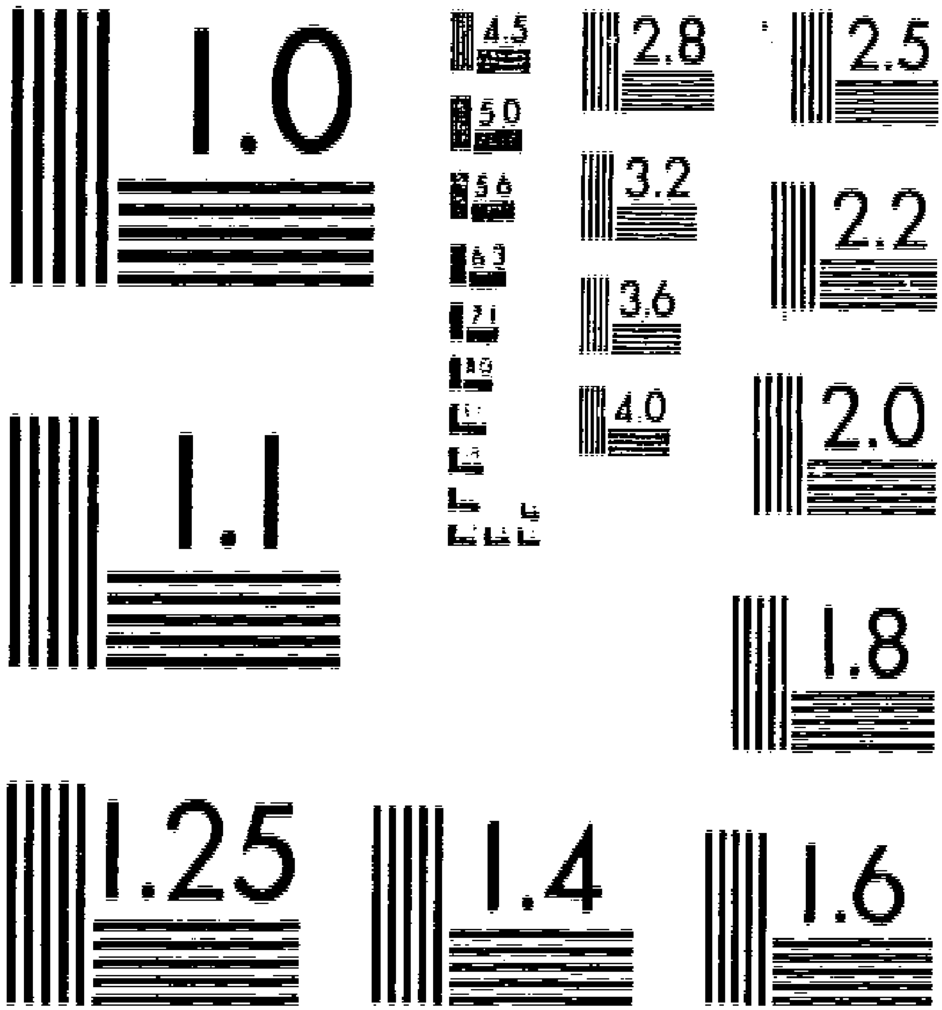

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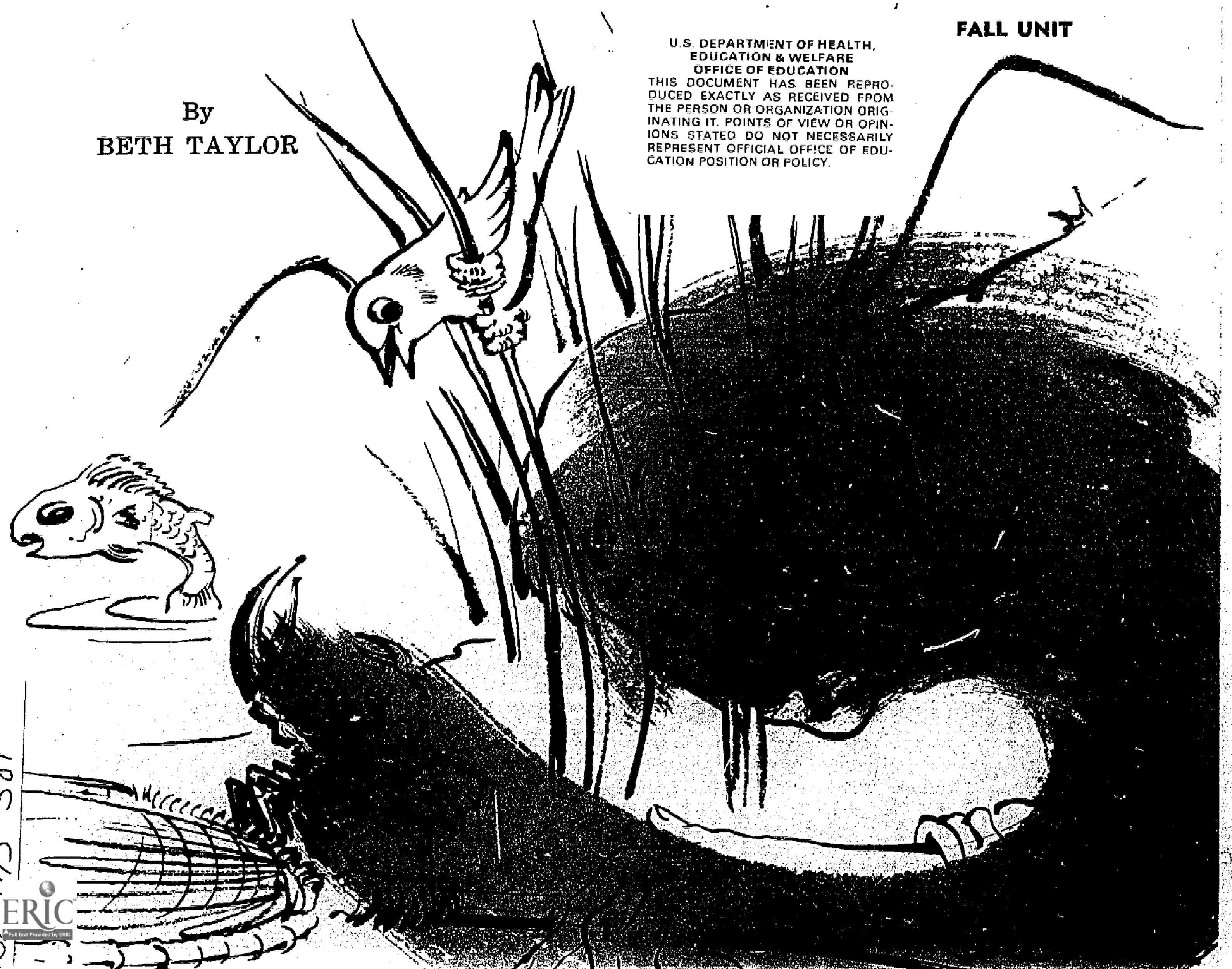
ABSTRACT

This publication is designed for use as part of a curriculum series developed by the Regional Marine Science Project. Coastal environments are utilized to demonstrate basic principles of ecology to tenth grade students with emphasis placed on salt marshes in this first unit for the fall season. (Unit 2 is for spring season.) Material presented in the informative text covers the scope of ecology, coastal and inland ecosystems, factors limiting survival and distribution, chemical cycles, photosynthesis, respiration, and food cycles. Coastal ecology lab exercises acquaint the student with a variety of organisms commonly found in the tidal salt marsh and give practice in collecting, analyzing, and presenting data in a scientific and orderly manner. Numerous line drawings, diagrams, and data recording sheets supplement the narrative material. This work was prepared under an ESEA Title III contract. (BL)

THE FIELD APPROACH TO COASTAL ECOLOGY

FALL UNIT

By
BETH TAYLOR



THE FIELD APPROACH TO COASTAL ECOLOGY

(Second Edition)

by BETH TAYLOR
illustrated by WILL HON

Second Edition; September, 1970; 3,000

CONTENTS

WHAT IS ECOLOGY?

Literally translated, **ecology** means "the study of houses". The word ecology is derived from the Greek word **oikos** meaning "house". Ecologists are not solely concerned with where organisms live, but why they are found in a particular **habitat** and specific **niche.** To understand or even attempt to understand the "whys?" of ecology, one must siphon information from many different branches of science.

As one studies ecology, it becomes increasingly clear that organisms do not exist alone, but are enmeshed in numerous direct and indirect relationships with other plants and animals and the physical environment. We cannot state that ecology is simply the study of habitats. We must broaden the statement to include the relationships between the organism and other organisms: (what he eats and what eats him), and also the organism's relationships to his physical environment: (water availability, temperature, salinity, soil type, light intensity, etc.). Ecology, may be defined as the study of interaction in any form between organisms, between organisms and habitat, or between habitats.

All living organisms inhabit a thin layer around the earth called the **biosphere.** We are all part of this system and our lives are related either directly or indirectly to all other organisms in this system. Some of these relationships are obvious whereas others are more subtle.

Living organisms, the **biotic community,** and their non-living **abiotic** environment are interrelated and interact upon each other. An area which includes both living organisms and non-living substances interacting to produce an exchange of materials between the living and non-living parts is an ecological system or **ecosystem.** The concept of ecosystem is and should be a broad one. Ecosystems may be studied in various sizes and conditions. A large salt marsh or a small tidal pool provide convenient units of study. As long as the major components are present and operate together, the entity is properly called an ecosystem.

Two terms should be considered before moving into a discussion of coastal ecosystems. **Habitat** is where an animal or plant lives. Where an organism lives is determined by its requirements for survival. These requirements are physical, and biological. Whereas habitat can be considered the address of an organism, its occupation in the community is its **niche.**

The most effective way to begin a study of ecology is by going into the field to study an ecosystem first hand. The tidal salt marsh has been chosen for a variety of reasons. You, as a resident of a coastal county, are already somewhat familiar with the salt marsh. However, you probably look on them as smelly, muddy, tracts of waste land rather than as valuable parts of your environment. Salt marshes are easily accessible and provide a tool for a convenient, compact study of a local ecosystem.

The starfish preying upon an oyster is fulfilling its role as a predator (its niche) on a small section of rock jetty which is its habitat.

COASTAL ECOSYSTEMS

OPEN BEACH — INTERTIDAL ZONE

Physical Factors

The open beach is a sandy, unvegetated expanse of flat beach located between high and low tide. The high tide boundary is generally seen as a pile of debris left behind when the tide began to fall. This debris in the **drift line** is a source of food and shelter for insects and other small scavengers.

Pounding surf and wave action result in constant and rapid motion of sand and shell particles. Shifting sand offers little solid **substrate** for the attachment of **sessile** organisms. Surfaces to which organisms attach or on which they move are called the "substrate." Organisms which are attached or permanently fixed to the substrate are sessile, as opposed to the motile or free-moving organisms.

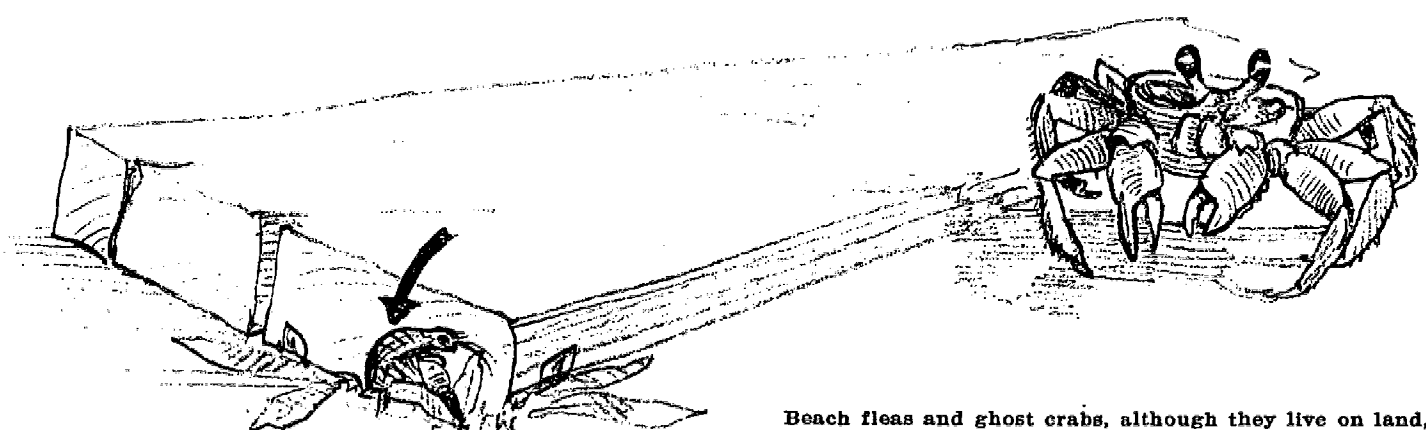
Tidal cycles produce the problems of exposure to drying air and increased temperatures. Comparatively few species have adapted to living in this environment. However, those species which do inhabit the area are present in large numbers since there is little competition from other species. Food is plentiful and a fresh supply is delivered with each incoming wave.

Plants

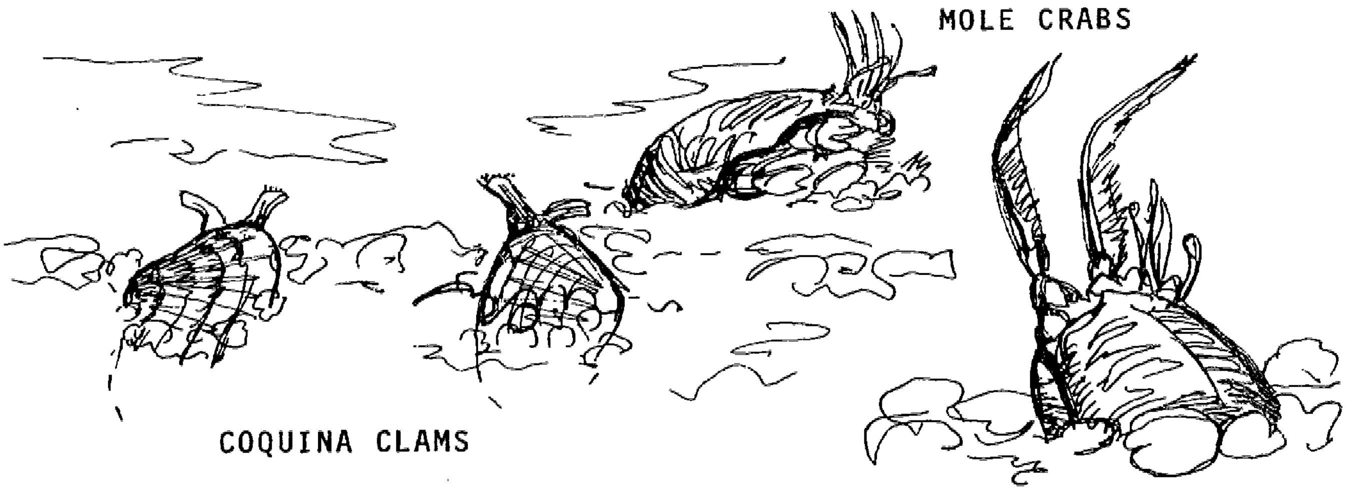
Due to strong wave action and unavailability of suitable substrate, rooted plants will not be found living in this area. Dead and decaying plant matter is deposited at the drift line, providing food and shelter for insects and other scavengers. The most important plants in this area, the **phytoplankton,** are swept into the intertidal zone by the waves and used for food by the coquinas and mole crabs.

Animals

Small forms, barely visible to the naked eye, are abundant between the sand grains but the most obvious inhabitants are the coquina clam and the mole crab. Both of these organisms feed on the phytoplankton, both are varieties of suspension feeders, both are burrowing organsms, and both are physically constructed to withstand the pounding surf.



Beach fleas and ghost crabs, although they live on land, must still wet their gills to breathe.



The mole crab and coquina burrow under the sand at the edge of the water. Both filter the water for food. The mole crab uses its feathery antennae to trap food from the water.

OPEN BEACH — UPPER BEACH ZONE

Physical Factors

The upper beach is seen as an area of open beach above the drift line. The light intensity is high, the temperature intense, there is little water, and the prevailing winds spread a cutting rain of sand particles. The following temperatures were taken at Shackleford Banks on June 16, 1967, along the upper open beach.

4 inches above the sand	28.5°C
Surface	39.5°C
Ghost crab burrow	26.0°C
Ocean surface	24.0°C

Plants

This wide stretch of beach is generally uninhabited by plants. Near the dune community, an occasional straggler from the fore-dune area may grow on the ocean beach and in so doing, may be forming the nucleus of a new dune.

Animals

Limited to those animal species adapted to intense heat, high light intensity, and a limited water supply. Most burrow into deep tunnels during the day. At night, they wander about the open beach and into the drift line in search of food. Most are scavengers. The ghost crab illustrates this type of adaptation. The beach flea avoids extremes of heat and light by seeking shelter under seaweed and other debris which litters the beach.

A ghost crab views the world from the mouth of its burrow.

DUNES

The sand dunes are areas of harsh physical forces. Prevailing winds carry abrasive sand particles and salt spray from the ocean. Trees, when present, are generally stunted, as the salt spray kills many of the buds on the side of tree facing the ocean. Organisms must be adapted to survive intense heat, wind-blown salt and sand, limited water supply and low soil fertility.

Plants

The sea oat is the most common plant on the fore-dune area. It is the primary dune builder in North Carolina and its extensive root system may reach as deep as 5-6 feet below the surface. Growing in the protected areas behind the fore-dune, a variety of plants may be encountered and salt meadow cordgrass usually replaces sea oats as the primary dune stabilizer. Some of the more common plants are sea kale, dune spurge, sea-side evening primrose, prickly pear cactus, sand spur, potato vine, sea elder and cat briar.

On some beaches, persistent winds pile the sand and form the large dunes one often sees north of Hatteras. These dunes frequently lack the characteristic dune vegetation since the sand grains are constantly blown about by the wind. The wind blows the sand grains up the slopes and over the other side. This constant movement generally prevents the growth of stabilizing plants and causes these naked dunes to migrate slowly over the land, engulfing the trees growing behind the dunes.

Animals

The dune area is populated by birds and insects and visited by others which find their food elsewhere.

MARITIME FOREST

Weathered live oak trees

The maritime forest is an area behind the dunes identified by a dense growth of vegetation, often stunted in appearance. This area supporting trees and shrubs has a richer soil and is more protected from the salt laden prevailing winds than the sand dune situation. The trees and shrubs common to the maritime forest have in some manner adapted to survival in an area where wind borne salt spray is a dominant physical factor. As winds move the dunes backward, sand covers large tracts of the maritime forest eventually killing the trees. The result is an area covered by sand-blasted, sun-bleached, grey remains of cedar trees often called "ghost forests." Numerous examples of this can be seen at Shackleford Banks, Nags Head, and Baldhead Island. Occasionally, the sea encroaches upon the maritime forest as strong shore currents erode away the land (Smith or Baldhead Island near Southport, for example). Man has also contributed to the destruction of maritime forests. Large areas of Cape Hatteras National Seashore, once forested, were stripped for timber.

The maritime forest is a narrow strip of vegetation and generally occupies an area within a few miles of the ocean. It is usually found on the banks and islands along the coast and in areas where the banks are narrow, it will be found on the mainland. There are many examples of mainland maritime forest in coastal counties.

Plants

There are numerous trees, shrubs, and vines represented in the maritime forest. The most common trees are live oak, yaupon, red cedar, red bay, American holly, beach olive, and ironwood.

Animals

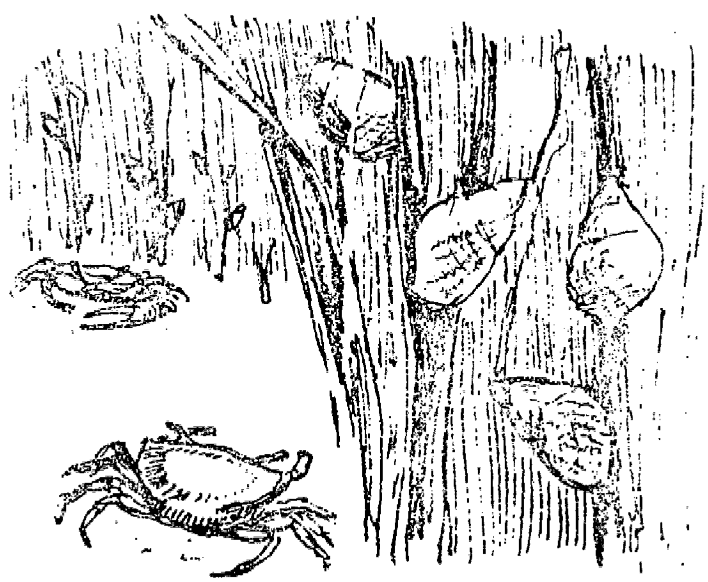
The maritime forest contains most of the animals represented in any "typical" coastal forest community.

TIDAL SALT MARSH

In this habitat, the organisms are subjected to gentle wave action and little wind action because they are protected by a heavy cover of plants. The salt marsh organisms face stress of another nature. The salt marsh is subject to tidal change, so the organisms must be adapted to surviving alternating periods of exposure to sun and air. As the tide falls, pools of water are left behind in shallow depressed areas. The heat from the sun results in evaporation and a corresponding increase in salinity. During periods of heavy rainfall, the runoff from the land into the salt marsh produces a period of low salinity. Many organisms cannot withstand a high salinity whereas others cannot withstand a low salinity. The organisms which live in the salt marsh must be able to tolerate a wide range of salinities. The substrate is generally muddy and the water is turbid and silt-laden. The substrate has a low oxygen availability. Due to high bacterial activity, resulting in the decay of organic materials, the mud is rich in hydrogen sulfide. After periods of heavy rainfall, overflow from the land, often rich in fertilizers, adds to the fertility of the salt marsh.

Plants

Phytoplankton abounds in the nutrient-rich waters around the salt marsh and mud algae are abundant in the surface mud of the intertidal zone. In the areas of the salt marsh covered by water during high tide, smooth cordgrass is the dominant plant. In well-drained areas, this plant grows to a height of 2-3 feet but in poorly drained, depressed areas, the grass is stunted due to the effects of increased salinity. In the higher intertidal areas of the marsh, needle rush is found. This is an ideal nesting area for many types of birds. The glasswort is also common. It is widely distributed in the intertidal zone and adds splashes of red to the marsh during the autumn.



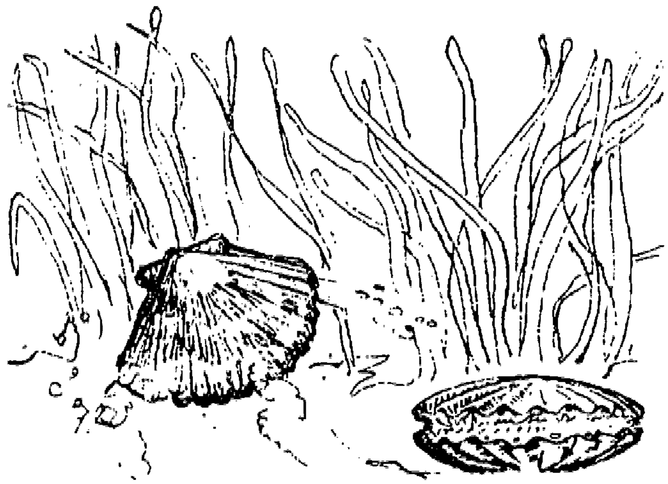
Fiddlers and marsh periwinkles feed during low tide.

Animals

Animals, like the plants, must be adapted to the rhythmically changing conditions of the salt marsh. Some of the more common animals to be found in the salt marsh are: mud fiddler, mussel, oyster, marsh crab, periwinkle, blue crab, birds, raccoons, fish, and the diamond-back terrapin.

TIDAL FLAT: Sand and/or mud flats

The tidal flat is an area of little wave action, varying salinities, and extremes of temperature. Firm substrates for attachment of sessile organisms are sparse and limited to shells, tin cans, and other types of debris. In areas of extremely gentle wave action, the substrate will be muddy and the oxygen availability low, whereas in areas where there is more wave action or current activity, the substrate will tend to be sand. Sand, being more porous than mud, generally has a higher oxygen availability. The majority of the species have adapted to these conditions by burrowing into the substrate or moving with the tidal cycles.



Scallops in a bed of eel grass

Plants

The waters surrounding the tidal flat abound in phytoplankton and the surface substrate contains mud algae. Some of the sessile seaweeds are frequently found attached to shells or debris. In the subtital zone, eel grass provides a protective bottom covering for scallops, burrowing anemones, crabs, etc.

Animals

The tidal flat represents an area extremely rich in animal life. Many types of molluscs, crabs, shrimp, annelids, echinoderms, coelenterates, and chordates are found in this habitat.

JETTY

Tidal cycles, alternate flooding and drying out, varied temperatures, predators, and wave action in varying degrees are factors which affect the organisms living on the firm substrate of the rock jetty or piling. These organisms must have some mechanism to protect themselves from drying out and must be adapted to withstanding extreme heat during periods of low tide. Some withdraw into a shell (barnacle), others attach to the underside of a rock (chiton, oyster drill), and others retreat to shaded tidal pools (sea urchins, starfish). Most of the plants attach to the rocks in the subtidal or intertidal zones.

Plants

Phytoplankton common to the ocean and estuary are frequently carried into the intertidal and subtidal zone by water currents. The larger forms of seaweeds will be found attached to the rock jetty or piling in the subtidal and intertidal zones. The types of chlorophyll possessed by a particular seaweed will determine the desirable light intensity for photosynthesis, and this in turn will determine the depth at which it can survive after attachment.

Animals

The animals are represented by those species able to withstand exposure to heat and drying out during low tide and strong currents and wave action during high tide. The more common organisms are sea urchins, brittle stars, starfish, oyster drills, banded tulip shell, oysters, barnacles, soft coral, sea anemones, slugs, sponge, sea roach, byrozoans, and various hydroids.

INLAND ECOSYSTEMS

From the spray-dominated dunes, there is a gradual change as one moves into inland areas. The maritime live oak forest, even on the back side of some of the Outer Banks, is replaced by other oaks and hickories.

However, there are many other types of communities scattered about coastal counties: fields, pine woods, bogs, swamps, grasslands, and odd mixtures of these types. Partly these reflect human interference. Disrupted communities are apparent everywhere.

Many communities are related in stages of development called "plant succession," which systemtaically changes grassland to weed field to pine forest to harwdood forest. This is explained in the "old field" section.

Other communities linger for many years without drastic change because they have special soil or water conditions, or because fire keeps setting back succession.

OLD FIELD

The "old field" sequence is an example of secondary succession, which generally occurs after the abandonment of a previously cultivated field or serious forest fire. The first five years produce a succession of grasses, horseweed, ragweed, and aster. Broomsedge is then the outstanding species for a few years, followed by the appearance of loblolly or short leaf pine. The pine forest develops rapidly and becomes an almost solid stand. However, pine seedlings require a high light intensity and cannot survive in the shade of the parent trees, and hardwoods which can now begin to grow in as an understory. As the original pines begin to die out in 75-100 years, oaks and hickories assume dominance. Since the hardwood forest will continue to replenish itself indefinitely without further succession, it is called the "climax community".

If a fire should occur in a pine forest when the hardwoods are still small, the hardwoods and undergrowth will be burned out and the pine forest will get a new lease on life. However, if the fire should occur in a pine forest which has escaped serious fire for several years and therefore has a tall understory of oaks and hickories, the complete forest will be destroyed and succession will once again begin at the old field stage. To prevent this situation, the Forestry Service "control burns" large tracts of forest land while the oak-hickory understory is still small.

SAVANNAH

A savannah is a rather permanent boggy area of grasses and sedges, which does not follow old field succession. Often there are scattered long leaf or loblolly pines. The soil is periodically flooded. In spring and summer, the savannah is a large natural garden covered by hundreds of species of wild flowers. The savannah is maintained by fire, for if the undergrowth were not burned out every 3-5 years, succession would occur and the characteristic wild flowers would be unable to compete successfully with the encroaching shrubs and trees. The savannah is the home of the unusual pitcher plant, sundew, and Venus fly trap. Railroad and highway right-of-ways frequently support savannah-type vegetation and are generally accessible to schools for study and observation.

POCOSIN

The pocosin is a damp, depressed area. It is recognized by its shrubby, evergreen growth. The plants most common to the pocosin are the loblolly bay, sweet bay, pocosin pine and myrtle bushes. The sweet bay is readily recognized by the white undersides of its leaf. It is in the area of the savannah near the pocosin where pitcher plants, sundews, and fly traps are generally found.

SANDHILL OR LONGLEAF PINE FOREST

The sandhill community is characterized by white sand supporting a sparse cover of wire grass and frequently lichens. Longleaf pines and turkey oak are the dominant trees. Water availability and nutrient-poor soils are important limiting factors and during the summer months. Heat and high light intensity are important physical factors. The turkey oak has adapted to these extremes of heat and light by turning its leaves vertical to the sand surface, so that the broad sides of the leaves are not exposed to the heat and light being reflected by the white sand. This community owes its continued existence to fire, which periodically clears out the understory.

FRESH WATER SWAMP

The swamp is an area surrounding moving fresh water and dominated by large cypress and gum trees. These are the "black water" swamps of coastal areas. Usually, there is a dense undergrowth of various hardwood, shrubs, and vines. Like the savannah, the swamp is populated with colorful species of wild flowers.

SUGGESTED QUESTIONS

1. Is there any relationship between the physical factors of an ecosystem and the animals that inhabit that ecosystem? The plants?
2. The mole crabs lives in the intertidal zone and feeds on phytoplankton. Describe the habitat and niche of the mole crab.
3. Do you think the destruction of one ecosystem could have an effect on another ecosystem? Discuss.
4. In old field succession, what physical factor prevents pines from becoming the climax vegetation

LIMITING FACTORS

Any environmental factor that tends to limit the survival and distribution of an organism or a community of organisms is said to be a **limiting factor.** In the first session, you were introduced to numerous limiting factors as they function in actual communities: temperature, salinity, water availability, light intensity, soil type, and oxygen availability. Limiting factors must be considered in the maximum as well as the minimum and it must be recognized that factors interact. For example, lobsters can survive in temperatures down to 10°C. when the salinity and oxygen content of the water is high, but when the salinity decreases, the lobster's tolerance to temperature lessens and it is killed at the higher temperature of 12°C. In this case, we see an interaction between three factors: temperature, salinity, and oxygen availability. **In many cases, when one factor is altered, the organism's tolerance to other factors is also changed.**

The prefix "**eury**" is often used to indicate a wide range of tolerance and "**steno**" to designate a narrow range. Organisms with wide ranges of tolerance are likely to be widely distributed but a wide tolerance range to one factor does not mean a wide range of tolerance to all factors. An organism may be euryhaline but stenothermal. The first attribute would contribute to successful survival in the varying salinity of the estuary whereas the second would not. The shallow estuaries are more subject to daily and seasonal temperature changes than the oceans, so either a eurythermal physiology or the ability to move periodically from the area would be required for successful adaptation to life in the estuary.

An organism's physiological tolerance for such factors as temperature, salinity, oxygen content, etc., can be accurately determined in the laboratory, but caution should be the rule in applying such knowledge to the field. What is true on the organism level may not be true on the community level. **The organisms are not found under optimum conditions in nature and there is an interrelation of factors that may or may not be apparent in the laboratory.**

Temperature as a Limiting Factor

More work has been accomplished in regard to temperature as a limiting factor because it is one of the easier factors with which to deal. When experimenting with limiting factors, one must first establish criteria to determine when an organism is to be considered dead. Such factors as heart rates, ciliary motion, and locomotion are frequently useful.

Stress refers to a condition in which an organism encounters a higher or lower temperature, more or less O_2, higher or lower salinity, etc., than it normally encounters. Some individual organisms and species are able to adjust to stress or **compensate** for stress more readily than other individuals or species. An individual may appear "happy" and active under thermal stress. Erroneous conclusions could easily be reached unless further experimentation indicated, for example, that these normal individuals were sterile. The individual survives but the population is doomed. Fiddler crabs under certain types of thermal stress lose their ability to move about. The individual is not dead, but cannot escape predators or feed. Either poses serious problems in the natural setting.

There is also a problem of individual differences. There are always unique animals in any group which can survive stresses. Some keel over quickly, and some do not. Researchers must use large numbers of animals and observe the point at which 50% are killed by the factor being studied. This is the explanation of the "$L.D._{50}$" term so often seen in such research.

Acclimation in respect to temperature adaptations, refers an organism's compensation under laboratory conditions for persistent changes in environmental temperature.

Fiddler crabs from the tropics, previously acclimated at warm temperatures of 22-24°C. (warm-acclimated), reached an $L.D._{50}$ in 35 minutes at a temperature at 7°C. After being cold-acclimated for 7 days at 15°C., it took 50 minutes to attain $L.D._{50}$.

Within genetic limits, organisms can compensate within their physiological make-up to changes in temperature, salinity, oxygen availability, etc. The range of physiological variation is determined by heredity, which in turn dictates the area of distribution or habitat of a given organism.

In the natural environment, northern and southern individuals of the same species of *Aurelia*, a jellyfish, were studied to determine upper temperature tolerances. No acclimation was attempted. The northern population showed an upper limit of 20.3°C. whereas the southern population survived in water temperatures up to 39.5°C.

A similar study was conducted on *Limulus*, the horseshoe crab. The group collected from the waters around Woods Hole, Massachusetts, had a high lethal of 39.5°C. whereas the group collected from Florida coastal waters showed a high lethal of 46.2°C.

Picture in your minds the habitats of oysters and scallops, and decide which of the two is most likely stenothermal and why. Your logic would be that the scallop, which remains under water all the time, would not be exposed to air temperature extremes each day, as the oyster is. Therefore the oyster must be more eurythermal. Using ciliated epithelial tissue from various molluscs, one researcher found that those molluscs from great depths had a lower thermal resistance than those from intermediate depths and especially intertidal forms.

Temperature was discussed thoroughly in order to give you an understanding of a limiting factor, how it is studied by biologists and how it fits into the total picture of an ecosystem. Other limiting factors are of equal importance and if time is available, you may wish to explore them further. As you read and study about the various coastal ecosystems, you will learn to recognize salinity, substrate type, food, light, oxygen and water availability as important limiting factors.

CHEMICAL CYCLES

In the opinion of E. P. Odum, the interaction of energy and materials in the ecosystem is of major importance to the ecologist. The circulation of materials and the one-way flow of energy are two major principles of general ecology, since these principles apply equally to all environments and all organisms, including man. The more or less circular paths of the chemical elements passing back and forth between organisms and environment are known as **biogeochemical cycles.**

Perhaps the earliest recognition of a chemical cycle appears in Genesis III: "Dust thou art, and unto dust that shalt return." Many natural cycles are known. Some of the cycles require only physical changes, as when liquid water is converted to water vapor in the water cycle. Other cycles involve chemical as well as physical changes. Although each of the cycles may be separated for identification and analysis, all are interdependent and operate continually and concurrently.

Of the ninety or more elements found in the natural situation, 30-40 are required by living organisms. Hydrogen, oxygen, and nitrogen are needed in large amounts whereas the others ar needed in minute quantities. A **perfect cycle** is one in which the elements travel quickly from organisms to environment. In less perfect cycles, the chemical may get "lost" for a period of time in a place or be bound in a chemical form inaccessible to organisms. The nitrogen and carbon cycles are more or less perfect as opposed to the phosphorus cycle. Phosphorus may be lost for centuries in the great ocean depths before it is converted to a form usable by plants and returned to the surface by upwelling currents, where it may be utilized by phytoplankton. Phosphorus is required for most of the basic energy transformations that distinguish living protoplasm from non-living systems.

The Nitrogen Cycle

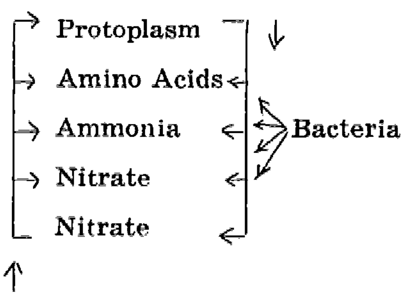
a. Protoplasm is broken down from organic to inorganic matter by a series of decomposer bacteria, each specialized for its special part in the cycle.

b. Some of the nitrogen ends up as nitrate (the form most readily used by green plants), and some of the nitrogen is used in other forms, completing the cycle.

c. The great reservoir for nitrogen is the air.

d. In the breakdown from protoplasm to nitrate, the organisms doing the "breaking-down" receive energy from the process.

e. In the return build-up by living plants, energy is required from other sources such as organic material or sunlight.



1. The build-up on the left hand side requires an outside source of energy.

2. The break-down on the right hand side provides energy.

SUGGESTED QUESTIONS

1. If all the trees along a mountain stream were cut down, there is a good chance that the trout would die whereas the bass would be unaffected. Which of the two is stenothermal?
2. Discuss the relationship of limiting factors to the area of distribution of organisms.
3. Why would organisms generally have a smaller margin of safety near the boundaries of their distribution?
4. Refer to page 42 in *Modern Biology*. Relate the chart "Elements Essential to Man" to the importance of chemical cycles.

PHOTOSYNTHESIS

All living cells require energy every second of their existence for cell activities such as growth and repair. Energy does not cycle like the elements discussed in the previous block. The flow of energy into a system must be constant and is generally derived from light or the breakdown of complex organic molecules. Plants use light as an energy source in the production of food, hence they are called **producers**. Animals are not capable of making their own food and are ultimately dependent on plants for survival. Those organisms dependent on an outside source of food are **consumers**.

The green plant is capable of converting simple inorganic compounds, carbon dioxide (CO_2) and water (H_2O), into a complex molecule called glucose ($C_6H_{12}O_6$). Without glucose, we could not live. Glucose is a component of every living cell and about one tenth of the blood is glucose. The living plant cell is capable of converting glucose into complex sugars, starches, fats, and proteins by the addition or subtraction of various elements or molecules, accompanied by specific chemical changes. A person could spend the reast of his life relaxing in the sun, blowing CO_2 through a straw into a glass of water without producing one single molecule of glucose. All the essential substances are present — water in the glass, energy from the sun, and CO_2 in the exhaled breath — but the essential catalyst, chlorophyll, is lacking.

$$6CO_2 + 6H_2O \underset{\text{Chlorophyll}}{\overset{\text{light}}{=}} C_6H_{12}O_6 + 6O_2$$

If you have already studied the process of photosynthesis, the inadequacies of the formula are obvious and familiar but at this point, it would be best not to confuse the issue or you, the student, with further elaboration.

RESPIRATION

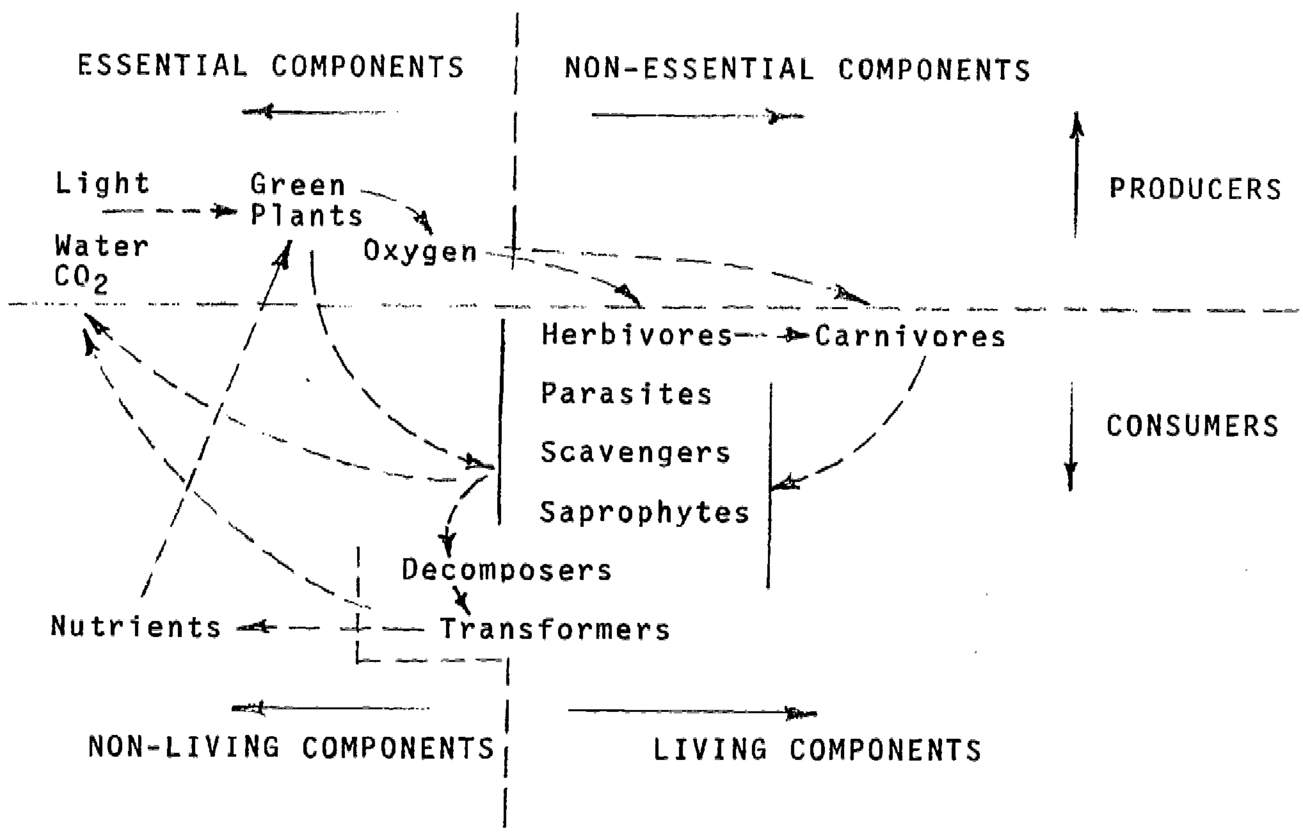
Most of you probably consider respiration as simply breathing. You have no real concept of oxidation and don't view respiration as the step-by-step breakdown of food and the release of energy. All cells require a constant supply of energy and this demand is satisfied by some form of respiration. For our purposes, only a brief explanation will suffice.

As you recall, during photosynthesis energy was stored in glucose and other foods produced by plants. Respiration results in the step-by-step breakdown of food in order to release this stored energy. Some of the released energy is made available to the cell and is utilized to maintain cellular activities.

The most effective method of presenting respiration may be to compare it with photosynthesis. Again, the comparison is over-simplified but will nevertheless serve to transmit the basic idea. Only the differences are presented whereas there are also similarities.

PHOTOSYNTHESIS	*RESPIRATION*
$6CO_2+6H_2O=C_6H_{12}O_6+6O_2$	$C_6H_{12}O_6+6O_2=6H_2O+6CO_2$
Energy is stored	Energy is released
Building process (simple to complex)	Destructive process (complex to simple)
Light required (intermittent process)	No light (continuous process)
Chlorophyll required	No chlorophyll
Occurs only in cells containing chlorophyll	Occurs in all cells

The following diagram is included to give you an overall idea of the relationship between the processes of photosynthesis and respiration and to present a picture of the flow of materials through the ecosystem.



FOOD CYCLES

It is important to emphasize that non-energy-yielding materials circulate, but energy does not. Nitrogen, carbon, water and many other materials circulate many times between the organic and the inorganic world. Once energy has been used by a given organism or population, it is converted into heat and lost from the ecosystem. Food eaten yesterday is no longer available once it has been respired. Life is kept going by the continuous flow of sunlight into the ecosystem from the outside.

The one-way flow of energy into an ecosystem is a result of the operation of the laws of thermodynamics. The first law states that energy may be transformed from one type to another (light to chemical) but is not created nor destroyed. The second law states that in such a change energy is always lost because of heat dissipation, so no change can be 100% efficient.

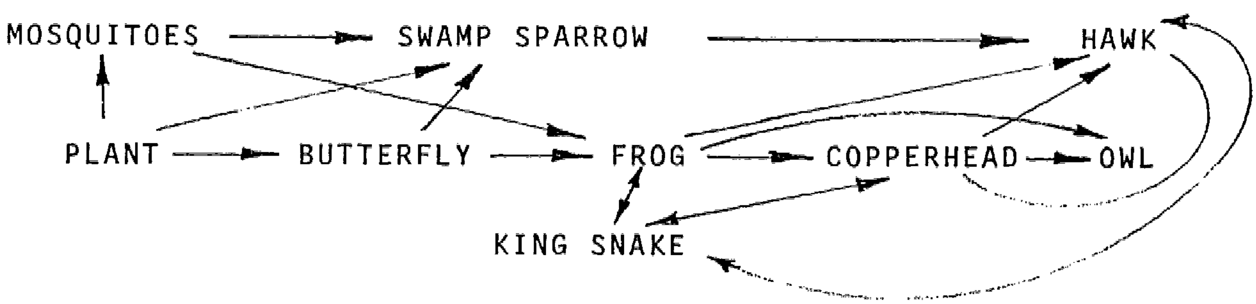
E. P. Odum defines a **food chain** as the transfer of food energy from the source in plants through a series of organisms with repeated stages of eating and being eaten. At each stage in the chain, energy is lost as heat (second law) and will not be available to the next stage in the chain. The shorter the food chain, and the closer the organism is to the original source, the plant, the greater is the availability of energy per mass eaten.

"Food chains follow a general pattern: Green plants, herbivores, carnivores, still larger carnivores, and so on until we come to the 'top carnivore' that has no larger predators. On land where there are many large herbivores, food chains are short and have only two or three links. In our western grasslands it could be grass, cow, and man; in an African grassland: grass, zebra, and lion. In a Pennsylvania meadow, with small herbivores, there might be five links: grass, cricket, frog, snake, and hawk. In aquatic habitats, herbivores or usually minute, and it usually takes five or more links to convert plant substance into an animal that has no larger enemies. The food chain is useful as a working tool in tracing out who eats what, but by itself it gives an inaccurate picture of what is happening in the community . . . Some organisms can fed in only one way and sometimes only on one species of plant and animal. Most members of a community are not so highly specialized and they can eat more than one kind of food . . . and regularly do so. So-called 'seed-eating' birds eat insects in the spring. Foxes eat mice when they are abundant, go after rabbits when mice are scarce, gorge on berries when berries are ripe, shift to fallen apples and grasshoppers in the fall. Small herring eat not only copepods but almost any kind of small marine larvae or snails and barnacles. Small herrings themselves are eaten by arrow worms, which are then eaten by larger herring. Such relationships, in which every predator eats several kinds of food and every kind of food is eaten by many different animals, cannot be expressed by a row of parallel chains lying side by side. When diagrammed, the total of all the food chains in the community becomes a food web."

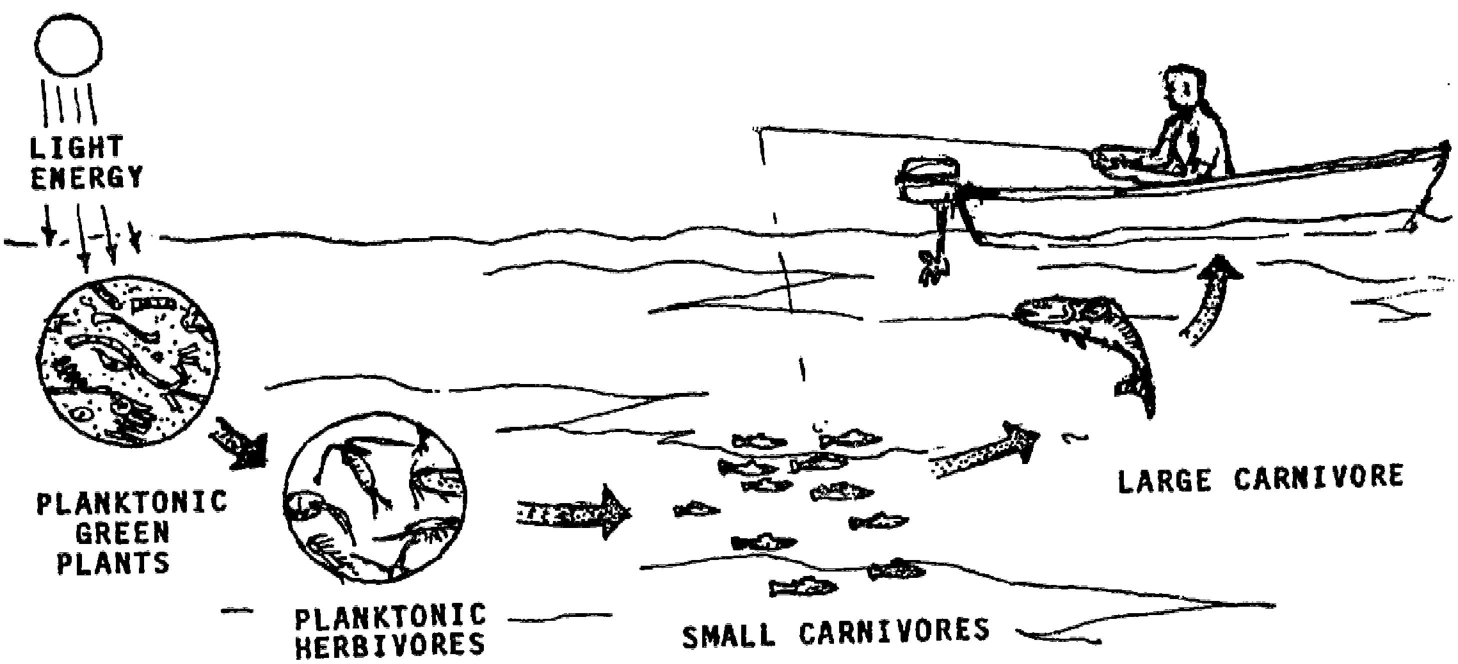
FRESH WATER SWAMP FOOD CHAIN

PLANT → BUTTERFLY → FROG → COPPERHEAD → OWL

FRESH WATER SWAMP FOOD WEB



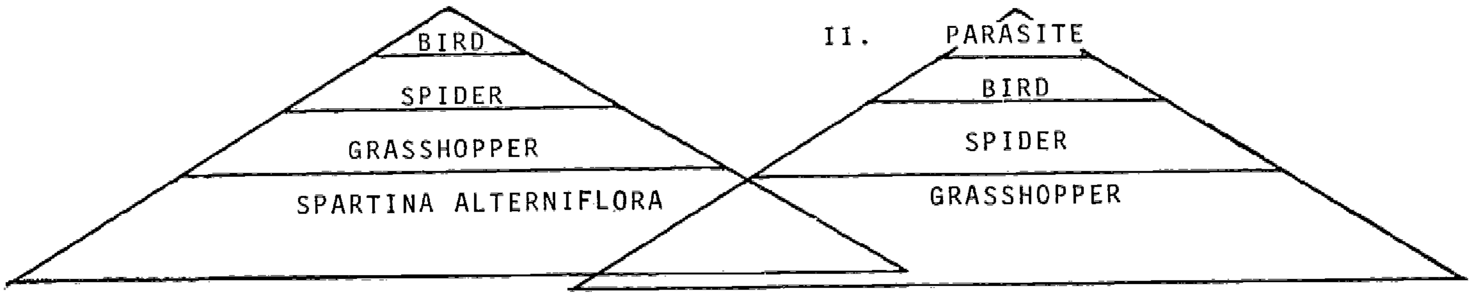
MARINE FOOD CHAIN



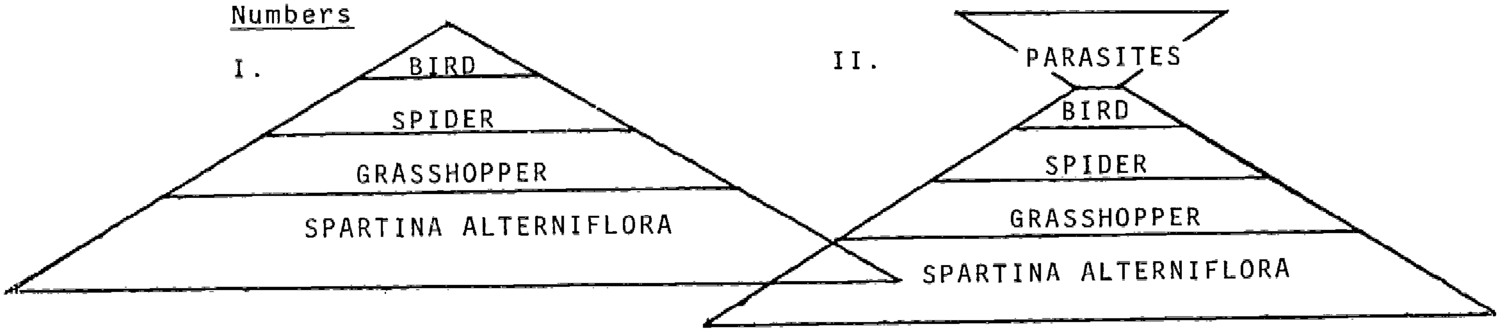
Food Pyramids

Food chains are sometimes represented as a food pyramid, with the top carnivore at the apex and the producers forming the base. A food pyramid can be constructed to represent the numbers of individuals present at each level or the biomass present at each level.

Biomass



Numbers



SUGGESTED QUESTIONS

1. Why is it essential that plants carry on respiration as well as photosynthesis?
2. How was light energy stored in the food you ate for breakfast?
3. Why is energy essential to the living cell?
4. Why isn't energy re-cycled?
5. Why doesn't a food chain present a realistic picture of the food relationships in an ecosystem?
6. Refer to pages 81 and 82 in *Modern Biology*, "Energy to Maintain Life Activities", and discuss the situations presented in that section.
7. What happens to energy in each step of a food chain? Why?

COASTAL ECOLOGY LAB EXERCISE

Purpose

These outlines will acquaint you with a variety of the organisms commonly found in the tidal salt marsh and give you an opportunity to observe and work with them. This experience should give you some measure of insight into the concepts of ecology and some practice in collecting, analyzing, and presening data in a scientific and orderly manner.

General Information

You will be assigned work as a group. The nature of the work and the manner in which it will be accomplished will require a certain amount of movement and conversation. Conversation should be kept as quiet as possible and movement should be deliberate and careful. One careless move can easily result in damage to an expensive microscope. The following hints will help reduce the possibility of accident or mishap during the lab period.

1. Clear table tops of pocketbooks, coats, books, etc.
2. When you leave your chair, always push it under the table.
3. Don't place your microscope too near the table edge.
4. Always transport a microscope with both hands.
5. **Do not** use the high power lens during this exercise.
6. **Do not** play in the lab — it's too dangerous.
7. If you find that you can't focus your microscope, don't hesitate to ask the teacher or lab assistant for help.

GROUP I

Your group will work with some of the producers in the tidal salt marsh. As a group, discuss the meaning of the Biblical quotation, "All flesh is grass." Divide yourselves into two sub-groups. Each sub-group should spend most of the period working independently. Both sub-groups should allot fifteen to twenty minutes at the end of the period to discuss together the findings of each sub-group.

Each individual will be responsible for writing a summary of the lab exercise conducted by his sub-group. The paper should include a brief explanation of the techniques and procedures used, the results obtained, and the answers to the questions on the lab sheet pertaining to your particular sub-group. Each group will be given fifteen minutes during the lab evaluation to make a report and answer questions. In the case of Group I, each sub-group will be given eight to ten minutes for reporting. Each individual will not be called upon to make an oral report to the class but each individual will be expected to answer questions concerning his lab activities.

SUB-GROUP A

Equipment

Slides, coverslips plankton sample, droppers, paper towels, lens paper, microscopes.

Procedure

1. Take a drop of water from the sample bottle and place it on a clean slide. Cover the drop of water with a coverslip.

2. Observe the various organisms, using the lower power lens. Make a diagram of the ones which appear most frequently.
3. Do any of the organisms move? If so, how?
4. Can you distinguish plants from animals? How?
5. Repeat the procedure several times. Compare your results with others in your sub-group?

Questions

1. Basically, what is the importance of plankton in the ecosystems?
2. What general types of organism are represented in the plankton?
3. How does the movement of plankton relate to water currents?
4. Are all planktonic forms destined to remain plankton throughout their existence? Why?
5. What are some factors which might influence the plankton population in any specific area?

Summary

1. Have you completed the lab activities?
2. Have you answered all the questions pertaining to your sub-group? The rest of the questions can be answered during the group reports.
3. Have you used the resource materials?
4. Have you discussed the lab exercise and questions with the other members of your sub-group?
5. Have you taken notes in preparation for writing your report?

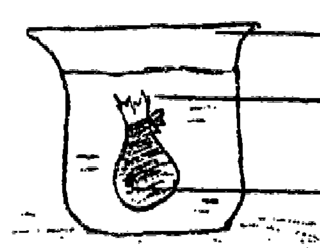
SUB-GROUP B

Equipment

Selectively permeable membrane, concentrated salt solution, distilled water, dye, and large beaker. Tidal marsh plants, preferably fresh specimens with roots (*Spartina, Juncus, Salicornia,* and *Borrichia*).

Procedure

Fill a membranous bag with colored water (distilled). Secure the top of the bag with a string and place in a beaker of highly concentrated salt water. Observe the results.



Questions

1. Do you observe a color change? If so, where?
2. What happens to the size of the sack?
3. What does this exercise tell you about the movement of salt and fresh water?
4. Your body cells contain about 0.9% salts. Sea water contains about 3.5% salts. Apply this to your experiment and indicate the results of drinking salt water in place of fresh water.
5. Apply the same principle to plants living in the salt marsh. Their cells also contain low salt concentrations but they live in an environment where the salt concentration may range up to several times 3.5% concentration. What sort of basic problem does this present to these plants? Does the quotation, "Water, water everywhere, but not a drop to drink", apply to plants living in a salt marsh? Explain your answer. Explain how *Salicornia* must be an exception to this principle.

Summary

6. Observe each plant specimen carefully in search of physical characteristics which may be part of its adaptation to high salinity.

1. Have you completed the lab activities?
2. Have you answered all the questions pertaining to your sub-group. The rest of the questions can be answered as each group reports during the lab evaluation period.
3. Have you used the resource materials?
4. Have you discussed the lab exercise and questions with the other members of your sub-group?
5. Have you taken notes in preparation for writing your report?

GROUP II

Your group will be working with some of the consumers found in the tidal marsh. Divide yourselves into two groups. Each sub-group should spend most of the period working independently. Both sub-groups should allot fifteen to twenty minutes at the end of the period to discuss together the findings of each sub-group.

Each individual will be required to write a summary of the lab exercise conducted by his sub-group. The paper should include a brief explanation of the techniques and procedures used, the results obtained, and the answers to the questions on the lab sheet pertaining to your sub-group. Each group will be gvies fifteen to twenty minutes to make a report and answer questions during the lab evaluation period. In the case of group II, each sub-group will be given eight to ten minutes for reporting. Each individual will not be called on to make an oral report but each individual will be responsible for answering questions concerning his lab activities.

SUB-GROUP A

Equipment

A large finger bowl, salt water, powdered carmine, live oysters, *Crassostrea*, and the following animals, preferably alive: *Nassarius* (mud snail), *Littorina* (periwinkle), *Uca pugnax* (mud fiddler), *Sesarma* (mud crab), *Modiolus* (mussel), and several small finger bowls.

Procedure

Part I Place one specimen of each organism in a small finger bowl.

1. Which of the salt marsh consumers appear to be the most closely related?

2. What is the basis for your answer?

Part II Hold an oyster with its hinge facing you. The left valve (shell) will then be on your left and the right valve will be on your right. Open the oyster carefully and remove the right valve and place the oyster (still in left valve) in a finger bowl half full of salt water. Sprinkle the exposed oyster with powdered carmine and observe the results.

1. Describe what you see.

2. Does the oyster appear to have any mechanism for the sorting out of food particles?

3. What sort of feeding relationship would you expect to find between the oyster and plankton?

4. How do you think the feeding habits of the fiddler crab and the oyster differ?

Summary

1. Have you completed the lab activities?

2. Have you answered all the questions pertaining to your sub-group? The rest of the questions can be answered as each group reports.

3. Have you used the resource material?

4. Have you discussed the lab exercise and questions with the other members in your sub-group?

5. Have you taken notes in preparation for writing your report?

SUB-GROUP B

Equipment

Beakers, salt water, *Nassarius*, *Littorina*.

Procedure

Part I Using the equipment provided and the two kinds of snails, *Nassarius and Littorina,* set up an experiment to indicate to you which snail prefers water to air as its habitat.

1. What are some factors you may have overlooked in your procedure?
2. How could you obtain more valid results?
3. *Littorina* climbs the blades of marsh grass as the tide rises. Does this correlate with the results of your experiment?

Part II There are two species of mud snails — *Nassarius vibex* and *N. obsoleta.* One prefers to live in sandy areas whereas the other prefers a muddy substrate. What advantage do you see in this arrangement?

1. Which differs, niche or habitat? Explain you answer.
2. List several explanations that may account for this situation?

Summary

1. Have you completed the lab activities?
2. Have you answered all the questions pertaining to your sub-group? The rest of the questions can be answered as each group reports.
3. Have you used the resource materials?
4. Have you discussed the lab exercise and the questions with the other members in your sub-group?
5. Have you taken notes in preparation for writing your report?

SALT MEADOW CORDGRASS
AND SHRUBS

THE SALT MARSH AS AN ECOSYTEM

Geological evidence indicates that salt marshes are thousands of years old. Tidal salt marshes are the result of land plants invading the shallow waters of the coastal areas. The most common boundary between sea and land is either a sandy beach, rocky shore, or salt marsh. The conditions in the salt marsh are not as harsh in many respects as those of the open beach. The quiet, protective waters of the salt marsh abound with myriads of species of shrimp, fishes, crabs, molluscs, annelid worms and crustaceans. The marsh is an example of an ecosystem in that it is an area which contains living organisms and non-living factors which interact. The boundaries of the salt marsh like ecosystems in general are not static. The fishes which inhabit the marsh during their juvenile stages may spend their adult life hundreds of miles out in the ocean. Migratory birds may stop for brief periods and raccoons from a nearby pine forest may wonder into the marsh during low tide in search of oysters and mussels. An ecosystem is not a self- contained unit but, instead, ecosystems tend to overlap.

Tidal salt marshes are greatly influenced by the tidal cycles. The total area of salt marsh covered during normal high tide depends on elevation, slope of the land, and to some degree, prevailing winds. In areas where the land slope is steep, the intertidal zone will be narrow but where the slope is gentle, the high tide waters may move far up into the upper reaches of the salt marsh during each tidal cycle. The tidal cycles and the contour of the land in the salt marsh combine to produce unique physical conditions. In depressed areas within the salt marsh where water may be trapped as the tide recedes, salinity increases due to evaporation of the water. The accumulation of salt in any given area depends on drainage, evaporation rate and the frequency of tidal flooding. On the other hand, river drainage and the acumulation of rain water tend to reduce the salinity of the salt marsh. The waters in and around the marsh are relatively shallow and are therefore subject to rather wide fluctuation in daily and seasonal temperatures.

Organisms living in the salt marsh environment must be adapted in some manner to surviving alternating periods of inundation and desiccation and the conditions which accompany the two. The zonation of the plant species in the salt marsh indicate this sort of adaptation. At this point, refer to student supplement sheets I, II, and III as this discussion is written to accompany these two diagrams.

In the drier supratidal zone several plants are commonly found growing in close association. The salt meadow cordgrass is generally dominant but shares the scene with sea ox-eye, spike grass, goldenrod and sea myrtle, as well as other plants and shrubs.

The salt barren represents a portion of the intertidal salt marsh flooded only twice a month during spring tides or during exceptionally high storm tides. As a result, the salinity content of the substrate is quite high and in some areas prohibits plant growth. The result is a path-like area which meanders about in the higher reaches of the "typical" salt marsh. Grasswort and spike grass grow on either side of the barren and frequently on raised areas within the barren itself. A few stunted individuals of salt marsh cordgrass will generally be found in this area.

The intertidal zone, is sub-divided into the upper and lower intertidal zone. In the upper intertidal zone, as a result of poor drainage and in frequent flooding, conditions are apt to be quite salty. The salt marsh cordgrass in this area is short, 5-8 inches, and is usually found in association with the dainty sea lavender, glasswort, and the widely distributed spike grass. The lower intertidal zone is flooded with each high tide so less salt accumulates in the substrate. As a result, the salt marsh cordgrass grows tall and thick. The height of the cordgrass seems to be directly related to water availability and indirectly to elevation, drainage, iron content in the substrate and salinity. The needle rush is found in the drier areas of the intertidal zone. It may be found growing on raised mounds in the lower intertidal zone or far back into the marsh where it is reached infrequently by tidal waters. Large stands of needle rush are evident in marshes which flood only irregularly.

The subtital zone is covered by tidal waters at all times. Various large attaching algae seaweeds are present as well as phytoplankton and zooplankton. Eel-grass, a flowering plant, grows in clumps along the bottom in the shallows. Close inspection of the eel grass beds will frequently reveal scallops and burrowing anemones.

It is evident from the written description and student supplements I, II, and III that certain groups of plants have adapted to the same factors and will be found living together in those areas with conditions compatible to their adaptations. The individual plants, however, may adapt to the same factor in a different manner. As an example, sea ox-eye and salt meadow cordgrass have adapted to living in the dry supratidal zone of the salt marsh. In sea ox-eye, water loss is reduced by the thickness of the leaf whereas in salt meadow hay, the leaf is long, narrow and curling inward, reducing the surface area.

The typical marsh substrate is mud-sand leaning greatly to mud. This type of substrate results in good drainage and low oxygen availability. Many of the burrowing forms such as annelid worms are sluggish and have low oxygen requirements. The fiddler crab is also a burrowing form but of a more active nature. The marsh crab is another crustacean common to the muddy substrate of the salt marsh. This crab constructs a larger burrow than the fiddler crab and feeds on salt marsh cordgrass as well as on an occasional fiddler crab.

The fiddlers and the marsh crabs retreat to their burrows during high tide and wander about feeding during low tide. The whitish marsh periwinkle, attaches itself to the salt marsh cordgrass and moves up and down the blades with the tides. The marsh periwinkle is an air-breather and cannot tolerate long periods of submersion. The blades of the salt marsh cordgrass are encrusted with various algae and planktonic forms.

During high tide the periwinkle grazes on accumulated material as it moves along the stalks of the cordgrass. Nassarius, the small black mud snail, is usually common on the muddy floor of the marsh. Melampus, another snail, is common in the drier, upper areas of the salt marsh. This creature is small and brown. Various fishes are common in the salt marsh and the shallow waters surrounding the marsh. The salt marsh is a nursery area for most commercial species in the Carolinas. All of the fishes of the salt marsh are small, even though some will later become large in the sound or ocean.

Study the chart below and compare the number of gills to the natural habitat for each crab listed. You will notice a trend toward gill reduction, especially among the more terrestrial ones. According to Nicol, modifications for holding water in the gill chambers is evident in many species of littoral crabs and in some terrestrial species.

GILL REDUCTION IN CRUSTACEA FROM AQUATIC TO TERRESTRIAL SPECIES

(After Pearse)

Species of Crab	No. of Gills	Body Gill Ratio	Habitat
Callinectes sapidus	16	23:1	Pelagic & Sublittoral
Menippe mercenaria	18	34:1	Sublittoral
Uca pugnax	12	46:1	Between tides
Sesarma cinereum	16	63:1	Hige-tide mark
Ocypode albicans	12	67:1	Upper beach

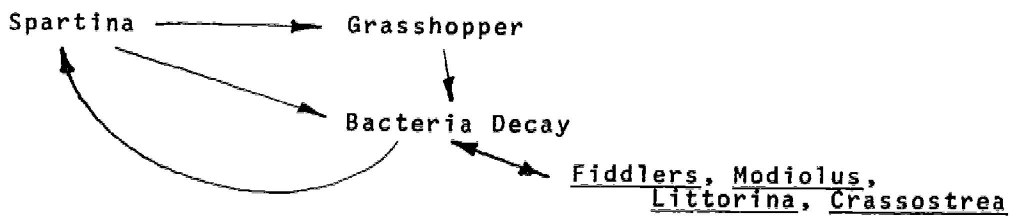
Few organisms feed directly on the salt marsh cordgrass but when it dies and decays, the nutrients are released into the surrounding waters and are ultimately used by mud algea and phytoplankton to construct complex organic compounds which are passed along the food chain. The waters around the marsh are shallow and nutrient-rich thus making them very productive in the sense of the amount of life they can support. The noted ecologist, Eugene Odum, found estuaries to be twenty times as productive as the open ocean and two times as productive as a corn field. The salt marsh is a nursery for many species of fish, crabs, shrimp, etc. Food is plentiful and protection from enemies is easily found in the shallows and eel grass. In the tidal creeks, only a few species of fish are usually represented by small numbers of individuals. As one moves up into a tidal creek, the species present change due to the decrease in salinity and the corresponding tolerances of the various organisms.

For purposes of nutritional division, the biotic portion of an ecosystem can be divided into two groups; producers (autotrophs = self-feeders) and consumers (heterotrophs = other-feeders). The producers argenerally the chlorophyll-containing plants whereas the consumers are those organisms lacking chlorophyll and thus unable to make their own food. The exceptional purple sulfur bacteria contain a unique form of chlorophyll called bacteriochlorophyll contained in granules rather than in grana common to the green plants. Forms such as these are called chemo-autotrophs.

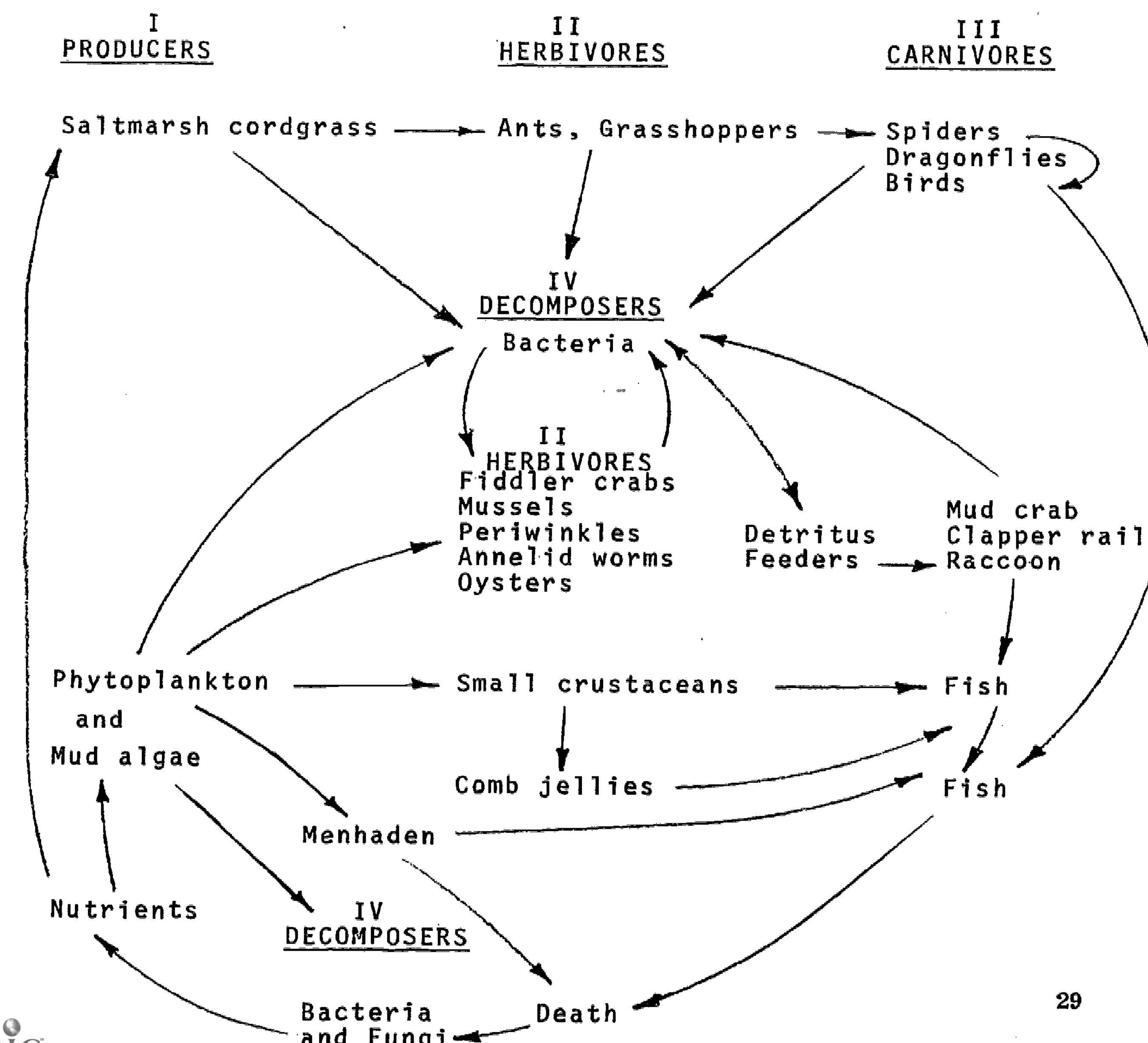
The heterotrophs may be further divided into three groups on the basis of diet: herbivores, carnivores, and scavengers or detritus feeders. These categories are not static since most carnivores eat plants occasionally, many predators are at times scavengers, and detritus contains small living animals that are eaten by detritus feeders.

Herbivores exist in two groups; those that eat plants directly and those that eat the plant in a stage of decay. An example of each type common to the salt marsh would be the grasshopper and the fiddler crab, mussel, oyster, and periwinkle. The grasshopper feeds on the plant tissue and juices whereas during low tide the fiddler crab and the periwinkle feed on deposited food. During high tide, the oyster and the mussel feed on suspended food particles of detritus and algae. The zooplankton and some fish such as the menhaden are included among the primary consumers or herbivores in the estuary.

The decomposers, generally bacteria and fungi, are those organisms which break down complex organic material into inorganic nutrients usable by plants. These nutrients thus are recycled to the producers.



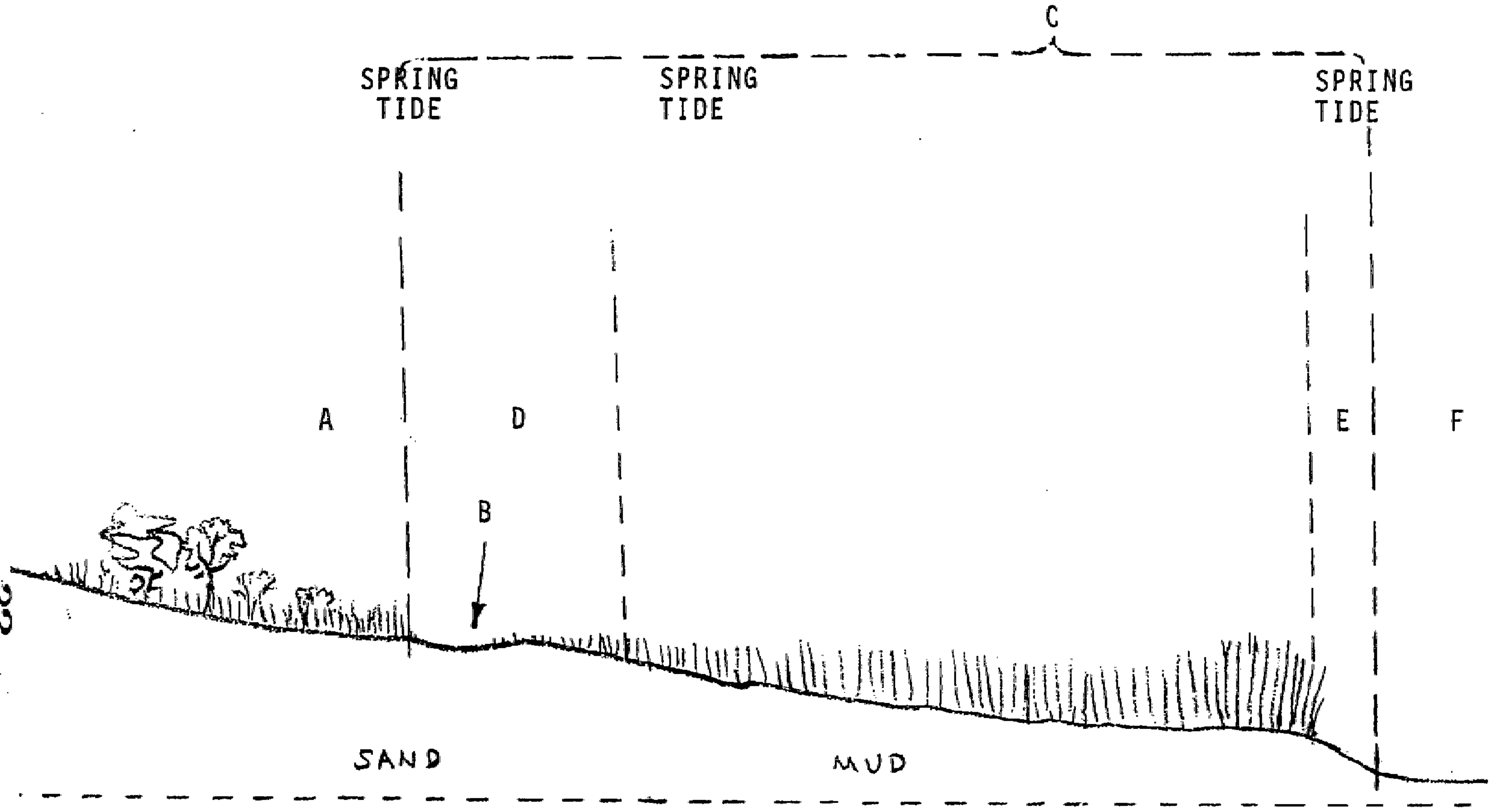
TIDAL SALT MARSH FOOD WEB



In other nutritional situations, the individuals live in direct association with each other. In some cases, the relationship is **beneficial to both organisms.** Some crabs carry living sponge or sea anemones on their back or pinchers. The crab benefits from the protective coloring of the sponge and frequently food is "shared" by the crab and the sea anemone. Both the sponge and anemone are sessile and are carried about by the crab. More environmental situations are available to their offspring. In other relationships, **one is helped whereas the other is neither hurt nor helped.** The remora or pilot fish attaches itself to a shark and feeds whenever the shark does. The final relationship occurs when **one organism is helped and the other hurt or damaged.** The larval form of the fresh water clam attaches itself to a fish for a period of its development. The Chinese liver fluke spends various portions of its life cycle as a parasite in fish, snail, and man.

STUDENT SUPPLEMENT I

Salt Marsh Transect



ZONATION

A. Supratidal Zone

B. Salt Barren

C. Intertidal Zone

D. Upper Intertidal Zone

E. Lower Intertidal Zone

F. Subtidal Zone

DIRECTIONS

The above diagram illustrates the correlation between elevation and zonation in the salt marsh. Refer to student supplement III for an aerial view of zonation and supplement II for a rundown of the plants and animals in each zone. Slides of these plants and animals are correlated with the diagrams to help familiarize you with the organisms common to the salt marsh. This transect is shown as a straight line on the aerial view.

STUDENT SUPPLEMENT II

ZONATION OF PLANTS AND ANIMALS IN THE SALT MARSH:

A. SUPRATIDAL ZONE

Plants

1.	*Juncus roemerianus* (infrequently)	black needlerush
2.	*Solidago sempervirens*	seaside goldenrod
3.	*Distichlis spicata*	spike grass
4.	*Spartina patens*	salt meadow cordgrass
5.	*Borrichia frutescens*	sea oxeye
6.	*Baccharis spp.*	cotton bush
7.	*Iva frutescens*	marsh elder
8.	*Myrica cerifera*	wax myrtle
9.	*Ilex vomitoria*	yaupon
10.	*Juniperus virginiana*	red cedar

Animals

1.	birds	
2.	raccoons	
3.	insects	
4.	rodents	
5.	*Melampus bidentatus*	marsh snail

B. SALT BARREN (no plants in the most saline areas)

Plants

1.	*Spartina alterniflora* (very stunted)	salt marsh cordgrass
2.	*Salicornia* (two species)	glasswort
3.	*Distichlis spicata*	spike grass

Animals

1.	*Uca pugnax*	mud fiddler
2.	*Uca pugilator*	sand fiddler

C. INTERTIDAL ZONE

D. UPPER INTERTIDAL ZONE

Plants

1.	*Spartina alterniflora* (stunted)	salt marsh cordgrass
2.	*Salicornia*	glasswort
3.	*Limonium carolinianum*	sea lavender
4.	*Distichlis spicata*	spike grass
5.	*Juncus roemerianus*	black needlerush

Animals

1. *Sesarma reticulatum*	marsh crab
2. *Uca pugnax*	mud fiddler
3. *Uca pugilator*	sand fiddler
4. *Littorina irrorata*	periwinkle
5. fishes	

E. LOWER INTERTIDAL ZONE

Plants

1. *S. alterniflora* (tall)	salt marsh cordgrass
2. Mud algae	

Animals

1. *Crassostrea virginica*	oyster
2. *Callinectes sapidus*	blue crab
3. *Nassarius obsoleta*	mud snail or basket shell
4. *Uca pugnax*	mud fiddler
5. *Uca pugilator*	sand fiddler
6. *Littorina irrorata*	periwinkle
7. *Modiolus demissus*	ribbed mussel
8. *Limulus polyphemus*	horseshoe or king crab
9. fishes	
10. marine worms	

F. SUBTIDAL ZONE

Plants

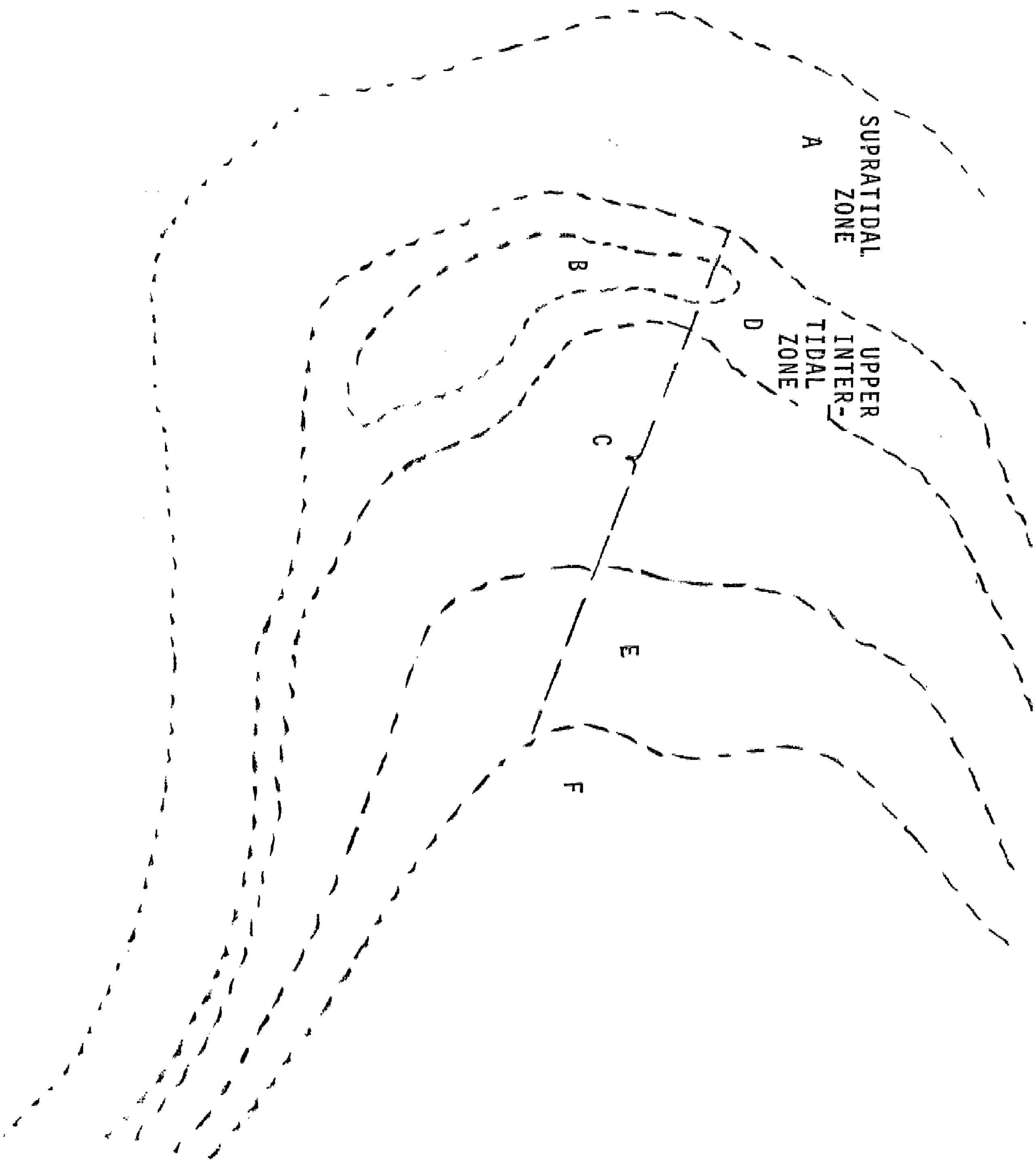
1. *Zostera marina*	eel grass
2. algal seaweeds	
3. plankton	

Animals

1. *Crassostrea virginica*	oyster
2. *Callinectes sapidus*	blue crab
3. *Nassarius obsoleta* (mud)	mud snail or basket snail
4. *Nassarius vibex* (sand)	mottled dog whelk
5. fishes	
6. marine worms	

STUDENT SUPPLEMENT III

Salt Marsh - Aerial View



STUDENT SUPPLEMENT IV

Study Sheet

Spartina patens

Spartina alterniflora

Salicornia spp.

Uca spp.

Littorina irrorata

Distichlis spicata

STUDENT SUPPLEMENT V

Study Sheet

	Areas	Conditions (Amount moisture, sun temperature range, competition salinity)	Plant Adaptations	Animal Adaptations
SUPRATIDAL	A. High Elevation			
	B. Lower Dry			
	C. Salt Barren			
INTERTIDAL	D. Muddy Area in (enter standing water)			
	E. Shore Mud			
SUBTIDAL	F. Water			

SALT MARSH CONSERVATION

According to the well-known ecologist, Dr. Eugene Odum, the estuary is the most naturally fertile area on the earth. In ecosystems, conditions of high fertility generally result in high productivity if other desirable factors are present and undesirable factors absent. Primary productivity is high in the salt marsh for a variety of reasons. The waters are shallow, allowing deeper penetration of light energy. The area is rich in nutrients due largely to the decay of great masses of cordgrass and to the erosion of nutrients washed from the land, into streams draining into the salt marsh. Many of these nutrients remain in the salt marsh and many wash out into the bays, sounds, and oceans, they help support primary productivity in those areas. The young of many species of fishes move into the salt marsh to complete various stages of their development. Food is available and protection is more readily come by in the muddy shallows of the salt marsh. Many species of crabs, shrimp, and shellfish spend varying portions of their life cycle in the salt marsh. The salt marsh serves as a natural protective barrier during periods of storms or extremely high tides.

The salt marsh is seen by John Q. Public as a buggy but otherwise lifeless and smelly area. In addition, he also views the salt marsh as totally useless and placed on earth for the sole purpose of filling in for real estate purposes or draining in the name of mosquito control.

The salt marsh is being destroyed at an unprecedented rate. A survey of the wetlands in thirteen coastal North Carolina counties was conducted in 1952. A similar survey in the same counties in 1967. The two studies were compared and the results showed that in the fifteen-year period covered by the study, 45,292 acres or 28.5% salt marshes in these counties have been destroyed by filling in, pollution, drainage for mosquito control, dredging for boat marines, diking by the Army Engineers, highway construction, canals, and industrial development or expansion.

Who is directly affected by the destruction of the salt marsh? Why should the ordinary citizen concern himself with the plight of the salt marsh? In 1965, there were 5,000 commercial fishermen in the state of North Carolina. During that year their dockside catch was valued at $9,500,000. After processing, the value of the catch increased to $66,000,000. Sports fishermen spent an additional $32,000,000 in North Carolina during this same period, and in Currituck County alone, hunters spent $500,000. These persons are influenced directly but many others are reached indirectly. The commercial fishermen help support the economy of many coastal counties. The sports fishermen spend money for fishing equipment, charter fees, motel accommodations and food. It is easy to see how the web of destruction would touch and affect the livelihood of many persons at many economic levels.

In North Carolina one must be issued a permit in order to fill in a salt marsh. The permit is easy to obtain and often ignored. A law without enforcement is a law without use. In the state of Massachusetts, the state can legally zone private property and prevent filling. The Massachusetts act, hopefully a model for other states, forbids anyone to "remove, fill or dredge any bank, flat, marsh, meadow, or swamp bordering on coastal waters without a hearing, a state license, and a biological investigation." In order to get this legislation passed many civic organzations worked hand in hand for five years with biologists, naturalists, and the Massachusetts Department of Natural Resources to study and publicize the plight of the salt marshes in that state. At the time of passage, one-fifth of the Massachusetts tidelands had already been destroyed. In the state of North Carolina, we lost one-third of our tidelands in fifteen years. When will the individual citizens, the civic clubs, the biologist and the naturalist unite to preserve the salt marshes of our state? Will it be too late? Will we wait too long in apathy while a few make their fortunes at the expense of many?

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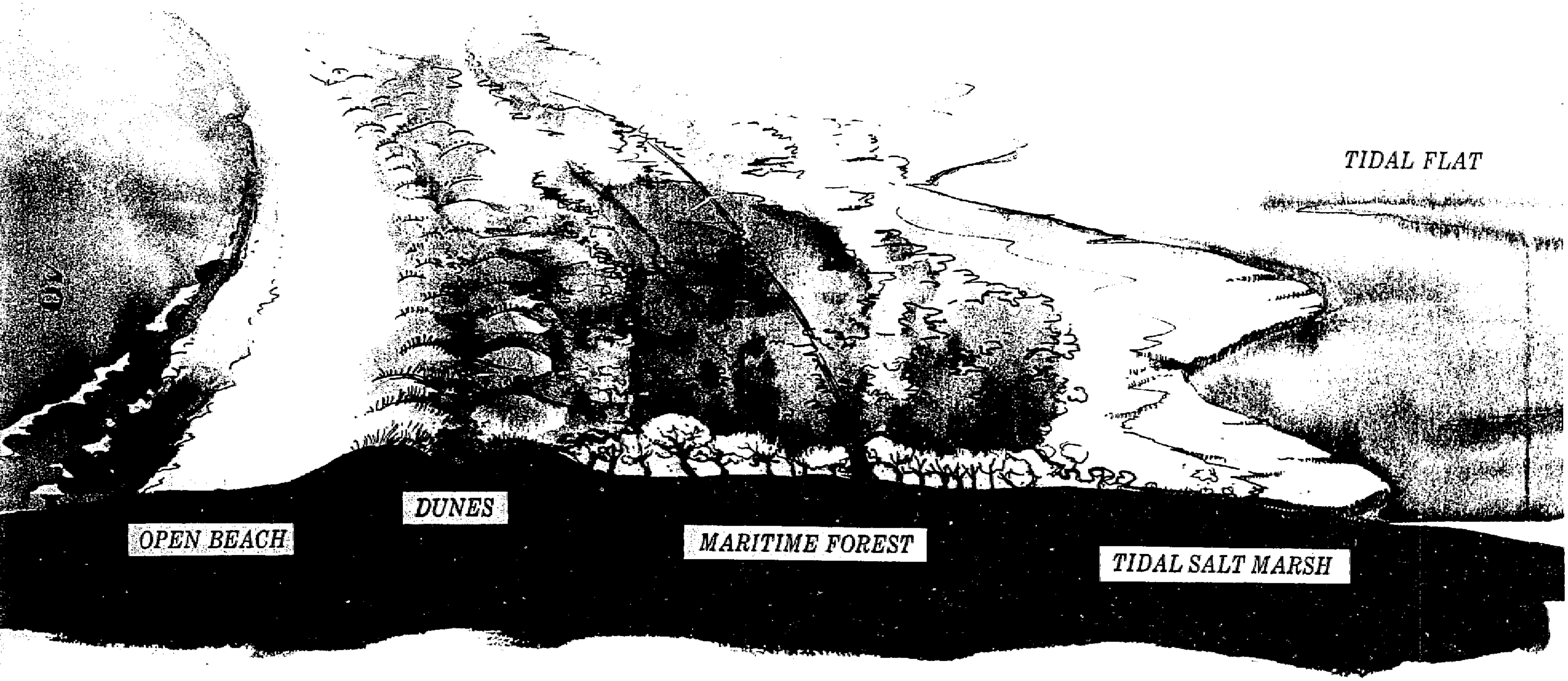
TIDAL FLAT
OPEN BEACH
DUNES
MARITIME FOREST
TIDAL SALT MARSH

This publication is designed for use as part of a curriculum series developed by the Regional Marine Science Project of the Carteret County Public Schools, financed primarily by ESEA TITLE III. The series will include three-week teaching units in marine science for grades 4-10 and two full-year high school courses in advanced biology.

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