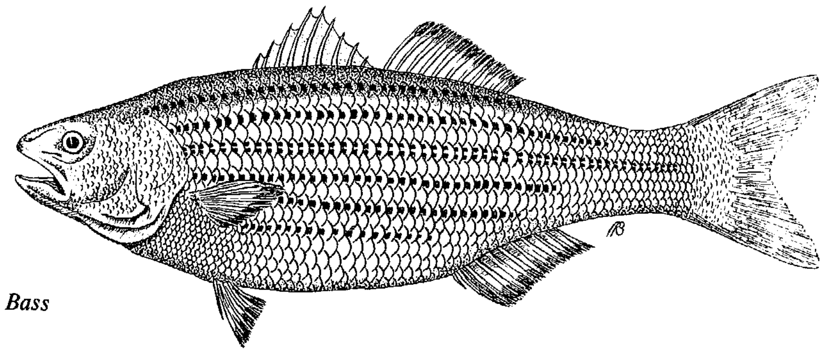
Blackfish

Figure 24. Finfish Distribution: Areas of Greatest Concentration





Bluefish



Striped Bass

females at maturity. Traveling in large schools, young as well as adult Bluefish are voracious and carnivorous feeders.

Bluefish are found both inshore and offshore. Young Bluefish (or Snappers) move southward along the coast during late fall, and it is not known whether they return to the Sound the following year or in any future year. Adult fish have an inshore-offshore migration pattern. They usually begin to arrive in Long Island Sound in May when water temperatures reach 12° to 15° Celsius. The fish follow the warmer water by entering the inner bays of Long Island or going to the western end of the Sound. Large numbers of Bluefish arrive in the general area during July and August after spawning in offshore waters. The offshore migration takes place in the fall when water temperatures in the Sound drop back to approximately 13° to 15° Celsius.

This species has withstood repeated fluctuations in number in the northern part of its range. Bluefish were plentiful off southern New England in colonial times. As early as 1764, however, they disappeared from southern New England waters, not to reappear until about 1810. In 1945 they again reached a very low level in this area; the total New England catch was 11,800 kilograms, while 1.1 million kilograms were harvested along the Atlantic and Gulf coasts.

Many consider the Bluefish to be an excellent table fish, but it has never supported a commercial fishery of any magnitude in New England. However, from New York to Florida this species does support an active commercial *gill net* fishery with an annual harvest of about 5 million kilograms valued at over 3 million dollars.

The Bluefish is perhaps the most important game fish in Long Island Sound. Young as well as adult Bluefish are avidly sought from boats, piers, jetties and bridges by anglers of all ages. It is one of the most active and hard-fighting fish in the Sound. Those caught range in weight from barely over 57 grams to 7 kilograms. The *Salt Water Angling Survey* reported that in 1970 over 22.7 million kilograms of Bluefish were caught by anglers in the area from New York to Maine.

Anadromous Fishes

Striped Bass The Striped Bass, also referred to as Striper, Linesider, Rock or Rockfish, is a member of the sea bass family. On the east coast the species ranges from the St. Lawrence River in Canada to the St. Johns River in Florida. It is easily identified by dark longitudinal stripes running parallel to the rows of scales.

The Striped Bass is *anadromous,* which means it lives in salt water but returns to fresh water to spawn. From March to July it ascends rivers to spawn. The number of eggs produced by each female varies: a 1.5 kilogram female can produce about 14,000; a 23 kilogram female can produce about 5 million. In water with a temperature of 18° Celsius, the eggs hatch in 2 days. At the end of the first year, the young range in size from 7 to 15 centimeters.

Females reach maturity in 4 or 5 years while males are mature at age 3. Growth is rapid during the first 10 years of life and then gradually tapers off. A 1.5 kilogram female is about 4 years old, and a 23 kilogram female is about 15.

After they are 2 years old, Striped Bass travel in large schools. They are carnivorous, feeding on other fish and on considerable quantities of invertebrates, especially crustaceans.

In the spring, segments of the Striped Bass population from Chesapeake and Delaware Bays migrate northward along the coast to southern New England and the Gulf of Maine. Some of the Bass from the Hudson River also migrate into Long Island Sound as far east as the Connecticut River. These migrants remain in the New England area throughout the summer until the fall, when they return to their home area.

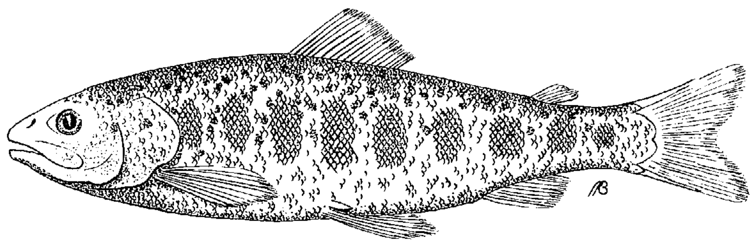
Although Connecticut law prohibits commercial fishing of Striped Bass, it is one of the more important game species in Long Island Sound. It is also an important species elsewhere along the Atlantic coast, with an annual commercial catch of over 4.5 million kilograms. The 1970 *Salt Water Angling Survey* estimated that from Maine to the Carolinas 780 thousand sport fishermen caught over 14 million Striped Bass that year. This amount exceeded the entire commercial catch. The bulk of the sport fishermen's catch consists of fish in the 1 to 5 kilogram range, but fish from 18 to 23 kilograms are also caught. The largest Striped Bass recorded, which was taken by commercial gear, weighed 57 kilograms; the sport record is 33.2 kilograms.

The Striped Bass played an important part in the fishery resources of early America. Together with the Codfish, it was among the first natural resources in colonial America to be subject to mandatory conservation methods: the General Court of Massachusetts Bay Colony in 1639 ordered that neither fish be used as fertilizer for farm crops. The first public (free) school of the New World was made possible through money derived, in part, from the sale of Striped Bass. A portion of the money was also used to help the widows and orphans of men formerly engaged in service to the Colony.

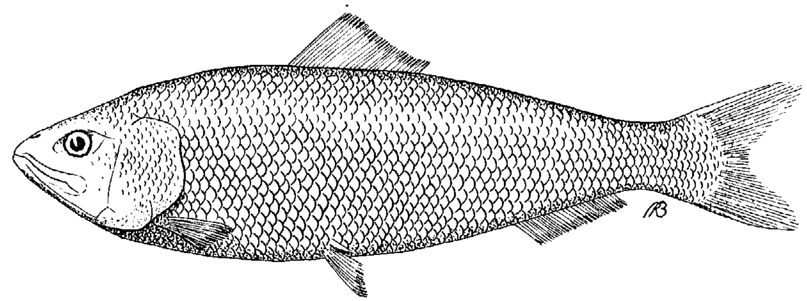
The early settlers in New England left records attesting to the abundance of Striped Bass. However, the construction of dams blocking access to spawning areas, the domestic and industrial pollution of rivers, and, to some extent, overfishing, both sport and commercial, all played a part in the decline of this species in its northern range.

Atlantic Salmon The Atlantic Salmon is the best known and most widely prized of the salmonid family, which also includes trouts and chars. The salmon is an anadromous fish, one that ascends fresh water streams to spawn. The salmon spends the first one to three years of its life in fresh water and then migrates to the sea to live for one or more years before returning to the home stream to spawn. The trip upstream is known as a "run." Following the spawning, the spent fish leave the nest and those that survive (approximately ten percent) return to the sea, then back to the stream at a later date to spawn again.

The body color of the Atlantic Salmon



Atlantic Salmon



Shad

varies: stream-dwelling young fish, very similar to Brown Trout, are brownish-olive with red spots on the sides and two (occasionally three) dark spots on the gill cover. The sides are marked with darker blotches called parr marks and the tail is forked. When ready to migrate to the sea, young salmon, called *smolts*, become dark blue-green above and silvery below, with an overall silvery sheen. Scales become temporary and are easily lost. After reaching the sea, adults are blue-black above with bright silver on the sides. As spawning time approaches, the silvery flanks turn black in females and a dirty red in males, and the males develop a hooked inner jaw.

In the past, the Atlantic Salmon have ranged over the entire North Atlantic, as far south as Portugal on the European shore and to the Connecticut River along the American coast. Natural runs of Atlantic Salmon up the Connecticut River have not occurred since about 1800. A dam built at Turners Falls, Massachusetts, in 1794 was the beginning of the end for this once abundant fish. Although the size of former runs in the Connecticut River are not well documented, it is certain that relatively large numbers returned each year.

Since the 1860's a number of attempts have been made to restore salmon to the Connecticut River. Early attempts met with failure due to inadequate fish passage facilities at the various dams and destructive commercial fishing methods which were practiced in the lower river and along the shores of Long Island Sound. In 1967, a cooperative restoration program was begun by the Connecticut River Basin states and federal fisheries agencies. The intent of this program is to recolonize a portion of the river with Atlantic Salmon and to return American Shad to their historical spawning area. The program includes construction of fish passage facilities at dams on the river's main stem and selected tributaries, as well as hatchery production and stocking of up to 1,000,000 smolts each year. Due to stocking efforts, the return of 5 adult salmon to the river has been documented. One male, taken alive in the Holyoke fishway in 1976, was used to fertilize some 32,000 eggs from female salmon from the Penobscot River in Maine. It is hoped that these eggs and others from returning salmon will produce salmon with a genetic makeup more suited to the Connecticut River.

The restoration of this great fish to the Connecticut River will be a long and difficult task but one well worth the effort.

Shad The American Shad is a typical member of the herring family, with soft-rayed dorsal and anal fins, a deeply forked tail and large scales. It is dark bluish or greenish above, and white and silvery on the lower sides and belly, with a dusky spot close behind the gill cover.

The American Shad is the largest of the herrings found in Connecticut waters and is reputed to reach 6.36 kilograms. The record size documented from the Connecticut River is slightly over 5 kilograms.

Shad range from the St. Johns River in Florida to the Gulf of St. Lawrence in Canada. It is an anadromous species, returning to the stream where it was born to spawn after four or five years at sea. Dams and other human activities have exterminated them from many of the streams in which they were once found. In Connecticut the only remaining run is in the Connecticut River. In the past, American Shad ascended the river as far as Bellows Falls, Vermont, but dam construction, begun in 1794 in Holyoke, Massachusetts, prevented the fish from swimming further upstream to spawn. In 1955 a fishway was constructed at Holyoke, and in 1976 over 345,000 Shad reached the next upstream barrier at Turners Falls, Massachusetts. It is hoped that proposed fish passage construction will return Shad to their former spawning grounds by 1981.

Shad first enter the Connecticut River early in April and make their way to their place of birth, where they spawn from mid-May to early July. Spawning takes place over various types of bottoms in the main stem of the river and in larger tributaries. Eggs hatch in four to seven days, depending on water temperature.

Feeding on plankton and various forms of insect life, young American Shad grow rapidly and are about 100 millimeters long by early fall, when they begin their downstream migration. Generally, all have left the rivers by early November. It is believed that young Shad spend their first two years close to shore in the North Atlantic and then begin a long migration which takes them north and east to the Grand Banks, then south through the mid-Atlantic. They finally come close to shore off the Carolinas in January of their fourth or fifth year. As the water temperature is rising in the spring, they make their way north until they reach the Connecticut River, which they instinctively recognize as their birthplace.

The American Shad is important to Connecticut's economy, as it supports a valuable commercial fishery in the lower Connecticut River and a high quality sport fishery. The 1976 commercial catch was nearly 180,000 kilograms, with an estimated worth of about $600,000. Most sport fishing in the Connecticut River is done below the Enfield Dam. Sport fishing techniques include trolling and casting with flies, spinners and small jigs.

Boned Shad and Shad roe are considered delicacies by many people. The boning process is difficult to master but is done commercially by a few individuals, and boned filets are available throughout the Shad season. The traditional Connecticut River Shad Bake includes charcoal-broiled filets, deep-fried roe with strips of bacon, and fresh strawberry shortcake for dessert.

With diligent management the Connecticut River Shad will continue to provide a welcome addition to the State's economy, a unique recreational opportunity, and a delightful addition to our table.

Suggested Reading

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11. Birds

Birdlife along the Connecticut shore is characterized by its great variety and abundance. Some 387 species have been known to occur throughout the State, and many of these have appeared at the coast at one time or another. This diversity is largely the result of the number of distinctive and highly productive habitats available for birds.

Habitats

Habitats fall into six broad categories: (1) open water areas, such as bays, coves, rivers, and Long Island Sound itself; (2) tidal marshes; (3) mudflats; (4) sandy beaches; (5) offshore islands; and (6) mainland uplands, including woodlands, old fields and agricultural land. Open water, marshes and mudflats produce vast quantities of essential food for birds, including insects, worms, amphipods, crabs, clams, snails, finfish, Widgeon Grass, Wild Rice and Eelgrass. Beaches and islands provide very specialized and limited nesting habitats for a number of Connecticut's rarer species. Uplands, with their variety of plant communities and land types, provide important habitats for terrestrial birds.

Seasonal Occurrence

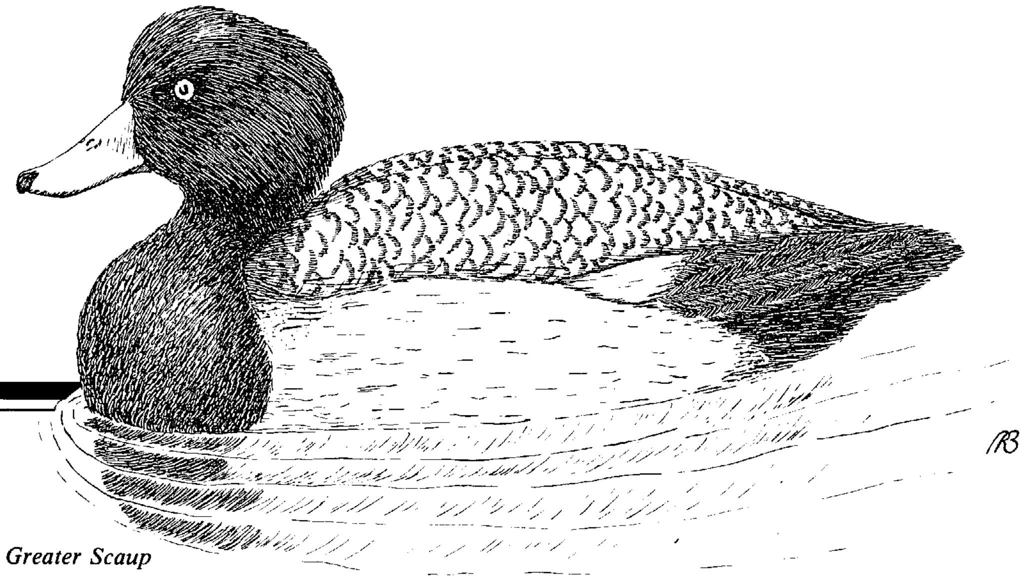
Some of the birds that occur in the coastal area are summer residents, some are spring and fall transients, and others are winter residents.

Summer residents are, for the most part, those species that actually breed on the coast. They include many species which do not breed elsewhere in the State. Some characteristic marsh breeders are the Seaside Sparrow, Sharp-tailed Sparrow, Clapper Rail, Mallard and Black Duck. Feeding in the marshes and mudflats and nesting on low trees and shrubs on offshore islands are the spectacular herons and egrets, such as the Black-crowned Night Heron and Snowy Egret. Beach nesters include the Least Tern and Piping Plover. Some upland species are the Hooded Warbler, White-eyed Vireo and Carolina Wren.

Transients generally are sighted along the coastline in greatest abundance from August to November and from March through May. These seasons are usually the best ones for bird watching. Because the Connecticut coast possesses such a variety of habitats and also because it lies along a major eastern migration route, the *Atlantic Flyway,* vast numbers of birds visit it annually.

Several groups of birds are particularly notable as coastal migrants (transients). These include the shorebirds, birds of prey, and waterfowl. Shorebirds, including plovers, turnstones, sandpipers and yellowlegs, nest in the arctic tundra and winter as far south as South America. During migration they stop in Connecticut to feed in the tidal marshes and mudflats. Birds of prey congregate along the coast mainly in autumn, and evidence suggests that shoreline features aid them in their migration south. At this season large congregations of species can be observed. On the morning of September 28, 1975, observers witnessed a flight of 1,000 Sharp-shinned Hawks past Lighthouse Point Park in New Haven.

Certainly one of the most important groups of migrants that move along the coastal area are the waterfowl, many of which winter along the coast. Large flocks of ducks, geese and swans form a prominent group of wintering coastal birds. Most of Connecticut's migrant and wintering waterfowl arrive here from the far north or west, although some species that breed here also winter here. Autumn migrants begin to arrive in large numbers in late September and continue to increase through November. Major spring movements northward take place from March through April.



Greater Scaup

In winter the concentrations of ducks in Long Island Sound and the protected coves of the Connecticut shore are considerable. In West Haven, around 8,000 Scaup (sometimes called Broadbill or Bluebill) are regularly counted by State wildlife biologists. Greater Scaup, Black Ducks, Mallards and Canada Geese are the most abundant wintering species, but others, including Red-breasted Mergansers, Common Goldeneyes, Buffleheads, Scoters, American Widgeons (Baldpate), Canvasbacks, Oldsquaws and Mute Swans, have significant populations. Species occurring less frequently include Gadwalls, Pintails, Green-winged Teal, Shovelers (also sometimes called Broadbill), Ruddy Ducks, Redheads, Ring-necked Ducks, Snow Geese and Brant. Figure 27 illustrates principal waterfowl wintering areas.

Recreational Importance

Waterfowl are, as a group, among the most important game species in the State. Every year in late autumn and winter, each licensed hunter is permitted to take a designated number of birds of different species. These quotas, set on both a daily and a seasonal basis, are termed *bag limits.* Bag limit regulations and other laws concerning waterfowl hunting are set by the State and federal governments. Money derived from the license fees is put back directly into waterfowl management. It is used for acquisition of important wildlife areas, habitat improvement and research on waterfowl biology.

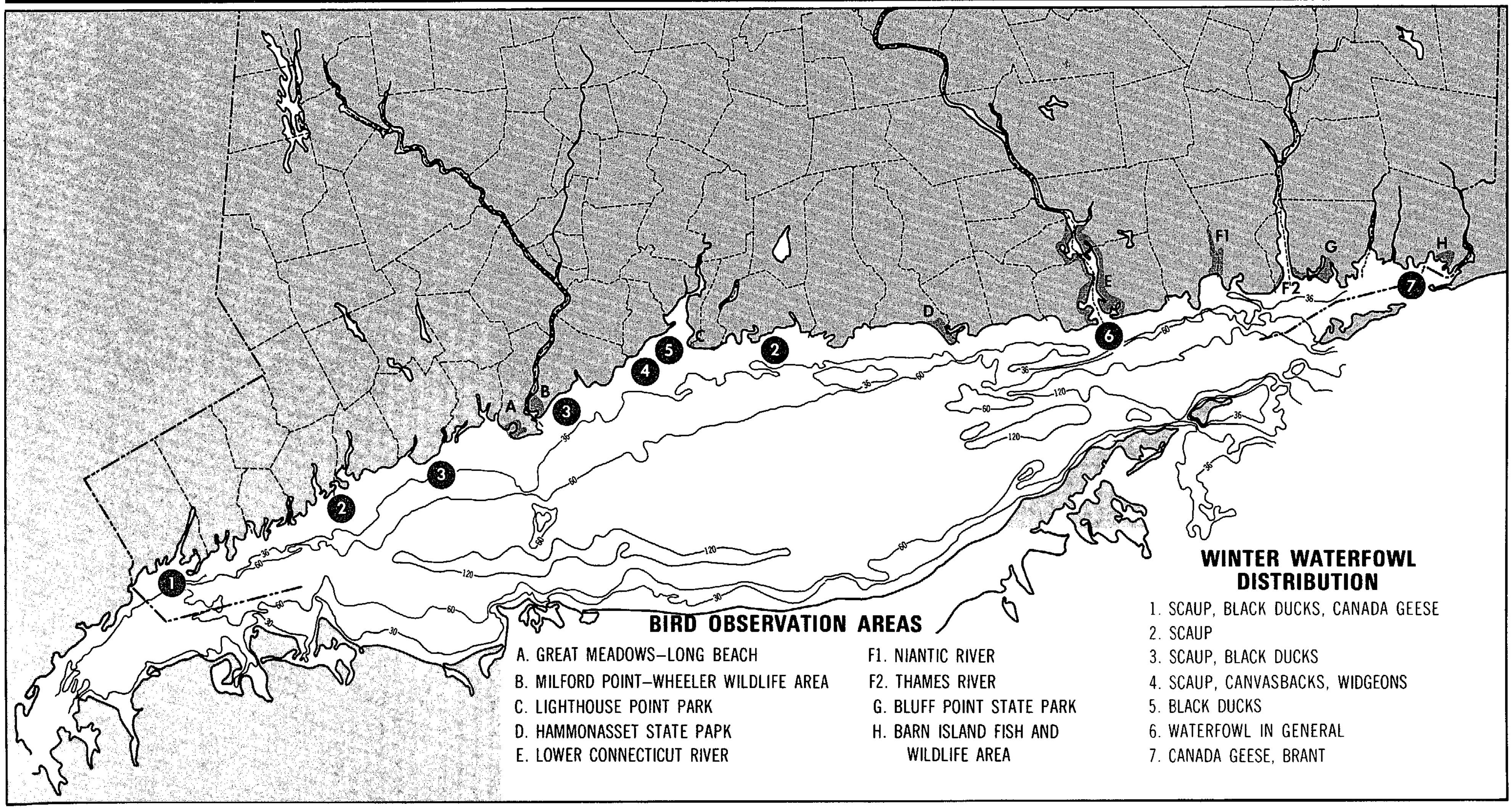
There are a number of shoreline areas that are especially suitable for observing waterfowl and other coastal birds. Some of the better locations are shown in Figure 27. They are also discussed briefly below:

A. Great Meadows - Long Beach, Stratford: Mudflats, marsh and sandspit; privately and town-owned. One of the finest areas in Connecticut for birdwatching. A number of species nest here. The Least Tern, Piping Plover, and Common Gallinule nest at few other spots in the State. Heavy concentrations of migrant shorebirds and waterfowl also use the area during the spring and autumn.

B. Milford Point - Wheeler Wildlife Area, Milford: Marsh, mudflat and sandspit; largely State-owned. Similar in many respects to Great Meadows. Hunting is permitted on State land. Excellent place to look for breeding marsh and beach birds, migrant shorebirds.

C. Lighthouse Point Park - New Haven Harbor, New Haven: Upland, marsh, mudflat and open water; the park itself is town-owned and offers a good view of the

Figure 25. Major Waterfowl Wintering Areas and Selected Birdwatching Spots



harbor. Particularly good for watching waterfowl, migrating raptors (birds of prey) and land birds. Unusual gulls, such as the Black-headed and Little Gull, may occasionally be seen at New Haven Harbor.

D. Hammonasset State Park, Madison: Grassy fields, marsh, mudflats and beach. Although parts of the park receive heavy recreational use, an amazing variety of birds breed in and use the marshes. During the migration season and winter, the broad, grassy fields provide excellent habitat for such uncommon species as the American Golden Plover, Buff-breasted Sandpiper, and Lapland Longspur. A Reddish Egret, a bird previously unrecorded in Connecticut, was seen at the park in 1975.

E. Lower Connecticut River, Old Lyme-Lyme-Old Saybrook-Essex: Marsh, mudflats, upland and sandspit; marshes largely State-owned, sandspit and surrounding areas privately owned. Hunting is permitted on State land. Along with Great Meadows, this area ranks as one of the most important areas in the State for birdlife. Breeding rails, waterfowl, bitterns and numerous songbirds may be seen in the marshes. In addition, terns, herons and great concentrations of migrant shorebirds use the area. This is a good place to look for both Bald and Golden Eagles, although the Bald Eagle is more commonly seen. Other rarities, the Gray Kingbird and Scissor-tailed Flycatcher, also were sighted here.

F. Niantic River, East Lyme-Waterford; Thames River, New London - Groton: The lower reaches of both these rivers are good places to watch for many varieties of wintering waterfowl in Connecticut. On occasion, even such oddities as the Barrow's Goldeneye, Tufted Duck and European Widgeon may be found here.

G. Bluff Point State Park, Groton: Marsh, mudflat, upland and sandspit. Hunting is permitted. An excellent spot for watching migrating land birds; also fairly good for shore and beach birds. The Roseate Tern occurs here regularly during the summer months. In autumn, the shrubby vegetation is excellent for warblers. The vagrant Orange-crowned Warbler has been seen here in late October.

H. Barn Island, Stonington: Marsh, mudflat and upland; State-owned. Hunting is permitted. Important area for breeding marsh birds, including rails, songbirds and waterfowl. Several species of herons, including the Little Blue Heron, are commonly seen here in summer; during spring and fall this is an excellent spot to see the uncommon Louisiana Heron.

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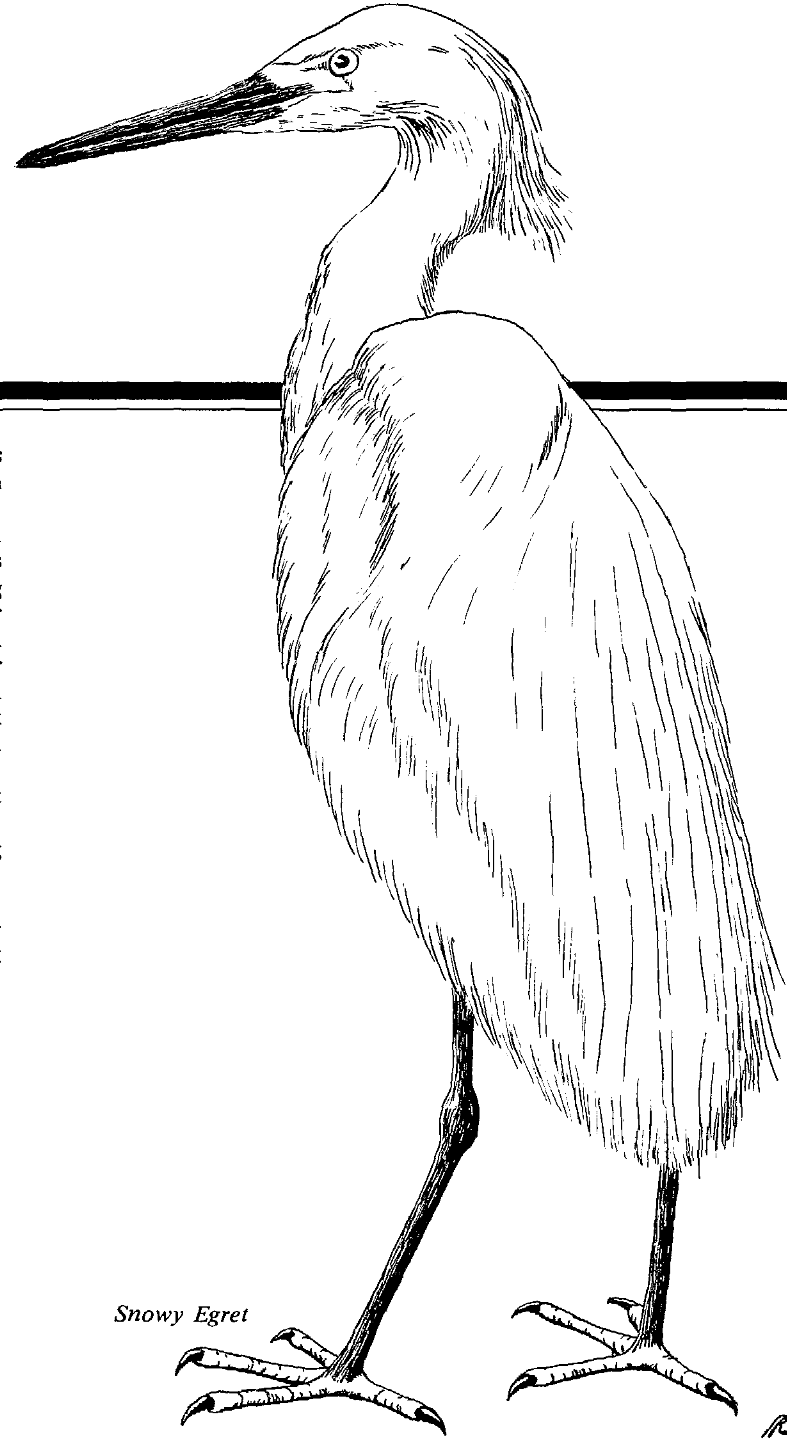
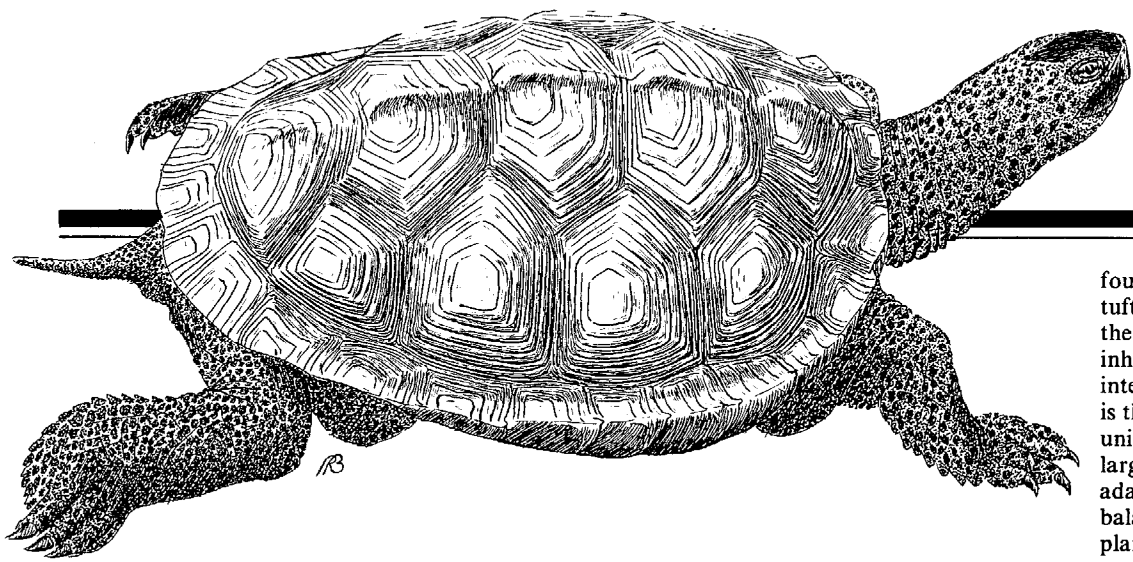


Snowy Egret

12. Mammals, Reptiles and Amphibians



Diamondback Terrapin

A number of *mammals, reptiles and amphibians* can be found in the various coastal communities. Mammals are warmblooded, furbearing animals that bear their young live. Reptiles are coldblooded animals with a scaley epidermis. Some reproduce by laying eggs, while other members of the species give birth to live young. The word Amphibian means "both sides of life." The animals of this group spend a portion of their life in the water. They are coldblooded and reproduce by laying eggs.

Mammals

The various coastal habitats support a wide variety of mammals. Most species found in the coastal region also occur inland, but some are particularly abundant along the shoreline.

Perhaps the coastal *community* most heavily used by mammals is the salt marsh. There are several conditions which determine what animals are present in this environment. The nature of salt marsh vegetation, which consists mainly of various grasses, with no trees, is one determining factor.

Also, species occurring in salt marshes must tolerate water salinity and periodic tidal flooding. Despite these adverse habitat features, which are not present in the upland community, a number of mammals flourish here.

Shrews Two species of shrews, the Masked and Short-tailed Shrew, are both quite common in salt marshes. These species, which live among the marsh grasses, eat the abundant insects and tiny marine animals found in the marsh. A third species, the Least Shrew, is essentially unknown in Connecticut although some suspect that it exists in limited numbers in salt marshes in the western portion of the State.

Small Rodents A number of small rodents may also be found in salt marshes. The White-footed Mouse often moves into marshes from adjoining woodlots, its primary home. The Meadow Vole is found in large numbers in the marshes and is probably the most abundant coastal mammal. Its presence is easily detected by the numerous tunnels it makes through the marsh grasses. Its curious domed nest may be found if a thorough search is made among the tufts of marsh grass. A third species of rodent, the Meadow Jumping Mouse, is also a common inhabitant of the salt marshes. Perhaps the most interesting of the three species discussed here, it is the smallest rodent found near the coast. It is unique in that its hind legs are proportionately larger than those of other rodents; this is an adaptation for jumping. Its very long tail aids its balance. All of these small rodents subsist upon plant material, insects, and other tiny animals.

Muskrat A much larger rodent, the Muskrat, is one of the most familiar and valuable of marsh mammals. Although it is found in salt marshes, it is considerably more abundant in tidal marshes dominated by Cattails. It is primarily a *herbivore* and eats plant species such as Cattails. Its presence is often indicated by large mounds of vegetation on the marsh surface, which comprise its den; it may also construct less conspicuous dens in mud banks. One of the Muskrat's adaptations for its aquatic existence is its sleek, thick fur, which is also prized in the fur trade. The Muskrat is in fact one of the most commercially important fur-bearing animals in the country today. Although it is heavily trapped in Connecticut, it remains an abundant species and a characteristic inhabitant of the coastal region.

Other Species Other species of mammals may also be associated with salt marshes. In particular, a number of the larger predatory species find the marshes to be suitable hunting grounds. Mammals such as the Raccoon and Red Fox, which inhabit upland areas, will often make forays into the marsh hunting small mammals, birds and crabs. Other predators, including the Long-tailed and Short-tailed Weasel, occasionally make their homes in salt marshes in the piles of dead vegetation and debris that collect at the high tide line.

In addition to the above species, most of which are land-dwelling, marine mammals may be observed along the Connecticut shoreline from time to time. As a group, marine mammals are a relative rarity along the shore because Long Island Sound is largely cut off from the open sea, where they normally occur. However, the Harbor Seal sometimes frequents the rocks off Stonington and Groton during the winter months, and on rarer occasions species such as the Harbor Porpoise may be sighted in the Sound or in one of the major rivers. On extremely rare occasions whales have been reported in the Sound, as in 1975 when a Finback Whale beached itself in Groton.

Reptiles and Amphibians

In Connecticut there are 42 known species of reptiles and amphibians, many of which may be found in the coastal region. These include turtles and snakes, which are reptiles, and frogs and toads, which are amphibians. The occurrence of a particular species depends upon the presence of suitable habitat. Thus, a species that requires moist woodlands for habitation can generally be found wherever such habitats are located, including the coastal area.

Diamondback Terrapin The Diamondback Terrapin is the only reptile in Connecticut which occurs exclusively along the coast. This aquatic turtle is limited to salt or brackish water marshes, where it feeds on dead fish, crustaceans, mollusks and some plant material. Adjacent sandy beaches are also important for the deposition and hatching of its eggs.

In the early 1900's Terrapin meat became such a popular delicacy that the price for a dozen adult females was as high as $120. Due to subsequent overhunting, populations declined until it became uncommon to rare throughout much of its range. In some areas it was completely eliminated. With the decline in its popularity as a food item, the Terrapin has become more common and it is now probably present in all major Connecticut salt marshes.

Sea Turtles The true sea turtles, those that inhabit the open ocean, normally are found only in tropical or subtropical waters, but occasionally they travel north in the Gulf Stream and wander into Long Island Sound. Records show that the Loggerhead Turtle, Green Turtle and Leatherback Turtle have been seen, though very rarely, along the Connecticut shore.

Eastern Spadefoot A rare amphibian, the toad-like Eastern Spadefoot, formerly occurred in a few locations along the Connecticut coast. This unusual species spends most of its life below ground, although it bred in tiny ponds of glacial origin *(kettle holes)* in the vicinity of New Haven. Until the 1930's, many thousands came out to the kettle holes to breed on warm, rainy nights in late spring and summer. Its old breeding sites have since been destroyed by urbanization, however, and it has not been recorded in this area since 1935.

Other Species Many other species of aquatic reptiles and amphibians can be found along the edges of salt marshes and adjacent bodies of water where the salinity is low. Common inhabitants of these areas include the Green Frog, Bullfrog, Pickerel Frog, Spotted Turtle, Painted Turtle and Northern Water Snake. The Snapping Turtle seems to be more tolerant of salt and can be found throughout the salt marshes.

Sandy areas along the shore are good places to find the Fowler's Toad, a close relative of the more common American Toad. Though they may both be found inland, the coastal area offers the sandy soil that the Fowler's Toad prefers. The Hognose Snake, a major predator on the Fowler's Toad, is also partial to such habitats.

Suggested Reading

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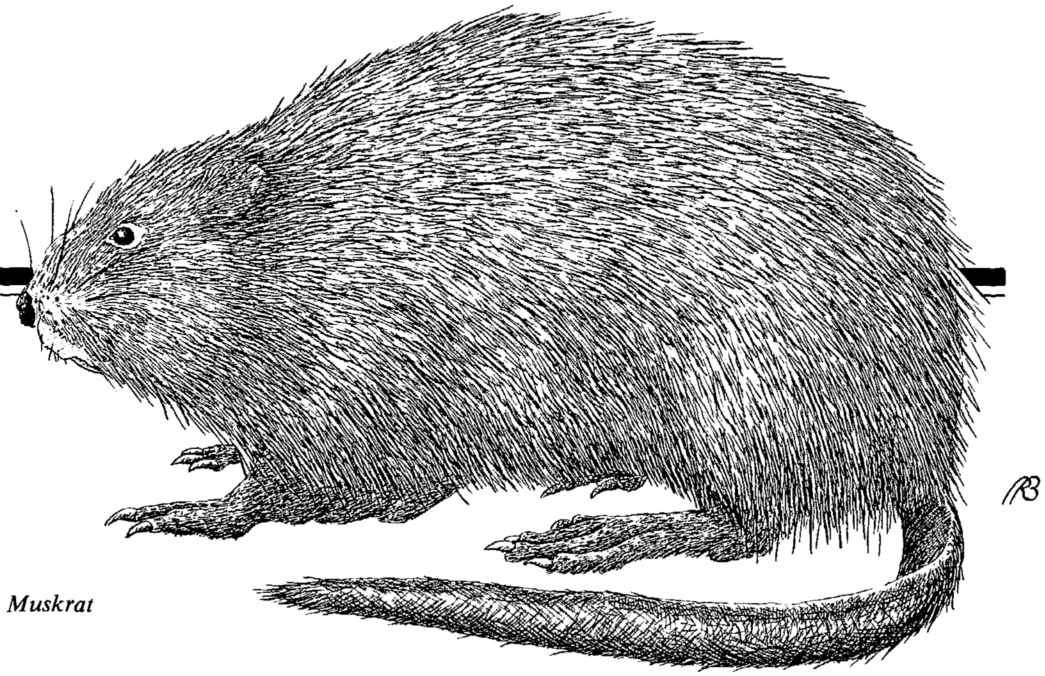
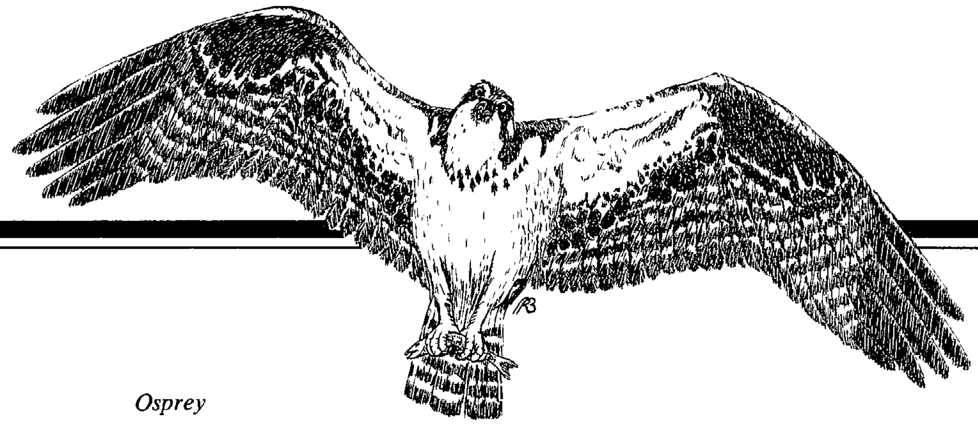


Muskrat

Meadow Vole

13. Rare and Endangered Species



Osprey

In Connecticut, a number of the plant and animal species that occur in the coastal area are not found elsewhere in the State. This is largely due to the unique features of the coastal environment. A number of these species, in addition to being specific to the coast, are found there only rarely and locally.

Causes of Rarity

Natural Factors A species may be rare within the State for a variety of reasons. Often a species' habitat requirements (in other words, the soil, water, food, light and other conditions necessary for its survival and reproduction) may be so specific that few localities are suitable for its colonization. The Piping Plover, a small shorebird that builds its nest on sandy, undisturbed beaches, is rare in Connecticut for this reason.

A species may also be rare because it is at the limit of its geographic range. This is usually related to diminishing amounts of suitable habitat at the fringes of the range, which in turn is partially related to differences in climate. The climate of the coastal area, mild in comparison with that of inland localities, is probably a major reason why many land plants reach their northern range-limit there. The Persimmon, a small tree with edible fruit, is such an example. Species may reach their range limit for other reasons as well, including predation by or competition with species not present in the central parts of their range.

Influence of Man Man influences the abundance of species in three major ways: he destroys habitats, he creates them, and he directly removes organisms.

Habitats are destroyed through urbanization, recreational development, agriculture, filling or draining wetlands, air and water pollution, and numerous other activities. An example of a species affected by habitat destruction is the Piping Plover. In Connecticut, the amount of naturally-occurring habitat suitable for the plover is small to begin with; it has been further reduced by man's development.

The current rarity of the Persimmon is also related in part to habitat destruction. It was formerly a native species in a few isolated areas along the coast, but its total population is now comprised of seven trees, all standing at Lighthouse Point Park in New Haven. A little over 100 Persimmons were present at Lighthouse Point in the 19th century, but as a result of the 1938 hurricane and intensive development of the park for recreation, most of them were lost. The remaining trees are dying of old age. No new trees have begun growing in recent years because the Persimmon's normal mode of reproduction, sending up root sprouts, is hampered by continued human activities around the trees. In other locations, stands of Persimmon have been completely eliminated.

Another example of a species severely affected by habitat destruction is the Osprey, a fish-eating hawk primarily associated with coastal habitats. Ospreys were once locally abundant breeders in the State, particularly around the mouth of the Connecticut River. In the 1940's there were over 100 pairs nesting in the vicinity of the river. By the 1950's, however, population levels began to decline. Chlorinated hydrocarbons (toxic chemicals such as the pesticide DDT) were being deposited into Long Island Sound through agricultural runoff and municipal wastes. Fish accumulated these substances in their tissues, and the Ospreys which fed upon the fish were either directly killed or their reproductive capacity was severely reduced. As a result, the number of Ospreys now inhabiting the State has decreased to approximately 10 pairs, or less than 5% of their former numbers.

Habitat creation, on the other hand, often allows the colonization of non-resident species, which do not normally occur in the area. This is particularly evident in pasturelands and other artificially maintained grasslands. Species characteristic of midwestern prairies, such as the Short-billed Marsh Wren, will invade these sites but will otherwise be nearly or completely absent from the State.

Direct removal of individual species by man was formerly a major factor in reducing the populations of a number of coastal vertebrates. In the late 19th century most species of herons, egrets and terns were nearly eliminated from large portions of their range by plume hunters. The elaborate plumes and tail feathers of these birds were used in women's hat decorations. The hunting was ended by international treaty in 1918, and now small numbers of many species, including the Great Egret, Little Blue Heron, and Yellow-crowned Night Heron, are breeding in areas along the southwestern Connecticut coast.

Direct removal of plantlife continues to deplete some species, particularly those with attractive flowers or those with purported medicinal uses.

Other factors Pests, diseases, or parasites have been important factors in the depletion of some plant and animal species. The destruction of Eelgrass during the 1930's by "Wasting Disease" is an example. The recent range extensions of other species, such as the Glossy Ibis, a wading bird, account for their rarity in the State. In Connecticut, the Glossy Ibis is near the extreme edge of its breeding range and has not as yet increased in numbers. In addition, some species have found rarity to be advantageous, and have evolved to be rare; for some species it can be an effective means of avoiding predators.

There are other factors, too numerous to outline here, which also contribute to rarity. The suggested reading at the end of this chapter provides additional information.

Ecological Role of Rare Species

The loss of any particular rare species in the State would in many cases have very little effect on ecosystems as a whole. The disappearance of a patch of rare orchids or a small colony of songbirds, for example, would usually not have a major effect on the overall functioning of an ecosystem. However, it must be realized that all native species are members of communities. Communities function as interrelated units in performing such vital processes as nutrient cycling, oxygen production, and food production. If members of the community are continually removed, or if key members are eliminated, the system will cease to function in an optimal manner.

In addition, rare species serve as very sensitive indicators of environmental quality. As has been discussed, rare species often require very specific habitat conditions or are very sensitive to environmental changes brought about by man. When they begin to disappear from an area the evidence is strong that environmental quality is deteriorating. As environmental quality deteriorates, man ultimately suffers.

It is important to realize that species that are rare today may not always be rare. As environmental conditions change over time, organisms with specific genetic attributes are selected. Thus a specific population of a species, rare because it is at the limit of the species' geographic range, and which has evolved a slightly different genetic makeup than other members of the species, may someday prove best suited to withstand some new set of environmental conditions and may even provide genetic material from which a new species will evolve.

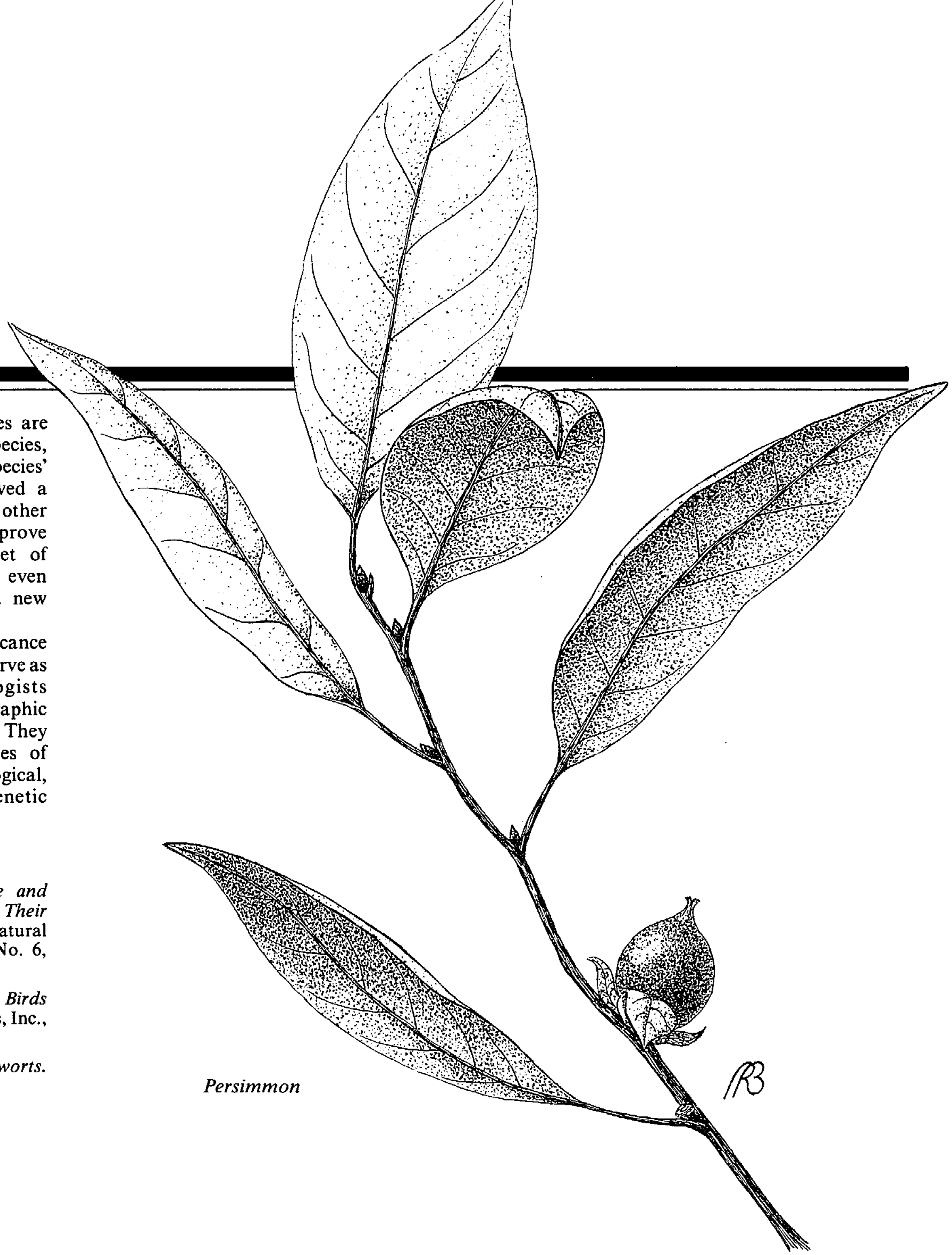
Rare species are of considerable significance in a number of other ways as well. Many serve as important tools in helping biologists characterize ecologically distinctive geographic areas because of their habitat specificity. They are ideal organisms for numerous types of biological research, including ecological, physiological, evolutionary, and genetic studies.

Suggested Reading

Dowhan, J. J. and Craig, R. J., *Rare and Endangered Species of Connecticut and Their Habitats.* Connecticut Geological and Natural History Survey Report of Investigations No. 6, 1976.

Greenway, J.C., Jr., *Extinct and Vanishing Birds of the World.* New York: Dover Publications, Inc., 1967.

Gosnell, M., *Please Don't Pick the Butterworts.* National Wildlife. 14:33-37, 1976.



Persimmon

14. Man and Long Island Sound

Long Island Sound is an estuary. Ocean water freely enters the Sound and becomes less saline because of dilution by fresh water from the many incoming rivers. Estuarine waters are rich and highly productive due to the combination and circulation of ocean water, fresh water and nutrients. The fresh water tends to float on the heavier salt water; when this occurs, the nutrients are trapped below the surface and remain in the estuary. Carried landward twice a day by the action of the tides, the nutrients enrich the marshes over which they flow. Other sections of this atlas have described the many additional factors that make natural estuaries complex and fascinating.

The marine environment of estuaries places many demands upon the organisms that live there. Relatively few species are able to adapt to the fluctuating levels of salinity. This is a key reason why the actual number of different species in an estuary is relatively small compared to the open ocean, although each species appears in greater number. Species that inhabit estuaries have adapted to tolerate the harsh conditions; genetic adaptations have become so specific that most organisms that live in estuaries cannot breed or reproduce in any other type of habitat.

Unlike other components of the estuarine ecosystem, man has the ability to manipulate the environment to suit his needs, and the effects of his activities may often be overlooked in studies of estuarine systems.

Historically, the development of civilizations has been most intense along sea coasts. Today, the heaviest population densities occur in coastal areas, where people use the water to provide a valuable source of food, to provide a means of transportation, to satisfy recreational needs, and to receive and dilute wastes from industrialization.

Prior to the Civil War, people regarded the resources of estuaries and oceans as limitless. From the mid-nineteenth century on, industrialization occurred along the shores with little concern for its long term effects. In recent times, the concept of the sea as a limitless resource has been proven erroneous. Yet, despite the fact that the need for wise management of this valuable resource has become apparent, many of man's activities, particularly in the watersheds that lead to the ocean, place considerable stress upon the marine environment. The modification of river flow and the municipal and industrial discharge into rivers are two activities that cause great impact to the Long Island Sound estuary.

Dam construction is the most common form of modification of river flows. Dams reduce both the volume and velocity of rivers entering estuaries. Dams may also block the movement of *anadromous* fish in their efforts to reach suitable spawning grounds.

Subtle effects, such as siltation problems, can result from the modification of rivers. With decreased river velocities, materials suspended in the water tend to settle on the bottom of river mouths rather than be carried into deeper water. This necessitates frequent dredging to maintain the depth of navigational channels. More important still is the alteration of natural chemical elements necessary for primary productivity in estuaries. Such changes can result both from removal of chemicals necessary for photosynthesis and from overloading estuaries with chemicals to the point where plants cease to function.

One of the more recent impacts on estuaries is the discharge of heated water resulting from cooling processes in industry and electricity production. The increase in water temperature appears to be a favorable condition for less desirable marine forms such as the shipworm, oyster drill and starfish. Also, if the heated water is not sufficiently diluted with cooler waters, the amount of dissolved oxygen in the receiving waters eventually becomes reduced. This, in turn, alters the existing biological populations.

The chemicals that are discharged by municipal and industrial facilities have entered marine food webs, sometimes with adverse effects. For example, PCB's (polychlorinated biphenyls) were ingested by terns when they fed on marine fishes, causing birth defects among their offspring. Some effects of agricultural use of insecticides, primarily chlorinated hydrocarbons such as DDT, are discussed in Chapter 13 - "Rare Species."

As people concentrated around seacoasts, alteration to the landforms in estuaries were made to suit human needs. Under the guise of reclamation, tidal wetlands and shallow, underwater lands were filled, primarily with dredge spoil. Although the effects of each dredge and fill activity is localized, the cumulative effect has radically changed saltwater, tidal, and water circulation patterns and has resulted in a significant loss of habitat. Water conditions essential for spawning and for nursery areas for many species of commercially important fish have deteriorated.

In attempts to create more beaches, *groins* and jetties were constructed for the purpose of trapping sand and thus enlarging beaches. After large amounts of money were spent, it was recognized that the long term effect of much of the construction was accelerated erosion and the consequent loss of beaches.

Human activity in estuaries has not always taken the form of environmental manipulation through careless practices. Aquaculture, for example, has increased the yield of some estuaries for food. Often human control can be positive, as exemplified by the creation of artificial reefs and impoundments, pollution abatement, management of fisheries and wildlife along the sea coast, and estuarine modifications to enhance production of marine life for human consumption.

With wise management of the estuarine environment, the multiple and often conflicting uses of this natural system by man are possible. Because the marine resources of the world are common property, man has an obligation to prudently manage these resources for the people of today and the generations of the future.

Suggested Reading

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Hay, J. and Farb, P., *The Atlantic Shore.* New York: Harper and Row, Publishers, Inc., 1966.

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Leopold, A.S., *A Sand County Almanac.* Oxford University Press, Inc., 1966.

Appendix I: Scientific Names

The scientific names of only those species that are likely to occur in Connecticut are included.

Species for which only scientific names are listed do not have common names.

PLANTS

American Holly *Ilex opaca*
Ascophyllum nodosum
Antithamnion cruciatum
Bayberry *Myrica pensylvanica*
Beach Clotbur *Xanthium echinatum*
Beach Pea *Lathyrus japonicus*
Beach Plum *Prunus maritima*
Beach Rose *Rosa rugosa*
Black Cherry *Prunus serotina*
Black Huckleberry *Gaylussacia baccata*
Blackgrass *Juncus gerardi*
Black Oak *Quercus velutina*
Blueberry *Vaccinium* spp.
Bramble *Rubus* spp.
Callithamnion corymbosum
Catbriar *Smilax rotundifolia*
Cattail *Typha* spp.
Chorda filum
Codium fragile
Dune Grass *Ammophila breviligulata*
Dusty Miller *Artemesia stelleriana*
Ectocarpus siliculosus
Eelgrass *Zostera marina*
Enteromorpha spp.
False Beach Heather *Hudsonia tomentosa*
Fucus spp.
Glasswort *Salicornia* spp.
Grinnellia americana
Groundsel-tree *Baccharis halimifolia*
Hazelnut *Corylus* spp.
Hildebrandtia prototypus
Irish Moss *Chondrus crispus*
Kelp *Laminaria agardhii*
Marsh Elder *Iva frutescens*
Mermaid's Hair *Cladophora* spp.
Mockernut Hickory *Carya tomentosa*
Monostroma pulchrum
Orache *Atriplex patula*
Oriental Bittersweet *Celastrus orbiculata*
Persimmon *Diospyros virginiana*
Phymatolithon laevigatum
Pignut Hickory *Carya glabra*
Poison Ivy *Rhus radicans*
Polysiphonia spp.
Pondweed *Potamogeton* spp.
Porphyra spp.
Post Oak *Quercus stellata*
Reed *Phragmites communis*
Rhodymenia palmata
Salt Water Cordgrass *Spartina alterniflora*
Salt Marsh Aster *Aster tenuifolius*
Salt Meadow Cordgrass *Spartina patens*
Sea Lavender *Limonium nashii*
Sea Lettuce *Ulva lactuca*
Sea Rocket *Cakile edentula*
Seabeach Knotweed *Polygonum glaucum*
Seaside Gerardia *Gerardia maritima*
Seaside Goldenrod *Solidago sempervirens*
Seaside Spurge *Euphorbia polygonifolia*
Sour Gum, or Tupelo *Nyssa sylvatica*
Spermothamnion repens
Spikegrass *Distichlis spicata*
Spikerush *Eleocharis rostellata*
Sweetgum *Liquidambar styraciflua*
Switchgrass *Panicum virgatum*
Ulothrix flacca
Viburnum *Viburnum* spp.
White Oak *Quercus alba*
Widgeon Grass *Ruppia maritima*
Wild Rice *Zizania aquatica*

ANIMALS

Acartia spp.
American Lobster *Homarus americanus*
American Toad *Bufo americanus*
American Widgeon *Mareca americana*
Atlantic Bay Scallop *Pecten irradians*
Atlantic Moon Snail *Polynices duplicata*
Atlantic Oyster Drill *Urosalpinx cinerea*
Atlantic Slipper Shell *Crepidula fornicata*
Bald Eagle *Haliaetus leucocephalus*
Barnacle *Balanus* spp.
Barrow's Goldeneye *Bucephala islandica*
Black-crowned Night Heron *Nycticorax nycticorax*
Black Duck *Anas rubripes*
Black-headed Gull *Larus ridibundus*
Blackback (Winter) Flounder *Psuedopleuronectes americanus*
Blackfish, or Tautog *Tautoga onitis*
Blue Crab *Callinectes sapidus*
Blue Mussell *Mytilus edulis*
Bluefish *Pomatomus saltatrix*
Brant *Branta bernicla*
Brown Trout *Salmo trutta*
Buff-breasted Sandpiper *Tryngites subruficollis*
Bullfrog *Rana catesbeiana*
Carolina Wren *Thryothorus ludovicianus*
Canada Goose *Branta canadensis*
Canvasback *Aythya valisineria*
Ceratium lineatum
Channeled Whelk *Busycon canaliculatum*
Clapper Rail *Rallus longirostris*
Codfish *Gadus callarias*
Common Gallinule *Gallinula chloropus*
Common Goldeneye *Bucephala clangula*
Diamondback Terrapin *Malaclemys terrapin*
Eastern Oyster *Crassostrea virginica*
Eastern Spadefoot *Scaphiopus holbrookii*
European Periwinkle *Littorina litorea*
European Widgeon *Mareca penelope*
Fiddler Crab *Uca pugnax*, *U. pugilator* and *U. minax*
Finback Whale *Balaenoptera physalus*
Fowler's Toad *Bufo woodhousei fowleri*
Gadwall *Anas strepera*
Glossy Ibis *Plegadis falcinellus*
Golden Eagle *Aquila chrysaetos*
Golden Plover *Pluvialis dominica*
Grass Shrimp *Hippolyte zostericola*
Gray Kingbird *Tyrannus dominicensus*
Great Egret *Casmerodius albus*
Greater Scaup *Aythya marila*
Green Crab *Carcinides maenas*
Green Frog *Rana clamitans*
Green Turtle *Chelonia mydas*

Green-winged Teal *Anas carolinensis*
Harbor Seal *Phoca vitulina*
Hard-shell Clam (Quahog, Cherrystone, or Littleneck Clam) *Mercenaria mercenaria*
Hermit Crab *Pagurus longicarpus* and *P. pollicaris*
Hognose Snake *Heterodon platyrhinos*
Hooded Warbler *Wilsonia citrina*
Jonah Crab *Cancer borealis*
Knobbed Whelk *Busycon carica*
Lady Crab *Ovalipes ocellatus*
Lapland Longspur *Calcarius lapponicus*
Least Shrew *Cryptotis parva*
Least Tern *Sterna albifrons*
Leatherback Turtle *Dermochelys coriacea*
Lesser Scaup *Aythya affinis*
Little Blue Heron *Florida caerulea*
Little Gull *Larus minutus*
Loggerhead Turtle *Caretta caretta*
Long-tailed Weasel *Mustela frenata*
Louisiana Heron *Hydranassa tricolor*
Mallard *Anas platyrhyncos*
Masked Shrew *Sorex cinereus*
Meadow Jumping Mouse *Zapus hudsonius*
Meadow Vole *Microtus pennsylvanicus*
Mole Crab *Emerita talpoida*
Mud Snail (Eastern Mud Nassa) *Nassa obsoleta*
Mute Swan *Cygnus olor*
Muskrat *Ondatra zibethicus*
Northern Moon Snail *Lunatia heros*
Northern Water Snake *Natix sipedon*
Northern Yellow Periwinkle *Littorina obtusata*
Odsquaw *Clangula hyemalis*
Orange-crowned Warbler *Vermivora celata*
Osprey *Pandion haliaetus*
Painted Turtle *Chrysemys picta*
Paralia dulcata
Pickerel Frog *Rana palustris*
Pintail *Anas acuta*
Piping Plover *Charadrius melodus*
Pseudocalanus minutus
Raccoon *Procyon lotor*
Red Fox *Vulpes fulva*
Red-breasted Merganser *Mergus serrator*
Reddish Egret *Dichromanassa rufescens*
Redhead *Aythya americana*
Ribbed Mussel *Modiolus demissus*
Ring-necked Duck *Aythya collaris*
Rock Crab *Cancer irroratus*
Roseate Tern *Sterna dougallii*
Rough Periwinkle *Littorina saxatilis*
Ruddy Duck *Oxyura jamaicensis*
Salt Marsh (Coffee Bean) Snail *Melampus bidentatus*
Sand Shrimp *Crangon septemspinosus*
Sandworm *Nereis* spp.
Scoter *Melanitta* spp.
Scissor-tailed Flycatcher *Muscivora forficata*
Scup (Porgy) *Stenotomus chrysops*
Sea Anemone *Metridium marginatum*
Sea Cucumber *Pentacta frondosa*
Sea Urchin *Strongylocentrotus* spp.
Seaside Sparrow *Ammospiza maritima*
Sharp-shinned Hawk *Accipiter striatus*
Short-billed Marsh Wren *Cistothorus platensis*
Sharp-tailed Sparrow *Ammospiza caudacuta*
Ship Worm *Teredo navalis*
Short-tailed Shrew *Blarina brevicauda*
Short-tailed Weasel *Mustela erminea*
Shoveler *Spatula clypeata*
Skeletonema costatum
Snapping Turtle *Chelydra serpentina*
Snow Goose *Chen hyperborea*
Snowy Egret *Leucophoyx thula*
Soft-shelled Clam, Steamer *Mya arenaria*
Spider Crab *Libinia emarginata* and *L. dubia*
Spotted Turtle *Clemmys guttata*
Starfish *Asterias forbesi*
Striped Bass *Morone saxatilis*
Sulfur Sponge *Cliona* spp.
Temora longicornus
Thalassionema spp.
Timber Rattlesnake *Crotalus horridus*
Tufted Duck *Aythya fuligula*
White-eyed Vireo *Vireo griseus*
White-footed Mouse *Peromyscus leucopus*
Yellow-crowned Night Heron *Nyctanassa violacea*

Appendix II: Glossary

Aeolian wind-blown; used in reference to wind-blown sand deposits, or dunes.

Algae the simplest of green plant forms, lacking roots, stems and leaves.

Amphibians the group of animals that includes frogs, toads and salamanders. The larvae usually live in water and breathe through gills, whereas adults usually live on land and breathe through their skins and lungs, but return to water to lay their eggs.

Anadromous oceanic or estuarine species (specifically fish) that migrate into fresh water to breed.

Atlantic Flyway a major path of bird migration roughly paralleling the east coast of North America.

Bag limit the number of individuals of a game species allowed to be taken by a hunter during a day or over the course of the hunting season.

Barrier beach a strip of beach running parallel to the shore, but separated from it (at least for the most part) by a body of water or marsh.

Bedrock solid rock which underlies the surface sediments. In some places it is exposed at the surface as an outcrop.

Benthic (organisms) see benthos.

Benthos animals and plants that live on or in the seafloor.

Berried female carrying eggs; used in relation to lobsters.

Berm a formation of sand deposited above normal high water by wave action.

Bivalves mollusks that possess two shells, such as clams and oysters.

Bloom a dramatic increase in the number of microscopic algae or plankton present in the water column.

Bluff a cliff of rock or sedimentary material. Bluffs often occur along the seashore or rivers.

Breaker a wave that falls over and "breaks" into foam as it approaches the shoreline.

Byssus the threads present on many species of mollusks that are used to attach them to a surface.

Carapace a hard shell-like covering on the upper side of the body of some animals, such as turtles or crabs.

Carnivore an animal that feeds largely upon other animals.

Carrying capacity the largest number of a particular population that a given environment can support.

Community a group of plants and animals, interacting with and closely dependent upon one another, that are tied to and strongly affected by their particular physical environment.

Continental Slope the Continental Shelf is the submerged shelf of land that extends from the exposed edge of a continent for a variable distance to the point where the steeper descent to the ocean bottom begins. The descent is called the Continental Slope.

Crustacea a large class of primitive animals that includes the true crabs, hermit crabs, lobsters, shrimp, and barnacles. They are primarily aquatic, and characteristically possess eyes, jointed legs, segmented bodies, and external skeletons.

Decomposers microscopic organisms, generally bacteria and fungi, which act in breaking down dead plant and animal material.

Deposit feeder animals (generally benthic animals) that feed on particles of organic matter either from the sediment surface or from within the sediment.

Dynamic equilibrium the state of fluctuation around some average position caused by the counteracting effects of opposing agents such as erosion and deposition.

Dorsal fin fin running along the spine or backbone of a fish.

Drift sediments deposited as a result of glacial activity.

Ebb tide an outgoing ocean tide.

Epibenthos animals and plants that live on the surface of the seafloor.

Epifauna animals that live on the surface of the seafloor.

Epiflora plants that live on the surface of the seafloor.

Estuarine circulation In Long Island Sound, estuarine circulation involves more heavy, saline water sinking to the bottom and flowing westward into the Sound, while less saline water stays near the surface and flows eastward out of the Sound.

Estuary a protected coastal body of water with an open connection to the sea, in which saline seawater is measurably diluted by fresh water.

Exoskeleton an external skeleton; present in many invertebrate species, such as crabs, lobsters, insects, and shrimp.

Fetch the length of unobstructed water over which the wind blows, generating waves.

Fish passage a man-made structure that allows anadromous fish to return to their place of birth to spawn by providing a means of getting over obstructions such as dams.

Flagella whiplike projections, used in locomotion, that occur on certain species of tiny organisms, including some of the zooplankton.

Flood tide an incoming ocean tide.

Food web the network of feeding relationships in a biological community.

Gill net a curtain-like net suspended vertically in the water; a fish thrusting its head through it is caught by the gills.

Glaciation the formation of ice sheets, specifically the formation of glaciers.

Groin a shore protection structure built (usually perpendicular to the shoreline) to trap sediment or retard erosion of the shoreline.

Habitat a type of area where the physical and biological living requirements of a species or community are met.

Headland land which projects out from the mainland into the open sea.

Herbivore an animal whose diet consists chiefly of plant material.

Holoplankton tiny organisms that spend their entire life cycle floating or swimming in the water column.

Infauna bottom-dwelling marine animals that live beneath the surface sediments.

Inflora bottom-dwelling marine plants that live beneath the surface sediments.

Intertidal zone the area between high-tide mark and low-tide mark.

Kettle hole depressions in the ground surface left by the melting of a block of glacial ice that had been covered by glacial drift.

Larva a juvenile form of those organisms that undergo a dramatic structural change upon reaching adulthood.

Longshore currents currents, created when waves break at an angle to the shore, which travel parallel to the shoreline.

Macrobenthos (megabenthos) bottom-dwelling marine organisms that are greater than or equal to 1 mm in diameter.

Mammal warm-blooded vertebrates, often possessing fur, that bear their young live and feed them with milk.

Megalopa an advanced larval stage of the true crabs.

Meiobenthos bottom-dwelling marine organisms greater than 0.05 mm but less than 1 mm in size.

Meroplankton organisms which spend only the juvenile part of their life cycle as plankton.

Metamorphosis the process of undergoing a dramatic change in structure during an organism's life cycle.

Microbenthos bottom-dwelling marine organisms that are less than 0.05 mm in size.

Mid-tide the tidal level intermediate between mean high and mean low tide.

Molt to shed the skin, feathers, or external skeleton.

Moraine an accumulation of earth and stones that were carried by a glacier and deposited when the ice melted.

Mudflats see tidal mudflat.

Nonvascular referring to plants with no organized water and nutrient transport system.

Nutrient "food" items essential for an organism's survival, including carbohydrates, proteins, fats, and minerals.

Organisms living creatures, either plant or animal.

Outwash sediments deposited by streams formed from melting glaciers.

Panne a slight depression on the surface of a salt marsh where salt accumulates and where the plant species present are different from those in the surrounding marsh.

Peat a layer of partially decomposed plant materials that accumulates on the land surface in environments of high acidity and little available oxygen, such as marshes and bogs.

Pelagic (environment) the open water, or water column, of the marine environment.

Phytoplankton minute plants, such as diatoms and dinoflagellates, which are present floating in the water column.

Plankton minute plants and animals that float or swim in the water column.

Pocket beach a beach which occurs in a small, crescent-shaped cove and directly fronts uplands.

Pods aggregations of crabs.

Prey an animal that is captured by another animal for food.

Producers green plants which use nutrients, water and carbon dioxide to transform light energy into organic matter through the process of photosynthesis. Producers form the basic link of many food chains.

Productivity the amount of living material produced in a given area over a specific length of time.

Race a relatively narrow gap that connects a sheltered body of water with the open sea. Seawater flows in and out of this gap.

Radula a file-like tongue, present in many mollusks, which is used to tear up food and ingest it.

Reptiles the group of animals which includes snakes, lizards, turtles, and others. They are usually covered by scales or horny plates, breathe through lungs, lay eggs, and live on land.

Rhizome a creeping plant stem found at or below the surface.

Scavenger an animal that feeds on the dead remains of other animals and plants.

Shoal elevated portion of the seafloor, composed of rock or sand. Such areas are often frequented by fish.

Slough an area of soft muddy ground, a low-lying area.

Smolt a juvenile stage of the salmon.

Spawn the process of laying eggs; used in relation to fish.

Spit a sandy projection of land attached at one end to the mainland or an island.

Spring tides exceptionally high and low tides. This happens when the sun and moon are in line with the earth, thus exerting a stronger gravitational attraction upon it.

Substrate a land or sub-marine surface; often used in reference to a surface where plants and animals can attach or burrow in some manner.

Subtidal zone the area of a beach that lies below the level of low tide.

Surf waves breaking at the shoreline.

Suspension feeder an organism that feeds by filtering or otherwise intercepting particles of decomposed plant and animal material that are suspended in the water column.

Terminal moraine sediment mounds deposited by a glacier at its southern margin when the rate of glacial expansion southward was offset by melting.

Tidal mudflat an intertidal area characterized by a lack of vegetation.

Tidal range the difference in water depth between high and low tide.

Tombolo a projection of sand connecting two islands or an island to the mainland.

Trophic level a level in the food chain; each group of organisms that obtains food from its ultimate source - the sun, water, carbon dioxide, etc., in the same number of steps. Examples are the producers and herbivores.

Turbid refers to water reduced in clarity due to the presence of suspended matter.

Univalve a mollusk whose shell is composed of only one piece, such as the periwinkles, moon snails, and oyster drills.

Upland land lying above the level where water flows or where tidal flooding occurs.

Vascular plants plants that have distinct structures for transporting water and nutrients.

Water column an imaginary section of water from the surface to the bottom.

Water-land interface the area where land and water meet.

Zoea a juvenile free-swimming stage of crabs.

Zooplankton minute animals that live in the water column.

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Figure Credits

Figure 5. Surface Salinity: National Marine Fisheries Service, Sandy Hook Laboratory

Figure 6. Bottom Salinity: National Marine Fisheries Service, Sandy Hook Laboratory

Figure 9. Mean Sediment Size: National Marine Fisheries Service, Sandy Hook Laboratory

Figure 10. Shoreline Features: Bloom, A.C., *Coastal Geomorphology of Connecticut*

Figure 16. Estuarine Benthic Habitats: Dr. Donald Rhoads, Yale University

Figure 17. Benthos — Number of Species: National Marine Fisheries Service, Sandy Hook Laboratory

Figure 18. Growth of Benthic Invertebrate Populations Relative to the Seasonal Temperature Cycle: Dr. Donald Rhoads, Yale University

Figure 20. Lobster Distribution: Zuboy, Coleman and Jones, *Computerized Catch/Effort Reporting System for Commercial Fisheries Management* (DEP Report)

Figure 21. Commercial Shellfish Beds: U.S. Dept. of the Interior, Federal Water Pollution Control Administration, *State of Connecticut Shellfish Atlas*

Figure 22. Phytoplankton Population Cycle: Conover, S.M., *Oceanography of Long Island Sound, 1952-1954.* Chapter IV, "Phytoplankton". Bulletin of the Bingham Oceanographic Collection, Vol. 15.

Figure 23. Zooplankton Population Cycle: Deevey, G.B., *Oceanography of Long Island Sound, 1952-1954.* Chapter V, "Zooplankton". Bulletin of the Bingham Oceanographic Collection, Vol. 15.