Food Webs in an Estuary

University of Maryland Sea Grant Program
Marine Science Education Project

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INTRODUCTION

Estuaries form a fragile boundary between marine and freshwater habitats. Their value as shipping lanes, commercial fisheries, recreational areas, and breeding grounds for thousands of species of aquatic animals and plants remains incalculable. As with most estuaries, the Chesapeake Bay is suffering from overuse, its natural processes potentially changed by human manipulation. To help ensure wise handling of this valuable resource in the future, the Maryland public school system is educating the state's school population about the complex interrelationships between the Bay as an ecosystem and the Bay as a commercial, recreational and industrial commondity. In producing these curriculum materials, the goals of the Maryland Marine Science Project are to assist in this education, provide insights into those interrelationships, and encourage for the future a more informed and conscientious management of the world's most productive estuary, the Chesapeake.

The Maryland Marine Science Education Project is sponsored by the Science Teaching Center, the College of Education, and the Sea Grant Program of the University of Maryland. This cooperative effort of scientists, educators, and classroom teachers has produced a series of mini-units in marine science education for the junior high/middle school classroom. Although the curricular materials specifically treat the Chesapeake Bay, they may be adapted for use with similar estuarine systems. Teachers can also incorporate these units into their existing life science courses by using the Chesapeake Bay as a specific example of working biological principles.

Each marine science mini-unit consists of the following components:

Teacher's Narrative, a brief content reading for the teacher on the subject of the mini-unit;

Student Activities, a section containing student activities and games related to the content of the mini-unit;

Resource Material, a bibliography for teachers and students, a list of resource people, additional suggestions for audio-visual aids and field-trip sites, and a list of various junior high/middle school science texts where the mini-unit may be incorporated.

The Teacher's Narrative provides content material for preparing the mini-unit, and the sections on Student Activities and Resource Materials include supplementary information for developing an interesting educational unit about the Chesapeake Bay.

Teacher's Narrative

The Fragile Food Web of the Chesapeake Bay

Preface

Although most junior high school life science books cover the topic of food chains, there is very little material which treats the subject in relation to the Chesapeake Bay. This mini-unit provides examples of both marine and terrestrial life as it appears around the Bay, taking advantage of many students' familiarity with the area and placing emphasis on the estuary itself, Maryland's greatest natural resource.

The mini-unit contains a teacher's narrative and student activities which are keyed to the student text. The activities should provide the students with some interesting and entertaining projects, while reinforcing what they have learned about the fragile and yet vital estuary we call the Chesapeake.

Introduction

As everywhere, the forms of life in the Chesapeake estuary can be divided into three categories which refer to the ways they provide energy for themselves in order to live: There are producers, consumers, and decomposers. Food chains, which identify specific producers and consumers, show the flow of energy and nutrients through each level of the feeding process.

Green plants are producers, and only they can turn the sun's energy into food that can be consumed by the rest of the organisms in the food chain. Through the mysterious process we call photosynthesis, green plants convert radiant energy into stored chemical energy. This chemical energy becomes food, its power released through the digestive processes of consumers.

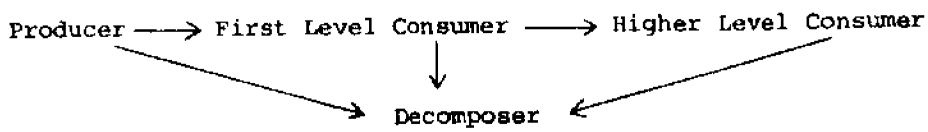
Consumers, who lack the ability of green plants to produce their own food, fall into two groups, based on the kind of food they consume. Those who feed directly on plants are called herbivores; those who eat herbivores, or each other, are called carnivores. So herbivores are first level consumers, and those who feed on them, the carnivores, are second or higher level consumers.

Some consumers, like man, are both herbivores and carnivores since they eat both plants and animals. These consumers are called omnivores.

Decomposers are primarily fungi and bacteria which obtain their energy and nutrients by breaking down dead plants and animals. They play a very important role in the energy cycle by making nutrients available that would otherwise be bound up in plant and animal tissue. If bacteria and fungi did not exist, the remains of plants and animals would simply accumulate. In the Chesapeake waters, the dead tissue would cause increased turbidity. As it is, bacteria and fungi break down the organic material of once-living things by digestive action, making it available to green plants as food. Thus, decomposers turn organic material into nutrients which feed green plants, and the plants then feed a new generation of organisms in the food chain.

Food Chains

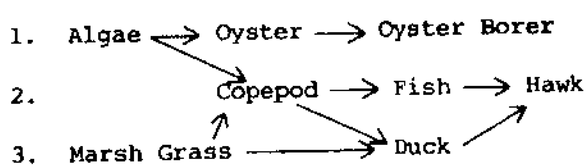
Energy relationships are often represented by a diagram like the one below of a food or energy chain.



The arrows show the direction of energy and nutrient flow. No arrows lead from the decomposers because they do not pass on energy, only nutrients. Because decomposers work at every level, and are commonly the same species at every level, they are usually omitted from depictions of the food chain. Students should be reminded that although decomposers are not shown, they are acting at each level. Listed below are examples of food chains.

1. Algae → Oyster → Oyster Borer (Sea Snail)
2. Marsh Grass → Duck → Hawk
3. Algae → Copepod → Fish → Hawk

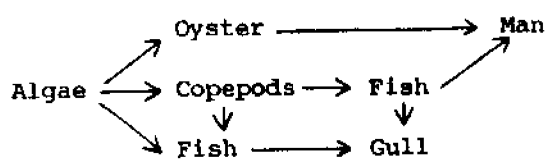
If arrows were added to show all the relationships, e.g., the duck in number 2 eating the algae in numbers 1 and 3, the food chains would form a food web showing all the possible feeding relationships in an ecosystem, as in the example below.



The chart that follows identifies the producers and the levels of the consumers, extracted from the preceding food web chart.

Consumer Level	Example 1	Example 2	Example 3
Third		Hawk	
Second	Oyster Borer	Fish	Hawk
First	Oyster	Copepod	Duck
Producers	Algae	Algae	Marsh Grass

The food web as illustrated in the preceding chart is simplified to introduce the concept of interrelation. In a marsh or estuarine environment, the food web seems simple, but because so many different organisms are dependent directly or indirectly upon marsh grass or algae, the food web becomes complex, involving intense competition among many varieties of consumers for limited varieties of producers. When dependence on a single species is demonstrated within a food web, the relationships become precarious. In the diagram below, for example, many varieties of consumers depend upon a single producer, algae.



Destruction of algae in such a fragile system could result in almost total loss of oysters, copepods and those varieties of fish which feed on algae and copepods.

Although food chains and webs are excellent ways of illustrating the energy relationships between organisms, they do not show that energy is lost at each level. As energy is passed from producer to consumer, some of it is always lost as heat into the environment. Energy loss may be illustrated by adding arrows that do not go to another organism, as in the following example.

Algae → Copepod → Fish → Man

Although such illustrations show energy loss, they do not indicate relative amounts. Food pyramids help to show this relationship. When a food chain is put into pyramid form, the producers make up the base of the pyramid, the broader base indicating more energy (food). The next level shows the first order consumers which are fewer and therefore represent less of the original energy. This trend continues to the top of the pyramid.

At each level pyramids represent population, mass, and calories. The following diagrammed chart illustrates each of these measurements.

PYRAMID	POPULATION Numbers	Mass (Kg)	Calories (Cal)
Man	1	5	1.5
Fish	10	50	15
Copepods	1000	500	150
Algae	100,000	5000	1500

This pyramid shows relative numbers and values (not absolute measurements), illustrating that large numbers of lower level organisms are required to feed fewer numbers of higher level organisms. Mass expressed as kilograms of weight is normally used as a measure, since population measurements will vary, depending on organism size. Ninety percent of mass is lost at each level, so that only 10 percent moves up the pyramid each time a new consumer appears. Calories represent the relative amount of energy available from the food source as it moves up the pyramid. Thus 5,000 kilograms of algae, containing 1,500 calories, is reduced to only 1.5 calories available to man, once it has passed through the food chain.

When a man eats a fish, some of the energy derived from the fish is stored, but most of it is burned in the process of respiration. And plants fix, as chemical energy, only about 1 percent of the radiant energy available from the sun, and make available to consumers only about 10 percent of the energy they fix. At each level over 90 percent of the energy obtained from food is lost from the food chain in life activities and heat. Note the following food chain in terms of energy lost.

$$\text{Algae} \xrightarrow[10\%]{} \text{Copepod} \xrightarrow[10\%]{} \text{Fish} \xrightarrow[10\%]{} \text{Man}$$

One can say that each 5 kilograms of man takes 50 kilograms of fish or 500 kilograms of copepods or 5,000 kilograms of algae for support. Should a large portion of the plants at the base of a food pyramid be destroyed, a proportionate number of consumers dependent on the plants would face starvation.

Biotic and Abiotic Features of a Marsh Food Web

It is very difficult to study food chains in depth without discussing biotic (living) and abiotic (nonliving) factors which affect the chains. Biotic factors include inter- (between different species) and intra- (among the same species) specific competition; introduction of new predators; introduction of nonnative (exotic) species; man's destruction of habitat; and disease. Abiotic factors include water, salinity, temperature change, and soil types (or sediments).

Biotic and abiotic factors become very complex when we examine the Chesapeake Bay area. The Chesapeake Bay is an estuary, a partly enclosed body of water which opens to the sea, where sea water is measurably diluted by fresh water. The Chesapeake has over 150 sources of fresh water, with nine important rivers including two great interstate rivers, the Potomac and the Susquehanna, which contribute 58,000 cubic feet per second of fresh water. This rate of flow would, in one minute, fill a football field to a depth of 75 feet.

The salinity of the Bay varies from near oceanic value of 30 ppt (parts per thousand, i.e., 30 parts of salt per 1,000 parts of water) to fresh water value of 0 ppt. The salinity also varies across the Bay, with lower salinity on the western side than on the eastern bank. The greater runoff of fresh water on the western side contributes to this lateral (side to side) variation, but the primary cause is the rotation of the earth, which throws the heavier salt water eastward.

Salinity also varies by season. Runoff in the spring keeps salinity values much lower than those for autumn. This change affects the population of fishes and shellfish, such as oysters, which spawn at certain salinities.

The sedimentary structure of the Bay affects the species of plants and animals that live there. Benthic, or bottom-dwelling species usually live in areas of medium to fine grain sand. Because they are filter feeders, few benthic species live in the silt and clay of the channels, since silt clogs their feeding apparati.

Within the Bay system are thousands of acres of marshland, part of the 300,000 acres of coastal estuarine marsh in Maryland. These marshes often strike onlookers as desolate, smelly, and useless, but appearances are deceiving. These estuarine habitats support many different food chains, and most of the food for the whole Bay system is produced in the marshes. The marshlands that ring the Bay are in fact organic factories. They are sediment traps, reservoirs for nutrients and other chemicals, and are productive and essential habitats for a large number of invertebrates, fish, reptiles, birds, and mammals.

Because the marshes are constantly washed by tides, the estuary itself is constantly replenished with nutrients washed from the marshes. This is true especially in the spring when dead plant material from the winter is washed into the estuary in the form of detritus (partially decayed plant material). The marsh's role as the major food-producing area also explains why it is the breeding or spawning ground for so many different fish. Yet in spite of the Bay's variety of habitats and its large area (64,000 square miles), its food chains are relatively limited. Scientists believe that since the Chesapeake is only eight to ten thousand years old--very young in terms of geological change--there has not been time for great specialization.

In the estuary the producers are usually algae and phytoplankton. First level consumers include oysters, clams, and zooplankton (such as copepods), which in turn provide food for numerous species of fish--perch, striped bass, herring, shad, anchovy--the second level consumers.

Among the 122 species of fish found in the Bay, several are commercially important. In 1971 striped bass alone accounted for catches worth more than $861,892; and oyster, clam and crab catches were worth more than $18 million. All these commercially important species are dependent, in some way, on nutrients from the marshes.

The producers of the Bay's marsh and upland areas--notably widgeon grass, eelgrass, wild celery, and olney three-square--support the largest concentrations of wintering whisling swans, Canada geese, American widgeon, and several other species of duck on the East Coast. These waterfowl in turn are preyed upon by red and grey fox, mink, otter, raccoon, owl, and hawk. These same areas serve as breeding grounds for such waterfowl as black duck. Duck eggs, in turn, provide food for crows, gulls, raccoons, skunks, and black pilot snakes.

The competition for food can be intense, as the mute swan's introduction into this area illustrates. In a period of 10 years the number of mute swans has increased from 10 to 60. Since the mute swan stays year round and is a voracious eater, it creates strong competition for the wintering whisling swans, geese, and ducks. As development has destroyed marshland, also limiting food and increasing competition, waterfowl have invaded neighboring farms and destroyed corn crops. In response, naturalists have grown corn on nature preserves in an effort to relieve stress on Bayside farms. The question arises whether efforts should be made to remove mute swans from the Bay to lessen demands on the food supply.

Aside from waterfowl, the marshes and estuary support numerous other species of birds including 11 species of gulls and terns, 13 species of snipe and sandpiper, 7 species of rail and coot, 9 species of heron, 4 species of blackbird, and 4 of sparrow. These birds fill many different niches in the Bay's ecosystem, many roles within the food chain.

Other animals in the marsh area include snails, frogs, fish, snakes, and small mammals. Turtles, which are omnivores, are near the top of the food chain and once full grown have few natural enemies. Reptiles, such as lizards, consume snails, spiders, and millipedes and in turn are consumed by other reptiles, birds, and mammals such as mink and otter.

Muskrats in the marsh eat the rhizomes (rootlike stems) of some of the marsh grasses. Because the habitats of his natural enemies, like the fox, have begun to disappear, muskrats have become a problem in some marshes. When their numbers exceed the carrying capacity of the land they often destroy the marshes by eating too many rhizomes and loosening the dirt around the marshgrass. This process creates a sediment problem in the estuary and reduces the nutrients which the marsh supplies.

Marshlands, then, represent a fragile and interdependent food web which is of great importance to the overall ecology of the Chesapeake Bay. Many fish which spawn in the Bay depend, when young, almost totally on zooplankton, especially copepods, for food. Since copepods feed on phytoplankton and detritus produced in the marsh, destruction of marsh would result in a dramatic drop in the number of fish. This could be disastrous for Maryland's fisheries, which depend on the bounty of the world's most productive estuary, the Chesapeake.

Current Problems

There are three current situations which may furnish examples of Bay-related problems one can approach with students. First, there is sewage disposal, a problem familiar to the public. The nutrients in sewage often cause an excess of algae, which creates a dense cover on the water's surface, cutting off photosynthesis below. This causes the dissolved oxygen level to go down. In addition, as the algae die and sink to the bottom, aerobic bacteria use up even more of the dissolved oxygen in decomposing the algae. This "algal bloom" ultimately causes the oxygen level in the water to fall so low that it brings death to fish and other organisms.

Studies have been made of the effect of marsh grasses on sewage. It was noted that Spartina (cord grass) grew taller and more lushly near a sewage outlet than in an adjacent area of marsh. Investigation showed that the Spartina was using fertilizer provided in the sewage. Further study demonstrated that these marsh grasses decreased pollution reaching the estuary by using the pollutants as nutrients. In this way cord grass helps to maintain the water quality of the Bay.

The third example illustrates "tradeoffs." For several years on the Eastern Shore a type of no-till farming has been used. It involves using herbicides to clear the land in the spring prior to planting. After the vegetative matter has been killed with the herbicide, a special type of planter makes a furrow two inches wide. This very narrow furrow cuts down on erosion, as does the dead vegetative matter which acts as a mulch and ground cover. Conservationists encouraged this type of farming because the normal tilling produced erosion causing too much sediment in the streams that feed the Bay. Sedimentation is one of the conditions believed to cause problems in spat (newly settled or attached young oyster) set.

While this use of herbicides has reduced the sedimentation problem, it may have created a new problem. During the time when oyster larvae are preparing to set and become spat, their entire diet consists of algae and other phytoplankton. Experiments have shown that concentrations as low as 1/10 part per thousand of herbicide can kill off almost all of the algae present. In the spring of 1978, heavy rains followed the herbicide use on farm fields and concentrations of 4 to 5 parts per thousand of herbicide were found in the Bay, presumably from runoff. Coincidentally, very little algae was found in some areas and very few spat seemed to be setting.

It would be easy to assume a cause and effect relationship between the herbicide use and the failure of spat set. However, studies have also shown that variabilities in algae populations of 50 to 100 percent can be within normal range. Therefore a limited sample of only one year cannot prove that the herbicide is causing the algae loss.

Farmers on the Eastern Shore made heavy investments in special equipment to convert to no-till planting and cannot be expected to give it up unless the cause of the low number of algae can be definitely tied to their use of herbicides. At the same time, the people employed in the oyster industry need to know if the declining number of oysters is being caused by the farmers.

In talking about solutions to these problems, students should begin to realize how man fits into the food web, how his actions affect the productive, though fragile, network of organisms that forms the balanced ecology of our Earth. The Chesapeake Bay provides a meaningful model of that network, as well as a symbol of the essential interdependency of all living things.

Student Activities

Guide to Student Activities

Food Chains

All life depends on plants, because only plants can produce food. Taking the radiant energy of the sun, plants combine water, carbon dioxide, and light in a process called photosynthesis. Photosynthesis allows the plants to turn solar energy into chemical energy, which they can store. Because they can actually produce food, plants are named producers.

Other life forms are called consumers, since they must consume plants in order to process the stored chemical energy. Some animals get their energy from eating plants directly, while others eat other animals and thus get plant energy indirectly. Animals which eat only plants are herbivores, and animals which eat other animals are carnivores. If an animal feeds on both plants and other animals, it is an omnivore.

Food chains show the relationships between producers and consumers, demonstrating the way energy flows from one level to another. In the following example the herbivore, a cow, takes energy from the grass it eats, like this:

grass → cow

The arrow shows the movement of the energy from the producer to the consumer. Another example of a herbivore would be an oyster, which feeds on algae. It's food chain would look like this:

algae → oyster

If an animal is a carnivore, it will eat meat (carne), as in this food chain:

algae → oyster → crab → man

Here the crab and the man are carnivorous because they take their food energy from other animals. Remember, only green plants are producers, because only they can create food directly from the sun.

Some tiny marine plants, called phytoplankton, live near the surface of the water, where sunlight enables them to perform photosynthesis. These phytoplankton provide food for other forms of marine life, including zooplankton, tiny marine animals. One kind of zooplankton, the copepod, a relative of the crab, is a favorite food for many Bay marine animals. Another important food source is detritus, broken up bits of plant fiber, such as leaves and stems.

Microscopic organisms that actually break down dead plants and animals are called decomposers. They perform a very important task by releasing nutrients from dead matter. When they do this they give off a gas, sulfur dioxide (SO_2), which smells like rotten eggs. This is why marshes often smell bad. Decomposers, primarily bacteria and fungi, work at every level of the food chain, and even though they do not pass on energy like the other members of the chain, the nutrients they set free form an essential part of the total food web.

Activity 1

1. In the following lists one organism differs from the rest. Cross off the one in each list that doesn't belong. Then label the list herbivore or producer.

____________________	____________________
grass algae maple crab phytoplankton	muskrat oyster algae fish grasshopper

____________________	____________________
muskrat bindweed wild celery marsh grass seaweed	mouse turtle swan eelgrass goose

2. A producer is ____.

3. A herbivore is ____.

4. Make up five food chains. Each food chain must have a producer and a herbivore.

5. In these lists there are producers, herbivores, and carnivores. Cross off the word that doesn't belong and label the list.

____________________	____________________
fox eagle man algae mink	celery eelgrass three-square (grass) bindweed grasshopper

mouse
fox
oyster
grasshopper
goose

algae
mink
goose
swan
fox

6. Make up three food chains of your own which include carnivores. An insectivore (an insect eater) is a type of carnivore.

__________ → __________ → __________

__________ → __________ → __________

__________ → __________ → __________

Activity 2

Salt and Seaweed

Because of tides and rainwater, marsh plants are often subjected to different salinities. Only some plants can tolerate different degrees of salinity.

In the Chesapeake Bay salinities range from 30 ppt to 0 ppt, where ppt means parts per thousand, but most of the water never gets any saltier than 20 ppt. Place elodea, a freshwater plant, in water of different salinities to see how much tolerance it has. Use salinities of 10 ppt, 20 ppt, and 30 ppt; and as a control to the experiment, keep one plant in completely fresh water.

First, answer these two questions:

1. How many ppt of salt will the water in the control experiment have?

2. How much salt do you predict the elodea will be able to tolerate?

Now do the experiment:

1. Get 4 test tubes or baby-food jars.
2. Label them 0 ppt, 10 ppt, 20 ppt, 30 ppt.
3. Fill each one with water and the proper amount of salt. (Your teacher will help with the measurements.

4. Put a piece of elodea in each tube or jar.
5. Observe the plants for four days and record your observations. Keep the tubes in racks, or place the tubes or jars where your teacher directs.

Observations				
Tube	Day 1	Day 2	Day 3	Day 4
Control 0 ppt				
#1 10 ppt				
#2 20 ppt				
#3 30 ppt				

Questions:

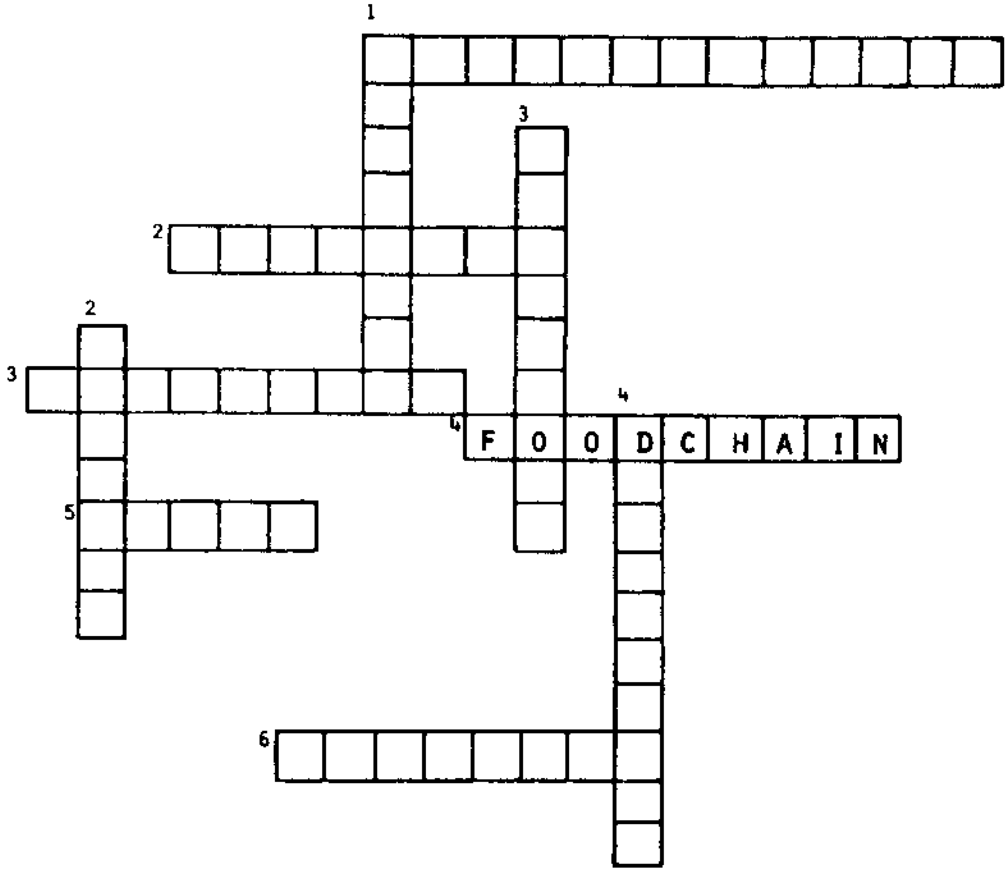
1. What were your results? How does the elodea in each tube or jar look after four days?

2. How much salt does elodea tolerate?

3. What do you conclude about elodea's tolerance to salt? What does this imply about the salt tolerance of plants in the Chesapeake Bay area?

REVIEW OR HOMEWORK

Activity 3



ACROSS

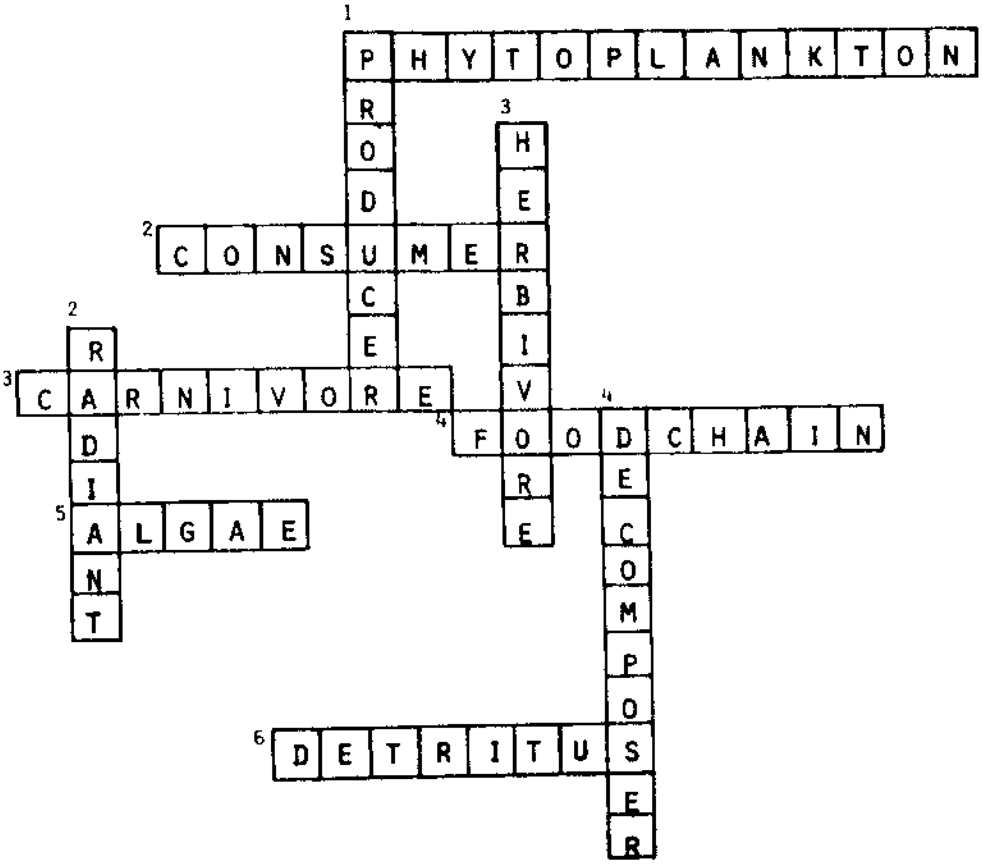
1. The microscopic producers of the sea.
2. If you can't be a producer you have to be a _______________.
3. An organism that eats meat.
4. The way energy is passed.
5. One celled green plants.
6. Partially rotted plants.

DOWN

1. A name for plants.
2. The type of energy only plants can use.
3. A consumer who eats plants.
4. Breaks down dead plants and animals.

REVIEW OR HOMEWORK

Key



ACROSS

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DOWN

1. A name for plants.
2. The type of energy only plants can use.
3. A consumer who eats plants.
4. Breaks down dead plants and animals.

<u>Activity 4</u>

Can you find the following terms associated with food chains?

ESTUARY	TIDES	NICHES	SWANS
BIOTIC	DETRITUS	MARSH	MINK
RADIANT	CARNIVORES	ALGAE	DUCKS
DISEASE	HERBIVORES	CLAM	OYSTER
ABIOTIC	PRODUCERS	COPEPOD	CATFISH
SALINITY	BENTHIC	STRIPED BASS	ZOOPLANKTON
WATER	FOOD	CRABS	OWLS
MUSKRAT	DECOMPOSERS	OYSTER BORER	GEESE

D H A S N M A B K D E U C F H J I E K R C O K T M B Q R Z
C L O P H I T L L B K T S K B H X S Q M O E K G B L G F W
W D C T M N C F H J P R A D I A N T Q B N C K E F J H N T
K L A T P H R H O B G M L N R C Z U F D S J E O I L M S R
H E R B I V O R E S Z F G L T Q R A B F U A H J K Q X A L
B X T D G L T M U S K R A T P R R R D H M F J N D Z Q W C
T O M M P Y T W B P T F E C Y B F Y D B E N T H I C B L N
T P H H B R K Y E S R F C K C Q N D H S R H J K S Q X A L
D T X Z F O O D Q F E R H Z A L G A P T B C K X E U I M M
C N R C F G Y D H X K I O R R Z A Z O Y T L O X A R W D N
M C A T F I S H U T A T X L N M O M B X M L D P S H J F T
T M X G R H T P L C I X M M I H Z A U J F F G K E P A E I
S D A D G J E K L M E N O P V Q B R C M P Q F H J P X T X
K F B D E T R I T U S R X Z O W L S D P P D Q U N L O F B
P G C O U F G I X K M Q S T R P O H M M M P C B M J Y D B
A O Z K L P H I M C D B Q O E O M O I D W X W S B H S C S
R B C O M N I V O R E S T F S A L I N I T Y A T S E T C H
H D I G O L E K U F C Q S B X N J S K Z I Z Z R X E E F W
W Z O O P L A N K T O N D P M L T C Q B D T B I Q F R R S
Q S W R T B C K Z V M T U Y V D B P A K E V I P U T B J K
C B P C Q I T F J W P Z S P J S N A K E S A Z E W Q O L X
T B I O T I C H M G O C L C K W O T B G R H T D F F R J G
A F O F W M K R H J S N T O O A E M N G L X H B B P E M O
E T V O V L N T A X E B T V M N F U Z G H K W A T E R L G
X C M G Y J G M V B R I K B T S Q V W Y J O J S L X D G P
Z F K R B C D U C K S Q R H C L M H H J G E E S E L C R X

Activity 4 ANSWER KEY

Can you find the following terms associated with food chains?

ESTUARY	TIDES	NICHES	SWANS
BIOTIC	DETRITUS	MARSH	MINK
RADIANT	CARNIVORES	ALGAE	DUCKS
DISEASE	HERBIVORES	CLAM	OYSTER
ABIOTIC	PRODUCERS	COPEPOD	CATFISH
SALINITY	BENTHIC	STRIPED BASS	ZOOPLANKTON
WATER	FOOD	CRABS	OWLS
MUSKRAT	DECOMPOSERS	OYSTER BORER	GEESE

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        N                         E     C
          I                       S     O
            C         R A D I A N T     N
              H         L         U     S
H E R B I V O R E S     G         A     U
              M U S K R A T       R     M       D
        P               E         Y   B E N T H I C
          R                 C           R       S
        F O O D             A L           C     E
            Y D             R   A           O   A
  C A T F I S H U           N     M           P S
            T     C         I     A             E
            E       E       V     R               P
      D E T R I T U S R     O W L S                 O
                        S   R     H M               Y D
A                   D       E       I         S     S
  B   O M N I V O R E S     S A L I N I T Y   T     T
    I               C               K   I     R     E
  Z O O P L A N K T O N                 D     I     R
        T           M                   E     P     B
          I         P         S N A K E S     E     O
  B I O T I C       O         W               D     R
              R     S         A               B     E
                A   E         N             W A T E R
                  B R         S               S
            D U C K S                   G E E S E
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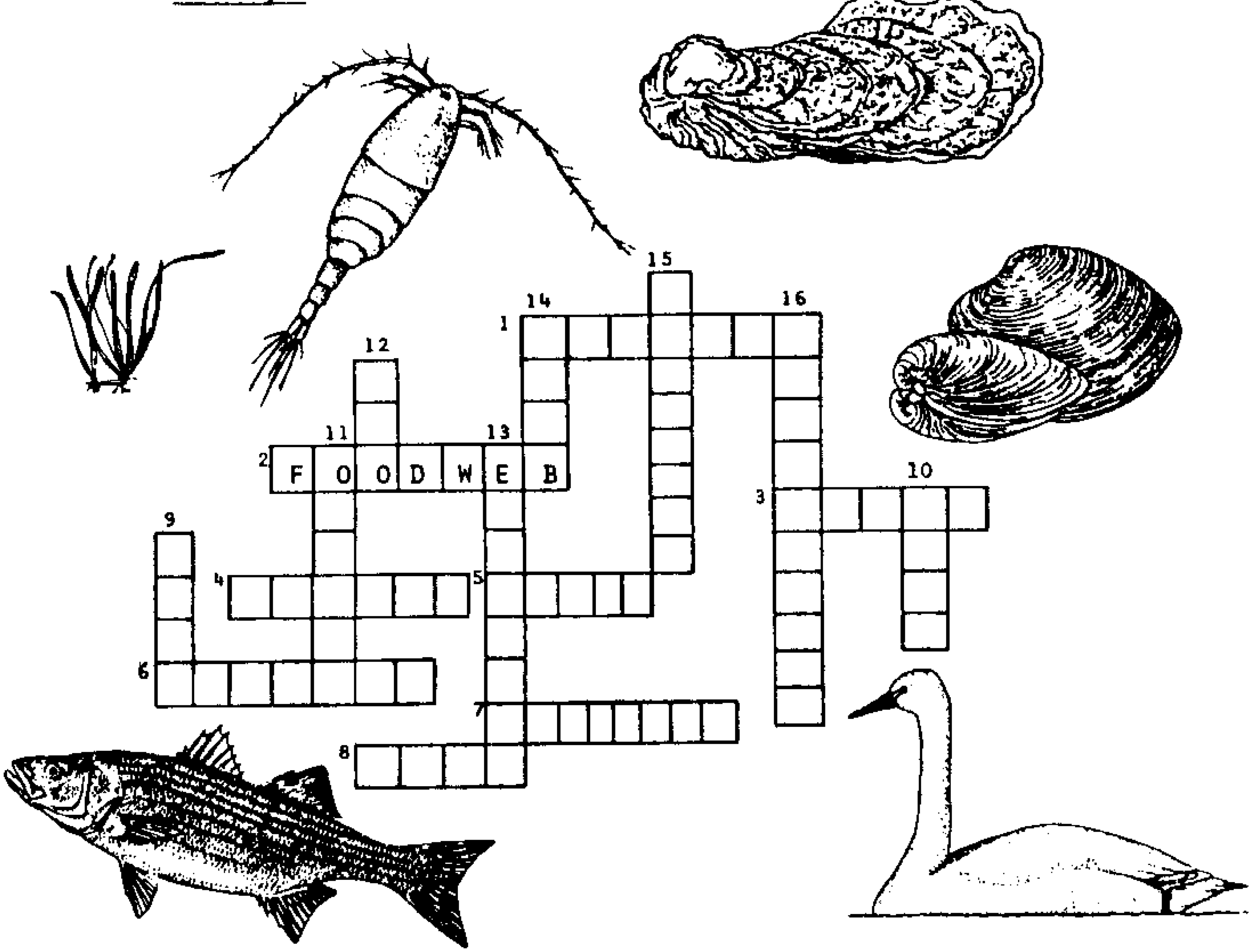
Activity 5



ACROSS

1. Microscopic zooplankton which feeds almost everything bigger.
2. The pattern of energy flow.
3. The food factory of the Bay.
4. The animal which competes with the muskrat.
5. This waterfowl winters on the Bay but nests in Canada.
6. This herbivore eats marsh grass and is hunted for his fur.
7. The measure of salt in water.
8. The most important fish in the Bay. Also called a rockfish.

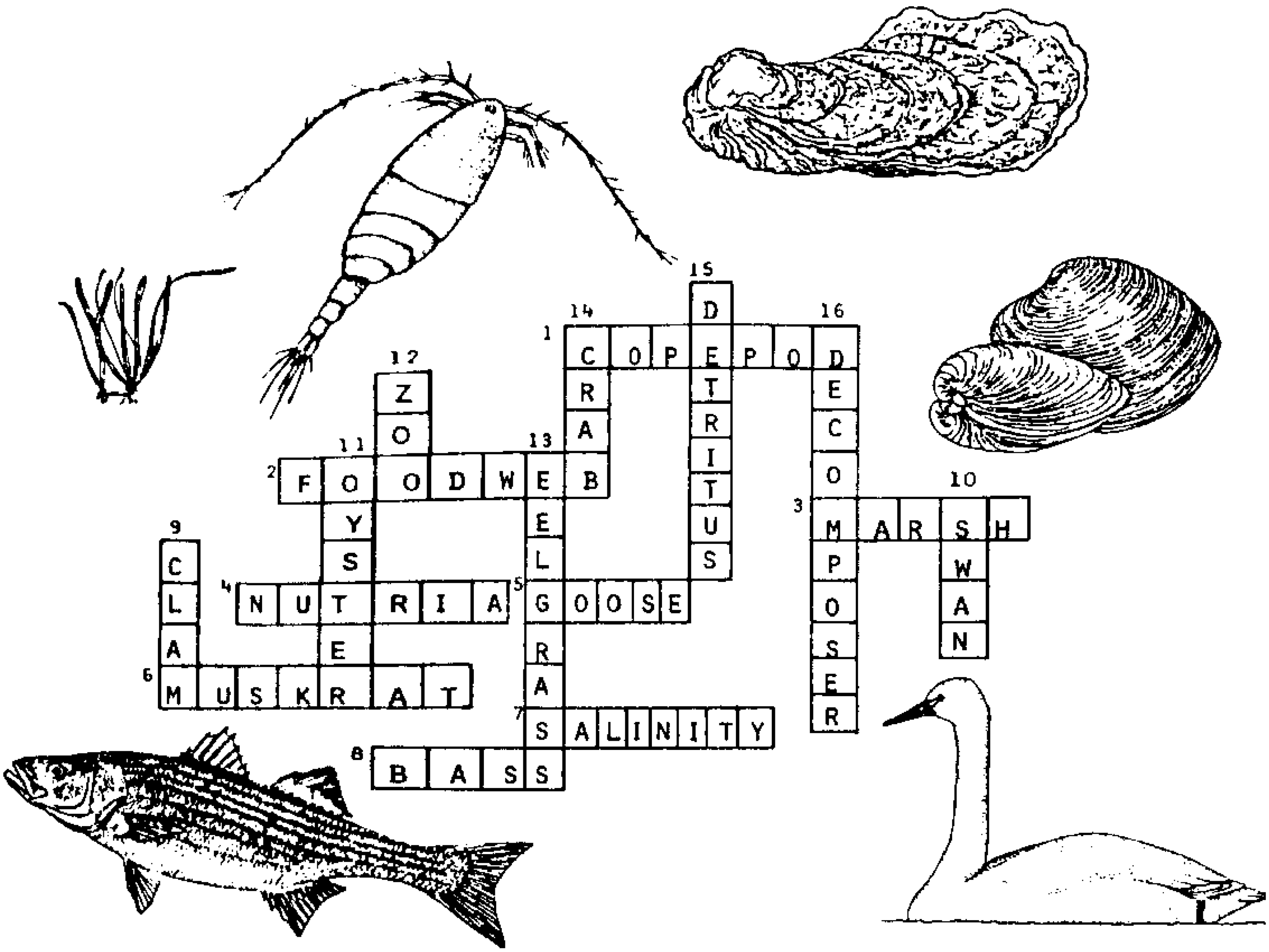
DOWN

9. A shellfish often served on the "halfshell."
10. A beautiful waterfowl that begins life as an "ugly duckling."
11. The most important shellfish in the Bay--it grows from tiny "spat."
12. The animal form of plankton.
13. A type of grass eaten by waterfowl.
14. This fourth most important shellfish from the Bay is often served hot and spicy.
15. The partly decayed vegetable matter which provides so much food to the Bay.
16. Organism which returns nutrients to the environment to be used again.

Drawings by Alice Jane Lippson, <u>The Chesapeake Bay in Maryland</u>

REVIEW

Key



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Activity 6

These definitions are operational, and based only on the meanings of the terms as used in the text.

1. Abiotic - Pertaining to nonliving things which affect an ecosystem, e.g., factors such as weather, climate, salinity, or sedimentation.
2. Benthic - Bottom dwelling.
3. Biotic - Pertaining to living things which affect an ecosystem, e.g., organisms which cause disease, the competition among animal species for food, or the decline of one animal as a food source which affects the population of animals that feed upon it.
4. Biomass - The mass or amount of matter that makes up an organism at any trophic level.
5. Carnivore - A meat-eating organism.
6. Carrying capacity - The maximum number of organisms that a habitat can support without serious disruption of the equilibrium of the community.
7. Consumer - An organism that gets the energy it needs from consuming other organisms.
8. Copepod - A microscopic crustacean, related to the crab, which obtains most of its energy from eating plant material, e.g., algae or marsh grass, and which, in turn, is eaten by virtually every larger organism in the Chesapeake Bay except shellfish.
9. Decomposers - Organisms that obtain their energy by breaking down the bodies of dead plants and animals. This process returns nutrients to the soil or water to be used again.
10. Detritus - Partially decayed plant material, especially marsh grasses.
11. Ecosystem - The living organisms together with their physical environment.
12. Exotic - A species not native to a particular area which competes with a native species. This competition can have a detrimental effect on the native species.
13. Habitat - The place where an organism lives, its particular area, e.g., marsh, river bottom, open water, uplands.
14. Herbivore - A plant eater or first level consumer.
15. Interspecific competition - Competition between two different species for the same food source or habitat.
16. Intraspecific competition - Competition among individuals of the same species for food or habitat.
17. Niche - The specific role an organism takes in a certain area. For example, two species of birds might be able to occupy the same geographical area because they eat different foods. If so, then each occupies a different niche in the habitat.
18. Omnivore - A consumer that eats both plants and animals.
19. Phytoplankton - One-celled microscopic plant species.
20. Producer - A green plant which transforms the sun's radiant energy by photosynthesis to chemical energy, which it stores.
21. Salinity - The salt content of water, measured in parts of salt per thousand parts of water.

22. Sessile - A nonmotile (not moving) species like the oyster.
23. Spat - The name given to an oyster larva when it settles on a surface and begins forming a shell.
24. Trophic levels - Successive levels of nourishment (food energy) in the food chain of a community.
25. Zooplankton - Microscopic animals or larvae of shellfish and fish. These may be herbivores or carnivores.

FURTHER ACTIVITIES WITH DIRECTIONS FOR THE TEACHER:

Activity 7

Food Webs: A Class Activity (1 period)

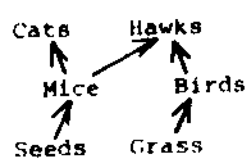
When you think students understand food chains, give each student the name of one of the organisms from the lists which follow. If you do this at the end of class, their homework could be to find out what that organism eats (if it's a consumer). An alternative approach would be to assign an organism in class and work out the eating pattern together as a class activity.

The following day, have students write the name in large letters on a 3 x 5 index card or piece of paper. Encourage students to draw the organism.

Ask all the students holding producer cards to identify themselves. Have these students tape their cards to the wall or board. Ask for the herbivores and tape those above the plants. Then tape the carnivores above those.

Using either chalk or yarn, connect each animal to its food source. Take suggestions from the class. The result should be a complex food web.

A good follow-up activity would be to cut out or remove one of the producers and all the animals that depend on that particular producer to demonstrate that unless an animal has an alternative food source, it disappears from the food web when its producer disappears. For example:



In this example, if seeds were removed, hawks could survive since they also feed on birds. Cats, however, would be removed since their only food source has been removed.

Here is the list for the Food Web Activity. There are 36 organisms. If one of your classes is larger than 36, assign more than one of each producer.

Producers:

algae, cord grass, wild celery, eelgrass, widgeongrass

Consumers:

Herbivores	Carnivores
copepod	frog
oyster larva	crow
zoea (crab larva)	gull
ant	raccoon
goose	skunk
duck	snail
swan	spider
nutria	crab
oyster	bluefish
clam	salamander
muskrat	lizard
mouse	striped bass
grasshopper	owl
	hawk
	mink
	otter
	fox
	biting fly

Activity 8

Food Chain Rummy

Playing time: 25 minutes

Materials: 52 cards for each group of 3 or 4 players. Each deck consists of 4 suns, 16 producers, 14 herbivores, 14 carnivores, and 4 higher level carnivores.

How to play: Deal out five cards to each player and place the rest of the cards face down in the center. The dealer takes the top card from the deck, and must discard one card (either the card he picked up or one from his hand) face up in the discard pile. The next player can take the top card of the discard pile or a card from the top of the deck. He checks his hand and must discard one card. The object is to get a Rummy consisting of five cards that would make a believable food chain. The first person to do this is the winner.

Instructions for making a Food Chain Rummy card deck: Draw lines dividing sheets of paper into playing-sized rectangles and in each rectangle write or type the words from the list that follows. A drawing of the item named should be included, if possible, on each card.

Cards for each deck should name:

4 suns	frog
4 algae	crow
4 wild celery	gull
4 eelgrass	raccoon
4 widgeongrass	skunk
1 each:	snail
copepod	spider
oyster larva	crab
zoea	bluefish
ant	salamander
duck	lizard
goose	striped bass
swan	owl
nutria	hawk
oyster	mink
clam	otter
muskrat	fox
mouse	biting fly
grasshopper	

Duplicate the sheets of paper, cut the duplicated sheets, and glue each rectangle to cardboard of the same size. Playing cards or index cards might be used for backing. Laminate for durability.

Correlation with Existing Texts

County:

Anne Arundel:

Laidlaw: The Biological Sciences
Chapters 22 and 23

Holt: Modern Life Science
Unit 2

Interaction of Man and the Biosphere
Section 8 Ecological Interactions

Life: A Biological Science
Chapter 2 Marine Environment

Focus on Life Science
Chapter 24 Ecology

Matter, Life, Energy

Charles:

Spaceship Earth
Chapter 4

Montgomery:

Challenges
Chapter 3 Ecosystems

Holt: Life Science
Chapter 2 Marine Environment

Ideas and Investigation--Wong
Idea II

Spaceship Earth
Chapter 4

Prince Georges:

Interaction of Man and the Biosphere
Section 8 Ecological Interactions

Ideas and Investigations
Idea II

Lab Inquiry--Cambridge
Interaction: Life and the Environment

Life: Its Forms and Changes
Chapter 2 Marine Environments

Resource Material

Prince Georges cont.:

Spaceship Earth
Chapter 4

Challenges
Chapter 3 Ecosystem

Focus on Life Science
Chapter 24 Ecology

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Heinle, Donald R., 1976. Conditions Affecting Rockfish Abundance Studied by C.B.L. Commercial Fisheries News, Vol. 9, No. 4. Dept. of Natural Resources of Maryland.

Lippson, Jane, ed., 1973. The Chesapeake Bay in Maryland. An Atlas of Natural Resources. Johns Hopkins University Press, Baltimore.

Natural Resources Institute of the University of Maryland, 1972. "Bay Biota." Chesapeake Science, Vol. 13, Supplement, Dec.

Renninger, Christian, 1978. "Fishing for a Dominant Year Class." Maryland Sea Grant Newsletter, University of Maryland, Vol. 1, No. 5.

Sherwood, Arthur W., 1973. Understanding the Chesapeake. Tidewater Publishers, Cambridge, Maryland.

Films

Life in the Ocean 16 minutes
Fish Out of Water 11 minutes
Water - Pattern of Life 28½ minutes
Between the Tides 22 minutes
The Sea 26 minutes
Plankton and the Open Sea
World in a Marsh 22 minutes
Cry of the Marsh 12 minutes
Web of Life two 15 minute parts
Marshland is not Wasteland 14 minutes

Check county and school libraries for availability of these and other films and filmstrips.

Filmstrips

Natural Geographic Society
Small Worlds of Life
The Marsh
Exploring Ecology: The Swamp

Reading Supplements

"Food, Will There Be Enough." Nat. Geo. (Vol. 148, No. 1, July 1975).

"Fragile Nurseries of the Sea. " Nat. Geo. (Vol. 141, No. 6, June 1972).

Resources

Tony Mazzaccaro, the Marine Advisory Program Coordinator from the University of Maryland, will come out to your class if given two or three days' notice. He can do demonstrations of oyster shucking, fish filleting, fly casting, and other activities related to the Bay's food chain. He can be reached at 454-4190 or by written request to:

University of Maryland
Cooperative Extension Service
1209 Symons Hall
College Park, MD 20742