What Is Our Coastal Future?

An Adult Marine Education Unit on the Resources of the Gulf of Maine

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A Note on Measurement

Most of the measurements used in this program (i.e., length, width, distance, depth, volume, temperature, etc.) are given in metric units and in the case of temperature, in degrees Celsius (°C). Where convenient, other systems of measurement have been included for comparison. For example, in some cases, the metric value is given directly with the U.S. and/or nautical measurement given in parentheses. The United States has, for some time, been *trying* to convert to the metric system of measurement so that it will be in step with the rest of the world in this regard. In the spirit of this effort, we have used metric units consistently, most of the time including the U.S. and/or nautical values.

However, since most people in the United States are not very familiar with metrics, we have included below a conversion chart containing metric values and corresponding U.S. and nautical values for your convenience.

Metric Measurement	**U.S. Measurement**	**Nautical Measurement**
Mass or weight:	*Mass or weight:*	
1 gram (1g)	App. 35/1000 ounce (Actually .03527)	
1 kilogram (1kg) = 1000 grams	App. 35 ounces or 2 lbs.	
1 metric ton = 1,000,000 grams	App. 35,000 ounces or 2000 lbs.	
Volume:	*Volume:*	
1 liter (1)	App. 1 quart	
1 milliliter (ml) or cubic centimeter (cc) = 1/1000 1	App. 1/1000 qt.	
1 cubic meter (m^3) = 1000 1 or 1,000,000 cc	App. 1000 qt. or 264.2 gal. or 35.31 cubic feet	
Speed:	*Speed:*	*Speed:*
1 centimeter per second (cm/sec)	App. 3/100 mph	App. 2/100 knot
1 meter per second (m/sec) = 60 meters per minute or 100 cm per sec.	App. 2 mph	App. 2 knots
1 kilometer per hour (km/hr) = App. 30 cm/sec or App. 3/10 m/sec	App. 1/2 mph	App. 1/2 knot
Distance/Depth:	*Distance/Depth:*	*Distance/Depth:*
1 centimeter (cm)	App. 4/10 inch	
1 meter (m)	App. 3 feet	App. 1/2 fathom
1 kilometer (km)	App. 6/10 mile	App. 550 fathoms or App. 1/2 nautical mile

Temperature

Degrees Fahrenheit (°F) = (°C x 1.8) + 32

Degrees Celsius	Degrees Fahrenheit
0°C	32°F
App.-18°C	0°F
27°C	App. 81°F
21°C	App. 70°F
15°C	App. 64°F
20°C	68°F

1 knot = 1.151 mph

1 fathom = 6 feet or 1.829 meter

1 nautical mile = 1.151 statute mile or 1,852 meters or 1.852 km

Forward

Marine education is a relatively new term embracing a multi-disciplinary approach to learning about the marine environment: how it relates to people and how people change and relate to it. "What Is Our Coastal Future?" is a marine education program developed by the Northern New England Marine Education Project (NNEMEP) at the College of Education, University of Maine at Orono. It was designed primarily for use by informal adult education groups and is projected to encompass a flexible number of two hour meetings.

The format of the program is such that the instructor need not have an extensive background in oceanography and/or coastal issues. Detailed background readings for each topic are included in each section. These can be used by the adult educator for notes or can be duplicated for program participants and serve as discussion material. In addition, each section contains suggestions for activities and demonstrations designed to illustrate certain concepts further. I encourage the instructor to involve program participants in the activities and demonstrations as much as possible.

Our objective is to help adult educators and informal adult leaders make learning more water-related. We did not plan a rigid sequence of lessons, but rather offer the ideas in the teachers guide and readings for your consideration.

The general focus within this project has been the Gulf of Maine. As the Gulf extends from Cape Cod to Nova Scotia it washes an extremely long and varied coast. We have dredged and seined themes from the activities, concerns, organisms, vessels, and the past of this vast watery region of North America. We aim to be inclusive rather than exclusive, suggestive rather than factual, and stimulating rather than expert. Our hope is that your students will become more questioning, interested and critical of watery concerns. We hope your use of these materials will add water back into our culture.

John Butzow

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Background Information Readings (right hand pocket)

Leaders/Teachers Guide (left hand pocket)

Section I: Basic Coastal Ecology

Leader's/Teacher's Guide

Introduction

The broad purpose of marine education is to develop a marine literate citizenry; that is to educate our people about the fundamental importance of the connections of human culture to the marine and aquatic environment. The general purpose of this marine education unit is to provide teaching and learning materials to make this broad purpose possible for adult educators in Northern New England. This unit on the Gulf of Maine and its resources seeks to introduce this promising area to the people of our region.

This unit is not a step-by-step piece of curriculum; it is designed to allow flexibility on your part. It will be necessary for you to adapt the material to your students' abilities and needs, your access to materials, and the availability of transportation for field trips.

In a separate pocket in this folder you will find nineteen readings and other handout materials your participants may want to read as part of your sessions or as home preparation of followup. They are packaged unbound to make duplication easy for you. You may also want to use these readings for personal background.

The Leader's/Teacher's Guide to ***"What Is Our Coastal Future?"*** *contains the following:*

1. *Learning objectives for each topic covered in the background information readings.*
2. *Indoor demonstrations and activities for each topic.*
3. *Suggestions for individual research projects for each topic.*
4. *Field activities for each topic.*
5. *Guidelines for conducting a community case study.*
6. *Two educational games.*
7. *An Annotated Filmography.*
8. *Additional resources.*

The indoor demonstrations and activities were designed for use by a wide variety of groups. Because many groups do not have access to sophisticated scientific equipment, the demonstrations and activities are intentionally simple, utilizing only equipment that can be easily obtained or made. Many of the discussion questions either do not have answers, or in the event that answers do exist, it is not necessary for the instructor to know them. These questions are included solely for the purpose of sparking discussion and stimulating the formation of theories within the group. Hopefully, program participants will feel inspired to go out on their own and find out some of the answers to the questions.

The individual research projects section represent only a few suggestions of activities that program participants may wish to undertake on their own. Many of the questions presented in these sections can also be used as "discussion stimulants" with the group.

The program is divided into four sections which are described briefly below:

Section I is an introduction to oceanography, and includes physical, biological, chemical and geological characteristics of the coast of Northern New England. It is important to have a basic understanding of marine ecology in order to be able to draw connections between human utilization of the coast and the impacts of that utilization upon the marine environment.

Section II briefly discusses the importance of the marine environment to Northern New Englanders and to all Americans, in general. It covers the various uses of that environment by humans and touches upon why so many of us truly love the coast.

Section III provides information and discussion materials on the various critical coastal issues facing our region today, including: fisheries development and management, industry sitting along the coast, energy resources, recreation and tourism, public access, and others.

Section IV contains two educational games: a simulation game involving a coastal industry, and a role playing game about fisheries issues in Northern New England.

Section I
Basic Coastal Ecology

Section I contains background information, demonstrations, and other activities designed to teach your group about the basics of coastal ecology and how the various natural processes and characteristics relate to the citizens of northern New England. The topics covered in this section are:

1. ***Physical Processes***
   a. ***Tides***
   b. ***Waves***
   c. ***Currents***
2. ***Chemical Characteristics***
3. ***Geological Processes and Characteristics***
   a. ***Movement of Materials***
   b. ***Beach Dynamics***
   c. ***Bottom Features of the Gulf of Maine***
4. ***Biological Characteristics and Relationships***
   a. ***Who Lives Here? (Some plants and animals of the Gulf of Maine).***
   b. ***Who Lives Where? (Habitats of some of the plants and animals of the Gulf of Maine)***
   c. ***What are the Relationships between plants, animals and their environment in the Gulf of Maine?***

Physical Processes

Tides

The background information for this subsection has been divided into three readings: Tides, Waves and Currents. Below are learning objectives, demonstrations and activities for each topic.

Learning Objectives

As a result of studying the information given on tides, the program participants should learn:

1. The definition and causes of tides,
2. The definitions and causes of spring tides and neap tides,
3. The definitions and cause of semi-duirnal, duirnal and mixed tides,
4. How the geography and geology of particular areas affect the tides of those areas (e.g. the Bay of Fundy),
5. How tides affect humans.

Indoor demonstrations and activities

1. For this demonstration you will need the following materials:

   A baseball
   A basketball
   A tennis ball
   A large rubber band
   A ball of string
   A pair of scissors

   Note: If the baseball, basketball, and tennis ball are not available, you may substitute other round objects of equivalent sizes.

Procedure:

a. Put the rubber band around the middle of the baseball (running horizontally around it). Make sure that the rubber band is large enough to be pulled several inches away from the ball.
b. Cut two lengths of string, one six inches long, the other forty-six inches long.
c. Cut two more lengths of string, one long enough to be tied around the tennis ball, the other long enough to be tied around the basketball.
d. Tie one end of the forty-six inch long piece to any point on the string that is around the basketball. Tie the other end to any point on the rubber band around the baseball. Tie one end of the six inch piece to any point on the string that is around the tennis ball. Attach the other end to the rubber band around the baseball *directly opposite* the point at which the basketball's string is attached (see Figure 1).

Figure 1

e. Have one participant hold the basketball and another hold the tennis ball. You hold the baseball. Ask the participants to pull gently on each ball until the rubber band begins to pull away from the baseball. If possible try to get the participants to pull with an approximately equal amount of force.
f. What *should* happen is this: the rubber band should be pulled away from the baseball on the side of the tennis ball about twice as far as it is pulled away on the side of the basketball.

Explanation:

This activity is intended to demonstrate the influence of the sun and moon on the tides of the earth. The basketball represents the sun, the baseball, the earth, and the tennis ball, the moon. The rubber band around the baseball represents the large water masses of the earth. The sun and moon together exert a gravitational attraction on the earth that affects primarily the large bodies of fluids on the earth's surface. The solid sections of the earth, (i.e., the continents), are too rigid to be noticeably affected by this pull, however the large water masses, since they flow, actually move in response to the attraction. The sun is much larger (about 400x) than the moon (sun's diameter 864,000 miles; moon's diameter = 2,160 miles) but the moon is about four hundred times closer to the earth than the sun (sun's distance from the earth = about 93,000 miles; moon's distance from the earth = 240,000). The moon's closeness, when compared with the sun, is much more important than the size difference, and, consequently, the moon's gravitational influence is about twice that of the sun.

2. For the demonstration you will need the same materials as for Demonstration # 1.

Procedure:

a. Keep the strings tied around the basketball and the tennis ball and leave the rubber band around the baseball. Untie the string that attaches the tennis ball to the baseball at the rubber band (on the tennis ball). Leave the basketball attached to the rubber band as is.
b. Attach the tennis ball, via its string, to the rubber band so that the three balls form a 90° angle (see Figure 2 — the tennis ball is coming out of the page)

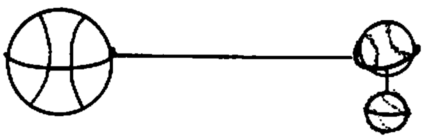


Figure 2

Figure 3

c. Have participants pull on the basketball and tennis ball as before. Ask the class to note what happens to the rubber band.
d. Reattach the tennis ball again so that its string joins the rubber band at the same spot as the basketball's string (see Figure 3).

Explanation:
This activity is intended to demonstrate how different alignments of the sun, moon and earth affect the earth's tides. Your participants may not be able to discern much difference in the distances the rubber band is pulled away from the baseball each time, however, the demonstration is still valuable in that it shows graphically the different positions of the three bodies that have an influence on the tides. In Figure 2 the sun and moon are acting against each other and produce what is called *neap* tides. These are tides in which the low tides are *not* as low as usual and the high tides not as high as usual (smaller tidal range). In Figure 3, the moon and the sun are acting together, so the effect is additive. In this case, the result is *spring* tides, where the highs are higher than usual and the lows are lower than usual.

In Figure 2 also, the moon and sun are acting together even though it appears that they are working against each other. This situation is true because of centrifugal force set up by the rotating earth-moon system. This force is equal at all points on earth, while the gravitational attraction of the moon is greater on the side of the earth that faces the moon and decreases as we move through the center of the earth to the other side, which faces away from the moon. On that side, the centrifugal force is actually greater than the moon's gravitational attraction and thus causes the water to bulge outward, *away* from the moon than to be "sucked inward" toward the moon (see Figure 4).

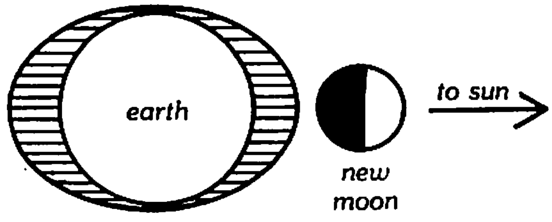


Figure 4

Followup to the demonstrations:

Ask the participants to make a record of the high and low tides for their locality for a period of three days. This information can be obtained from the daily newspaper or from tide charts available from numerous sources (marine supply stores, local fishermen, etc.). Using the times and the heights of the tides, one can graph a tide curve for the locale. See Figure 5 for an example.

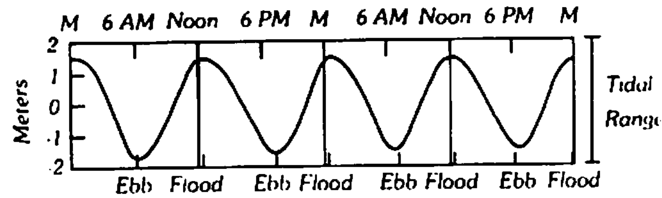


Figure 5

3. Try to stimulate group discussion by having the participants write down any questions they may have regarding tides *before* and *after* the class meeting on that topic. Questions that were not answered during the meeting can be used as follow-up "discussion stimulants". In addition, the following suggested questions may help spark a discussion:

a. What determines the time of the tides at different locations: (For example, the following list gives the time of the first high tide on January 1, 1981 at different locations on the east coast:
   - Halifax, N.S. 4:05 a.m.
   - Eastport, Maine 6:58 a.m.
   - Portland, Maine 7:27 a.m.
   - Bar Harbor, Maine 7:05 a.m.
   - Bath, Maine 8:25 a.m.
   - New York, NY 4:44 a.m.
   - Boston, MA 7:25 a.m.
   - Baltimore, MD 2:40 a.m.
   - Charleston, SC 4:13 a.m.

   What factors influence these times:
b. Along the same lines, what factors help account for the differences in heights of the high tide at different locations?

Halifax, N.S.	Height	6.3 ft.
Eastport, ME	Height	16.7 ft.
Portland, ME	Height	8.3 ft.
Boston, MA	Height	8.9 ft.
New York, NY	Height	4 ft.
Baltimore, MD	Height	0.4 ft.
Charleston, SC	Height	4.7 ft.

c. If it is low tide at Portland, Maine at 8:00 a.m., what would be the tide in California at 8:00 a.m. our time (5:00 a.m., *their* time)? Would it be high or low? How about along the coast of Europe at 8:00 a.m. *our* time (about 1:00 p.m. their time)? How about the east coast of Asia? Why?
d. The use of tidal power to generate electricity is discussed in some detail in Section III of this program (Critical Issues), however you might want to bring up the topic here to spark interest. What might be some of the impacts on the coastal environment of northern New England (including the plants, animals and people who live in that environment) of a tidal power generating project? What could happen globally if *all* the potential tidal power sites in the world were developed?

4. Check the *Annotated Filmography* for filmstrips and films dealing with tides. These can be found under Section I of the Filmography.

Individual research projects

Some or all of the members of your group might be interested in further pursuing some other questions related to tides. These projects can be done on the individual's own time and then reported back to the rest of the group. The following are only a few suggestions:

1. How does a tidal power generating station operate?
2. What has been the experience of tidal power stations that have been built elsewhere in the world? (e.g. Rance River, France). Have they been successes or failures?
3. How would a sailor take into account tidal currents when navigating a course?

Waves

Learning Objectives

As a result of studying this section on waves, the members of your group should learn the following:

1. The definition and causes of waves,
2. The factors determining the size of waves,
3. The structure of waves,
4. The movement of water particles within waves,
5. What causes waves to "break,"
6. The characteristics of waves (reflection, refraction, diffraction),
7. Some examples of waves caused by earthquakes and other seismic activity,
8. How waves affect the lives of people dwelling or working along the coast of northern New England and elsewhere.

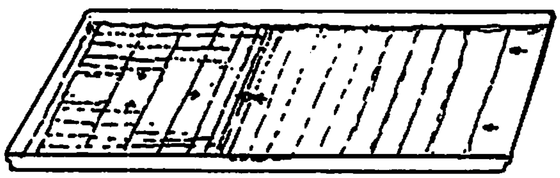
Indoor demonstration and activities

1. For this demonstration you will need the following materials:

An overhead projector	Water
A rectangular glass baking dish	Food coloring
A marble	Electric fan (if available)

Procedure

a. Fill the baking dish about three-quarters full of water and place on overhead projector.
b. Turn on projector.
c. Drop the marble into the water at one end of the dish and observe "waves" on the projector screen.
d. Remove the marble. Place the fan at one end of the dish and angle it so that it will blow onto the water. Turn on the fan to low. Observe the "waves".



Explanation

Dropping the marble into the dish simulates a seismic disturbance like an earthquake which can cause waves. The fan shows how wind generated waves are formed.

Followup to the demonstration:

a. Try building a small clay "island" in the dish. Generate wind waves with the fan and observe what happens to the waves as they strike the island.
b. Place small floating objects in the dish. Watch how they react to waves.

Note: If you used a fan to generate waves here, it will probably blow the object along. Try "marble generated waves" and see what happens to the object.

2. Try to stimulate group discussion by having the participants write down any questions they may have regarding waves. In addition, the following suggestions may help spark a discussion:

a. Every now and then you hear reports of disaster at sea resulting from the occurrence of a "freak" wave. What causes these "freak waves"? If you were a sailor and encountered such a wave, what would be your course of action?
b. What are "whitecaps"? What causes them?
c. What are "swells"? What causes them?
d. What would be the impact on the marine environment of "wave power" electrical generating stations?

3. Consult the Filmography for films on waves.

Individual Research Projects

The following are suggestions for projects to be done on an individual's own time and reported back to the group:

1. Does any agency (federal or state) keep records of unusual wave heights? If so, what is the record for the Gulf of Maine or the North Atlantic?
2. What is the method used by ships at sea to measure wave heights?
3. How would a wave power generating station operate?

Currents

Learning Objectives

As a result of studying the information given on currents, the program participants should learn:

1. The definition and causes of currents,
2. Where currents can be found,
3. The definition, causes and characteristics of surface currents,
4. The definition and causes of *gyres* (circular currents),
5. Some abnormalities associated with currents (e.g. "El Nino" event off Peru) and their impacts,
6. The characteristics and importance of the Gulf Stream,
7. The definition and impacts of the Coriolis effect,
8. The current patterns of the Gulf of Maine,
9. The importance of currents to humans.

Indoor demonstrations and activities

1. For demonstration #1, you will need the following:

A small (15 gallon) aquarium or
A large glass baking dish
Sea water (or tap water mixed with table salt, or sea salt — available in health food stores), or artificial seawater made from "Instant Ocean" which is available from most aquarium shops.
Food coloring
A hot plate, bunsen burner or some other device for heating water
Tap water

Procedure:

a. Fill the aquarium or baking dish about two thirds full of tap water.
b. Mix a container (about 1 cup) of saltwater with some food coloring. (You can make "saltwater" by adding about 2 tbls. sea salt or table salt to a cup of tapwater. This will not have the same "saltiness" as seawater, but it will suffice for this demonstration.)
c. *Slowly* pour the saltwater down the inside of the aquarium or baking dish. Be careful not to agitate the freshwater as you are adding the salt water.
d. Observe the results.
e. Heat about 3 gallons of uncolored saltwater. Pour into empty aquarium.
f. Add some food coloring to a cup of cold saltwater. *Slowly* pour the cold saltwater down the inside of the aquarium into the hot water. (Note: this can also be done with hot and cold tap water.)
g. Observe the results.

Explanation:

The above activity is designed to demonstrate the occurrence of currents due to density difference in the water. The addition of saltwater to freshwater, and of cold water to hot water create density currents. The saltwater is heavier than fresh and sinks below the fresh, while the cold water is heavier than the warm and sinks below it.

2. An additional activity you might try, if time permits, is this simple demonstration of the Coriolis effect:

Materials needed:

Record player
An old record you don't care about
Chalk

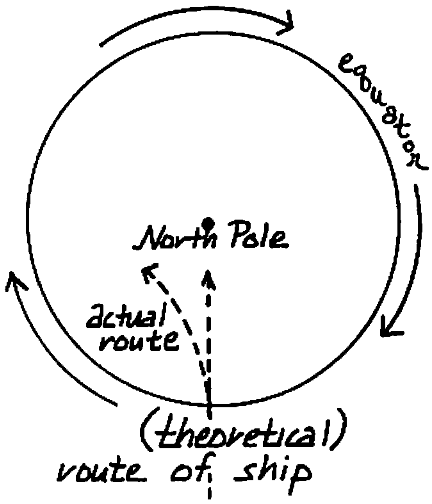
Procedure

a. Put the record on the record player and turn the player on slow speed (16 rpm).
b. Have several participants attempt to draw a straight line on the record with the chalk while the record is turning.
c. What happens?

Explanation:

The turning record represents a top view of the earth as it rotates. The edge of the record is the Equator and the hole in the center of the record is the North Pole (assuming all record players turn records clockwise). The chalk line could represent the transit of a ship from the equator. What happens to the sh[illegible] as it attempts to go straight from the Equator to the North Pole?

Note: The ship is deflected to the right of the record, the observer's left.



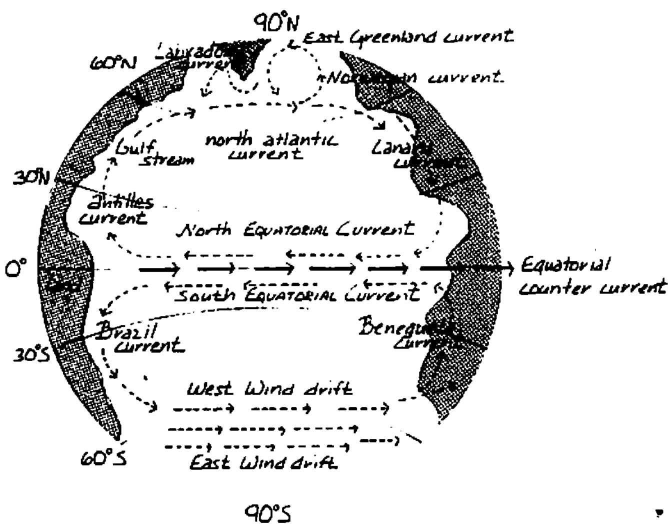
3. Try to stimulate a discussion, utilizing either questions from the group or the following suggestions.
   a. What would the currents of the world look like if there were no continents on earth?
   b. What would be the environmental impacts of a "current power" electrical generating station?
   c. Why are the currents that run along the western edges of gyres stronger and faster than the ones that run along the eastern edges? How does this fact affect the coastlines along which these currents run?
   d. Why are the currents that run along the western edges of gyres warm, while those that run along the eastern edges cold? How does this fact affect the coastlines (and their inhabitants) along which these currents run?

4. Consult the Filmography for films on currents.

Individual research projects

One of the following suggestions might inspire an individual within the group to do some extra research on his or her own and report the findings back to the group:

1. How do sailing peoples in various parts of the world use currents to navigate?
2. How would a "current power" electrical generating station operate?
3. The background information for this topic emphasizes chiefly worldwide and Gulf of Maine current patterns. How are local currents generated (e.g. longshore currents, "rip currents", etc.)? What effects can these local currents have on the shorelines of the vicinity?



Chemical Characteristics

Chemical Composition of Seawater

Learning Objectives

After studying the material contained in the background information for this topic, the program participant should know the following:

1. The major, minor and trace constituents of seawater, the sources and characteristics of these constituents (including water, minerals, nutrient elements and dissolved gases),
2. The effects of the salt content of seawater on freezing,
3. What the seawater "buffer system" is and its importance,
4. What the salinity structure is in the Gulf of Maine,
5. What estuaries are and why they are chemically important,
6. What some of the relationships are between the chemical composition of seawater and the activities of humans along the coast.

Indoor demonstrations and activities

1. For this demonstration you will need the following materials:

Table salt	Several large jars (qt. mayonnaise jars)
Tap water	Several small jars, clear pill vials, test tubes, or whatever is easily available
Food coloring	Measuring cups and spoons
Plastic straws or eye droppers	

Procedure:

a. Mix up several different solutions of salt water in separate jars. For example:

   Solution #1 might be 1 cup tap water and 1 Tbls. salt
   Solution #2 might be 1 cup tap water and 10 Tbls. salt
   Solution #3 might be 1 cup tap water and ½ Tsp. salt

b. Color each solution a different color using food coloring.
c. Supply participants with smaller jars, vials, etc., straws or eyedroppers.
d. Without telling the participants the strength of the solutions, ask them to try to make different colored layers in their own jars. Which solutions had the highest salinity? The next highest? The lowest?

Explanation

The solution with the largest amount of salt in it is the most dense. (Recall from the background information that increased salinity means increased density.) The solution with the smallest amount of salt in it is the least dense. By experimentation, the participants should eventually be able to create a "salt water parfait" that has the most dense water on the bottom, the next dense water in the middle and the least dense water on top. The solutions must be added carefully to each other as too much agitation will aid the mixing of the solutions.

2. Another activity to try if time and equipment permit is the folowing:

Materials needed:

Tap water
Table salt or Seawater sample
Refrigerator with freezer
Ice cube tray or shallow plastic containers

Procedure:

1. If seawater is not available, mix a solution of salt water using tap water and table salt. (It need not be the same salinity as seawater. One cup tap water and 1 Tbsp. salt should be adequate.)
2. Fill half the compartment of the ice cube tray with plain tap water and the other half with the seawater or salt water mixture. Put tray in the freezer compartment of the refrigerator.
3. About how long did it take for the plain tap water to freeze solid? What happened to the salt water?

3. Try to stimulate discussion within your group by calling for questions from them or by using the following suggestions:

a. Manganese nodules are blobs of minerals (e.g. manganese, nickel, copper, etc.) that are formed on the bottom of the sea. How does the chemical composition of seawater relate to the formation of these nodules? Of what importance are these nodules to people?
b. What happens to a fresh water creature when it is placed in salt water? To a salt water creature placed in fresh water?
c. What would happen to the Gulf of Maine if the concentrations of carbon dioxide and carbon monoxide in the air over the Gulf were suddenly to increase one hundred fold?

4. Consult the Filmography for films on salinity.

Individual research projects

Some individuals may wish to look further into one or more of the questions posed as "discussion stimulants" for this topic or may want to pursue one of the following suggestions:

1. How are manganese nodules formed from seawater?
2. How does desalination (the removal of salt from ocean water) of seawater occur? What is the potential of this process for increasing the earth's fresh water supplies? What would be the impact on marine environments of large scale desalination projects?
3. Of what benefit can the salt content of oceans be to people (besides manganese nodule formation)?
4. When fresh water and salt water meet, energy is released. How does this happen? Is it possible to harness this energy for human use? How could this be accomplished?

Geological Processes and Characteristics

Movement of Materials

The background information for this subsection has been divided into three readings: Movement of Materials, Beach Dynamics, and Bottom Topography of the Gulf of Maine. Below are learning objectives, demonstrations and activities for each topic.

Learning Objectives

The participants should learn the following from this section:

1. The primary ways that sediments are moved in coastal environments (water, wind, organisms),
2. The three ways that water moves materials (in suspension, rolled along the bottom, in solution),
3. The size categories for sediments (clay sized, silt sized, sand sized, gravel sized, pebbles, cobbles, stones, rocks, boulders),
4. How the size of the particle and the velocity of the moving water influences what materials can be moved,
5. How sediments are deposited by moving water,
6. The sediment transport patterns in the Gulf of Maine.

Indoor demonstration and activities

1. For the first demonstration, you will need the following materials:
Samples of several types of sediments (silt, sand, coarse sand, pebbles, etc.)
A jar for each sediment type that you have plus a few extra (quart mayonnaise jars are good)
Tap Water

Procedure:

a. Put enough sediment into each jar to cover the bottom of the jar. Put silt in one jar, sand in another, pebbles in another, etc.
b. Add water until each jar is about ¾ full.
c. Put a mixture of the sediments in another jar and add water until the jar is ¾ full.
d. Divide all jars up among the participants. On signal, they should all shake their jars vigorously for five seconds, put the jars down and time how long it takes for the sediment to settle out and stop moving. The person with the jar of mixed sediments should note the layers that form. What type of sediment is on the bottom? In the next layer?
e. The participants should record the time needed for each sediment to settle out. (In the case of the very fine sediment, the water should be perfectly clear before the timing stops. Be prepared for a bit of a wait!)

Note: Be sure the jars are not disturbed, jiggled or picked up while sediment is settling.

2. Try to get a discussion started regarding the importance of sediment transport in the Gulf of Maine. Ask participants to write down any questions they may have about the process and/or use of the following suggestions:

a. What would the Gulf of Maine be like if no sediments were transported into it? How does the movement of materials from land areas into the ocean affect the living organisms in the sea? How does the movement of materials from one place to another *within* the marine environment affect the nearby land?
b. What is the impact of certain man-made structures along the coast (e.g. jetties, breakwaters, seawalls, piers, boardwalks, buildings, etc.) on sediment transport within the marine environment?

3. Consult the Filmography for films on sediment transport.

Individual research projects

1. Devise a simple indoor demonstration to show how erosion occurs (both erosion by rain and rivers on land and erosion by waves along the coast).

Beach Dynamics

Learning Objectives

From the background information on beach dynamics, the program participants will learn the following:

1. The importance of sandy beaches to northern New England,
2. How sandy beaches are formed,
3. Why there are so few sandy beaches in northern New England compared with the rest of the East Coast,
4. What the major sources for sand are in the Gulf of Maine,
5. How waves build and erode sandy beaches,
6. How winds build and erode sandy beaches,
7. How currents build and erode sandy beaches,
8. What the effect of global sea level rise is on sandy beaches,
9. In what ways the dynamics of sandy beaches are important to the citizens of northern New England.

Indoor demonstrations and activities

1. A list of the major *undeveloped* sandy beach areas in northern New England is given below. Locate these areas on a map of Maine. What special features characterize these

beaches? Are they located along a particularly straight stretch of coastline or along a very indented section? Are they found nearer the tips of peninsulas or farther upstream along the shores of bays and coves?

Maine

1. Ogunquit Beach, Wells, York County
2. Laudholm Beach, Wells, York County
3. Crescent Surf Beach, Kennebunk, York County
4. Parsons Beach, Kennebunk, York County
5. Goose Rocks Beach, Kennebunkport, York County
6. Western Beach, Scarborough, Cumb. Co.
7. Scarborough Beach, Scarborough, Cumb. Co.
8. Main Beach, Ram Island Farm, Cape Elizabeth, Cumb. Co.
9. Strawberry Hill, Ram Island Farm, Cape Elizabeth, Cumb. Co.
10. Crescent Beach, Cape Elizabeth, Cumb. Co.
11. Bailey Beach, Phippsburgh, Sagadahoc Co.
12. Seawall Beach, Phippsburg, Sagadahoc Co.
13. Popham Beach, Phippsburgh, Sagadahoc Co.
14. Reid Beach, Georgetown, Sagadahoc Co.
15. Pemaquid Beach, Bristol, Lincoln Co.
16. Louds Island Beach, Louds Is., Lincoln Co.
17. Merchant Island-Pocket Beach, Isle Au Haut, Knox County
18. Merchant Island-Cupsate Foreland, Isle Au Haut, Knox Co.
19. Pond Island Beach, Pond Is., Hancock Co.
20. Marshall Island-Sand Cove, Swans Island, Hancock Co.
21. Marshall Island-Carbonate Sand Beach, Swans Island, Hancock Co.
22. Swans Island-Irish Cove, Swans Island, Hancock Co.
23. Swans Island-Fine Sand Beach, Swans Island, Hancock Co.
24. Sand Beach, Bar Harbor, Hancock Co.
25. Sandy River Beach, Jonesport, Washington County
26. Rogue Island Beach, Jonesport, Washington County

2. Consult the Filmography for films on beach dynamics.
3. "Discussion stimulants" — suggestions:
   a. What kinds of actions have been taken by your town (if you live along the coast) to try to prevent beach erosion? What effects have these actions had?
   b. What kinds of actions could be taken to help alleviate beach erosion that would have the least damaging impact on beach dynamics?
   c. What effect is the historical rise of the worldwide sea level likely to have on beach dynamics in northern New England?

Individual research projects

The following are but a few suggestions for projects that can be pursued by individuals in the group:

1. What are the major geological features of sandy beaches and how are they formed? Which are erosional features? Depositional features? (Note: The Sea Grant report cited as a reference for the background information on beach dynamics devotes several pages to the description of the various geologic features of sandy beaches.)
2. What are the most common plants found on sandy beaches? How do plants contribute to sandy beach dynamics? (Again, the Sea Grant report is an excellent resource for this question.)
3. Find out about the role of the Critical Area Programs of the Maine State Planning Office in preserving significant undeveloped sandy beach habitats in Maine. Interview the director of the Critical Areas Program or invite him to speak with the group.
   Critical Areas Program
   Maine State Planning Office
   Augusta, ME 04333
   Phone: (207) 289-3155

4. Does any agency within the states of Maine and New Hampshire (including the Universities of those states) maintain records on the growth or disappearance of various beaches? If so, find out and report back to the group, what has been happening to one or more beaches in your vicinity over the past 50 years or so. (Note: Maine has a state geologist who might be able to help with this project. He can be contacted at:
   Maine Geological Survey
   State House
   Augusta, ME 04333
   Phone: (207) 289-2801

Bottom Topography of the Gulf of Maine

Learning Objectives

As a result of studying the information given on this topic, the program participants should learn:

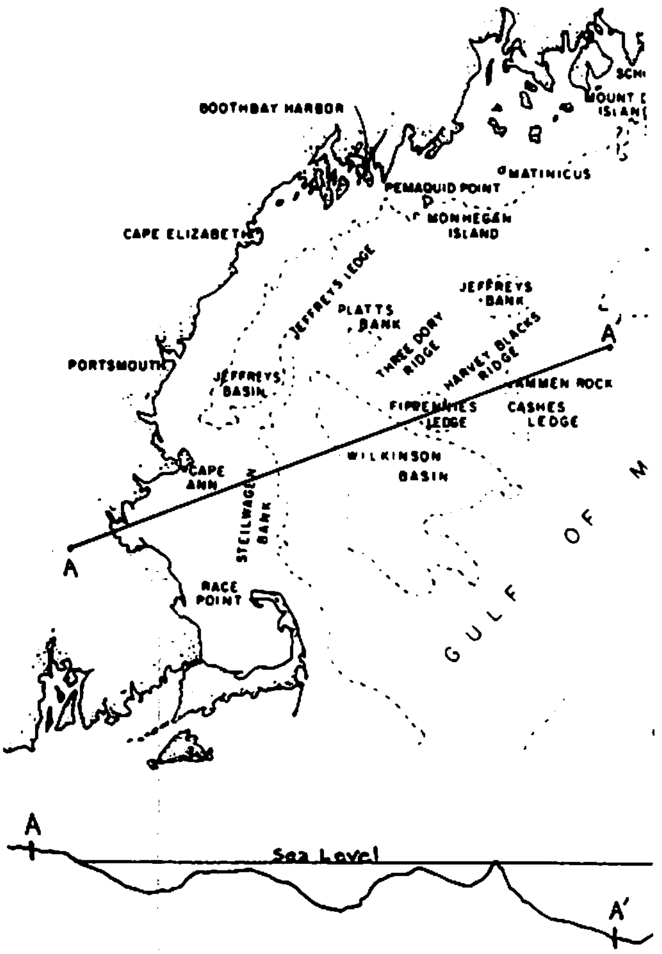
1. The boundaries of the Gulf of Maine,
2. The influence of the shallow bordering banks (Georges, Browns, etc.) on the characteristics of the Gulf of Maine,
3. The significant bottom features of the Gulf of Maine,
4. The importance of the topography of the Gulf of Maine to the activities of people in the region.

Indoor demonstrations and activities

1. For the following demonstration, you will need certain equipment:
   A nautical chart for the Gulf of Maine. A full sized chart can be obtained from:
      The Chart Room
      10 Dana Street
      Portland, Maine 04112
      Phone: (207) 772-7989
   The chart number to ask for is National Oceanic Survey #13260
   The chart will cost about $4.00.
   Paper (graph paper would be handy, if available) and pencils.

Procedure:

a. Xerox various sections of the chart or cut the chart into enough portions for each member of the group to have one. Pass out a different section of the Gulf of Maine chart to each participant.
b. Ask each participant to choose a transect across his/her section of the Gulf. A transect is simply a straight line running in any direction from one edge of the section of chart to the opposite edge.
c. Using the scale of miles indicated on the chart, each participant should plot depth versus distance across his transect or graph or plain paper. This is done in the following way:
   a. Figure out the length of the transect using the scale of miles. (ie. what would be the *actual* length of the transect if you were at sea doing it?)
   b. Across the bottom of the graph, make a scale for that distance. For example, if the length of the transect is 20 miles, you might want every inch of your graph to be equal to 5 miles, or every 5 squares on graph paper to equal 5 miles.
   c. Look at the depths recorded on the chart along your transect. Choose a scale to put along the edge of your graph that starts with the deepest depth shown on the transect. For example, if the deepest depth is ‹00 feet and the shallowest is 50 feet, you need to draw a scale along the edge of your graph that will include these two values. You might want to make every inch along the edge of your graph equal to 50 feet (or every 10 squares of graph paper equal to 50 feet).
   d. Start with zero in each case (distance and depth). On the depth recording, the zero goes at the *top* of the graph.
   e. Record the value of the depth at the beginning of your transect and mark it on your graph with a dot. Move along 20 miles (or whatever value you have chosen) and note the depth there. Mark it on your graph. When you have finished moving along the transect, connect the dots. This will give you a picture of what the bottom of the Gulf of Maine looks like along your transect. Is it totally flat or does the bottom along your transect have hills, valleys, holes, etc? (For an example, see Figure 6.)



2. An ambitious, but interesting undertaking would be to construct a model, using papier mache or plaster of paris, of the floor of the Gulf of Maine. The *Quoddy Times* in Eastport has such a model of the Passamaquoddy Bay region. If you are in the Eastport area, you should stop in and see it. The *Quoddy Times* is located on Water Street near the town wharf.

3. "Discussion stimulants" — suggestions:
   a. How does the bottom topography of the Gulf of Maine (e.g. islands, ledges, channels, etc.) affect various human activities? (e.g. commercial fishing, oil and gas drilling, shipping, recreation, coastal defense, etc.)
   b. How would the Gulf of Maine be different if the bottom were completely flat and featureless? How would *this* situation affect human activities in the region?

4. Consult the Filmography for films on bottom features of the oceans.

Individual research projects

The following are but a few suggestions for individual research projects on this topic.

1. Find out where the traditional fishing grounds are in the Gulf of Maine (in addition to Georges Bank). What kinds of fish were/are commonly caught on each? What geological features characterize these fishing grounds? You may want to approach this project from one of two angles: a. there are historical records available in some libraries as to where the traditional fishing grounds are located (an example is "Fishing Grounds of the Gulf of Maine" by Walter H. Rich, in the report of the U.S. Commissioner of Fisheries for 1929, U.S. Dept. of Commerce, Bureau of Fisheries, Washington, D.C.) or b. interview a number of fishermen as to *where* they fish in the Gulf of Maine and for what type of fish.
2. Why are the shallow banks (e.g. Georges Bank, especially) in demand by oil companies for exploration and exploitation? Why do these companies believe that oil and gas might be found there? For what other reasons do they want to drill there? What geological features of the banks lend themselves particularly well to oil drilling?

Biological Characteristics and Relationships

The background information for this topic has been divided into three readings: Who Lives Here?, Who Lives Where? and What are the Relationships Between the Plants, Animals and their Environment in the Gulf of Maine? Learning objectives for each topic are given below. Demonstrations and activities for this subsection will follow the learning objectives for the last topic (relationships).

Who Lives Here?

Learning Objectives

The background information for this topic will teach the program participants the following:

1. How living things (plants and animals) on earth are organized into groups (called *phyla*, singular, *phylum*).
2. What the major plant and animal phyla are in the Gulf of Maine and examples of plants and animals from each.

Who Lives Where?

Learning Objectives

The background information for this topic will teach the program participants the following:

1. What the four basic habitats are in marine environments.
2. That the *shore* habitat itself is divided into several "zones".
3. What types of plants and animals live in each marine habitat and in each shore zone.
4. That there are four basic types of shores in the Gulf of Maine.
5. What kinds of plants and animals are associated with each shore type.

What Are the Relationships Between the Plants, Animals and Their Environment in the Gulf of Maine?

Learning Objectives

The background information for this topic will attempt to draw together all the previously covered topics in Section I in such a way as to show some interrelationships between the various processes in the Gulf of Maine (tides, waves, currents, sediment transport, beach dynamics, etc.), the geological and chemical characteristics (bottom topography and salinity structures) and the biological characteristics (what kinds of plants and animals live here, where do they live). The significance of these relationships to human activities in the Gulf of Maine is also discussed.

Indoor demonstrations and activities

1. For this demonstration you will need the following equipment:
   An aquarium of any size
   A water filter (the undergravel filters are best for use in a saltwater aquarium)

An air pump (we recommend "Silent Giant")
Seawater or "Instant Ocean" (available at aquarium shops)
Aquarium gravel or crushed shell

Note: If the above equipment is not obtainable, a simple aquarium can be made using:

A gallon jar
An air pump
Clean sand

Marine specimens (fish, crabs, snails, mussels, seastars, etc.) including several examples of algae
Shallow pans (dish pans, glass baking dishes, etc.)
Heavy white unglazed paper (construction paper is fine)
Newspaper
Plant presses (can be homemade — see #5 below)

Procedure

a. The best way to observe marine life is to set up a saltwater aquarium. If it is at all possible for you and your group to do so, we highly recommend it. You do not need expensive aquarium equipment as a simple, but adequate, aquarium can be made from a gallon jar. Complete instructions on how to set up a "traditional aquarium" can be found in the NNEMEP unit: *Have You Been To the Shore Before?*

b. Some marine creatures that are easy to obtain and keep alive in an aquarium include: periwinkles, blue mussels, seastars, dogwhelks, sea urchins, rock crabs, soft clams, green crabs, hermit crabs and sponges. Most of these can be collected from the intertidal area of a rocky shore or from a tidepool. Other animals such as fish, sea cucumbers, lobster, spider crabs, etc., can be obtained by someone who dives. (Live lobsters, of course, can be bought from a lobsterman or a seafood market.)

c. The behaviors of the occupants of the aquarium can be very interesting to observe. For example:
   a. Which creatures tend to hide? How and where do they hide?
   b. Do the creatures have a preference for certain bottom types? Do some prefer sandy bottoms? Do others prefer rocks?
   c. How do the creatures react to each other? With aggression? Defense? Etc.
   d. Where do different animals stay while in the tank? Near the surface? Along the side of the tank? On the bottom? In the gravel?

d. In addition to observing the animals in their aquarium habitat, some simple (and nonharmful) experiments can be done to test the animals' reactions to various situations. For example, the following:

A. Changes in bouyancy:

Materials needed:

Some small fish
Plastic tubing (about 2 inches in diameter) or glass jars
Plastic netting, cheesecloth or some other material that will allow water to pass through it (the red plastic mesh bags that onions come in work very well)
Flexible wire

Procedure:

1. Put one fish inside each plastic tube or jar. Place some stones or a small rock inside one tube or jar along with the fish. Secure the mesh over the openings of the tubing or jar.
2. Place the weighted "fish cage" on the bottom of the aquarium.
3. Bend the wire around the other "fish cage" and suspend it from the side of the aquarium so that it is very close to the surface of the water.
4. Leave this apparatus set up overnight or for several hours.
5. Release the fish from their "cages" and observe their behavior.

Explanation:

The buoyancy of the fishes will change according to their positions. The fish on the bottom will become slightly *positively* buoyant and should rise to the surface while the fish at the surface will become *negatively* buoyant and should descend towards the bottom.

B. Light and Dark

Materials needs:

A flashlight with good batteries

Procedure

1. Keep the aquarium in total darkness for an hour or more.
2. Shine the flashlight into one end of the tank, and keep it there for several minutes.
3. Observe the reactions of the tenants of the tank.

2. Marine algae can be preserved for study by making "seaweed prints".

Materials needed include:

Several specimen of different kinds of algae
Shallow pans (dish pans, glass baking dishes, etc.)
Unglazed white paper (construction paper, herbarium paper, etc.)
Seawater
Plant press (can be easily made — see below)
Small paint brush
Nylon stocking material or waxed paper

a. A plant press can be constructed from ¼ inch thick plywood or peg board. Cut two pieces 10" wide by 14" long. Cut numerous holes in the two pieces about 1 inch in diameter. These holes will facilitate drying, however, they are not absolutely necessary. Two long ¼ inch carriage bolts and wire nuts can be used to hold the top and bottom together with proper tension. (See Fig. F) A simpler apparatus can be made by merely piling bricks on top of the press for pressure, however, a portable press is more useful in the field.

b. The pressing is accomplished as follows:
   1. Place mounting paper in the bottom of a shallow pan such as a large glass baking dish. Metal dishes or pans are alright but may get rusty. Add about one inch depth of water preferably sea water, and finally the sea weed piece. Arrange the plant material attractively and carefully to show all parts. Final arrangements can be accomplished with a small paint brush, toothpick, or pencil point. Encourage careful arrangement.
   2. This is the tricky step. Carefully slide the paper and plant, "short end first," out of the pan. If this is done *slowly* the plant will retain its position.
   3. Place plant-on-paper onto a stack of newspaper for several hours up to a day to remove excess water. Be careful not to allow the plant to begin to dry out.
   4. Each press may contain 6-8 plant pressings. Start on the bottom with a thick pad of newspaper. Then add a sheet of blotter paper, corregated box board or poster board. The first plant pressing goes next, plant side up, with a covering of nylon stocking material or waxed paper (nylon is better). The layer above the nylon is another pad of newspaper. Now the process of stacking can be repeated. Finish off each press at the top with a thick pad of newspaper. The limit on the contents of each press is the length of the screws to tighten it.
   5. Newspapers should be changed every day or so to hasten drying. Care must be exercised to avoid dislodging the plant while drying. As plants become dry they also become brittle, so care is required to avoid bending dry or semi-dry pressings. When drying is complete the results can be identified by consulting a field guide, and placed into a class sea weed book or into a box style herbarium.

3. Try to stimulate a group discussion on these topics by calling for questions from the participants or by using the following suggestions:
   a. What would happen if one member of the marine food web were completely removed from the environment? (To graphically demonstrate this, have the members of the goup assume the roles of different organisms of the food web. Run strings between members to show the food relationships between organisms. Use the illustration of the food web in the background

information as a model. Have one member leave the group, particularly one who holds a large number of strings, leave the group, taking his/her strings along. What is the result? Is there anyone left in the food web who is not holding a string? What would happen to such an organism in a food web?)

b. What would happen to the organisms of the Gulf of Maine if all the water in the Gulf were the same temperature? What would be the result if all ocean water were the same temperature?
c. What would happen to the Gulf of Maine if the polar ice caps melted completely? What would this do to the salinity structure of the Gulf? How about the effect on beach dynamics? Would tides and currents be affected? How? What would this mean to the organisms in the Gulf? To the people along the coast?
d. What causes some types of plankton to "bloom"? (For example, the occurence in Maine waters of the "red tide" is caused primarily by a bloom of the plankton Gonyaulax.)
e. Suppose a particular species of phytoplankton was drastically reduced by a disease. What effect would this have on the other organisms, both plant and animal, of that area?
f. Why is it important that the oceans be preserved in a productive state? What difference would it make to people if absolutely *nothing* lived in the seas? What is the significance of the oceans to humankind?

4. Consult the Filmography for films on marine organisms, habitats and relationships.

Individual research projects

Some suggestions for individual research projects follow:

1. How would an "ocean thermal" power generating station operate? What would be the environmental impacts of such a project?
2. Research the phenomenon of "red tide". What environmental conditions are necessary for a "red tide" to occur? What marine organisms does the "red tide" affect? How do scientists determine whether or not a "red tide" exists? What disease does "red tide" cause in people? How does a person get the disease? What are the symptoms? The cure?
3. What steps are being taken by various agencies within the state and federal governments to help preserve our marine environment? Interview someone from the Maine State Department of Marine Resources or one of the various departments within the New Hampshire State Government that has responsibility for marine resources.

Field Activities in Basic Coastal Ecology

The best way to study marine environments is to visit one. We encourage you and your group to take at least one field trip to the shore to experience first-hand the ecological processes and characteristics we have been discussing in the background information for Section I. The following activities are just a few suggestions of the many ways that a group can go about studying a marine environment from the shore.

A. Physical Processes

1. Tides

Before the trip, try to get some tide tables for the area you will be visiting. These are generally available from local newspapers, marinas, or chambers of commerce. Familiarize yourself with them. Using the tables, try to pick a day for your trip when you will arrive at low tide or, at least, at ebbing tide.

When you arrive at the site, put a flag (about 10 feet tall) at the water's edge.

a. Every hour mark the extent of the tide with a flag of a different color and record the time that color was put out.
b. Measure the distance between the flag and the last one put out.
c. At the end of the day, you will be able to determine how fast the tide was moving during different hour-intervals of the day. When you get home, you can graph your results.

You can also measure the vertical height of the tide by marking a stake with one-foot intervals.

a. Label the intervals so they can be easily seen.
b. Drive the stake in the sand down to the 0 foot mark. Then record the readings every hour. (For the Gulf of Maine, you will need a pole about 20 feet tall!)
c. You can graph these results also to keep in your trip log.

2. Waves

Materials needed:

Seven foot pole marked off in one foot intervals
A stopwatch or watch with a second hand

Recall from the background information on waves that the height of a wave is related to the strength of the wind, the length of time it blows and the expanse of water over which it blows. The height of a wave can be easily measured from shore in the following way:

a. One person holds the pole upright at the water's edge.
b. A second person stands facing the ocean about three feet behind the pole holder.
c. The second person should adjust his/her height (by standing on a rock or squatting slightly) until the crests of the incoming waves are in line with the horizon.
d. The observer then scans his/her eyes from wave to the pole and notes the height of the pole. The height as marked on the pole, the wave and the horizon should all be in the same line of sight. The reading is the approximate height of the incoming waves.

The period of a wave can be measured as follows:

a. Choose an offshore point of reference (a rock for example).
b. Watch a wave crest wash over the reference point and begin timing as soon as it has passed. Stop timing when the second wave crest washes over the point. The intervening time is the period.

Make a record of the wave height and period. Compare the wave height findings with the predicted seas given by Coast Guard weather reports.

3. Currents

Often we find in the debris that is washed up on the beach items that came there from other areas like boxes with addresses on them, notes in bottles, etc. How did they get there?

Materials needed:

Balloons	Bottles with caps or corks
Old tennis balls	Measuring stick or tape
Water-proof magic marker	Watch with a second hand
Pen and paper	Poultry baster

a. Using the baster, fill some balloons with sea water and others with fresh water. Keep the balloons about the size of tennis balls. Gently squeeze the balloons to remove any air and tie off the ends.

b. Then toss the salt water balloons, the fresh water balloons, and the old tennis balls (marked w/magic marker) into the ocean and keep track of their progress.

Do they come straight back to shore, are they carried right out to the sea, or do they travel along the shore in one direction or another?

The salt water balloons will be somewhat difficult to follow as they are neutrally buoyant (i.e., will neither float nor sink, but rather will locate somewhere in the middle of the water column), so be sure to use brightly colored ballons.

Why will fresh water balloons float?

If the ballons and tennis balls move through the water parallel to the beach, recover one (or use a spare) for this next activity.

a. Toss it into the water and time its progress until it has moved 100 feet along the beach from where it was tossed.
b. Then divide the 100 ft. by the time to determine how fast the current is running along the beach.
c. Record the speed and direction of the current.

The current directly below the surface may be going in a direction different than the surface current as may the bottom current. Try to keep track of the salt water balloons for an indication of how the subsurface current is running.

To test for the bottom current:

a. Have everyone gather some shells and write their names or initials on them with water-proof magic markers.
b. Then have them toss these shells into the surf and watch closely to see if the marked shells are washed back up onto the shore or if they never reappear.
c. If they do show up, did they come straight back in or did they come farther down the beach?

Another suggestion:

The people in your group might be interested in casting drift bottles into the water to see where they turn up. The bottle should contain a self-addressed stamped envelope with the person's name and address along with a note explaining that the person is studying currents and would like the finder of the bottle to supply the following information:

Name and address of finder
Where the bottle was found
Date bottle was found

The person might include in the note the date and place of the launching of the bottle.

B. Chemical Composition of Seawater

1. Salinity

Here is your chance to prove to yourself that ocean water indeed contains salts: taste a bit of ocean water!

Unless you have access to a salinometer or can do silver nitrate titrations (another method for determining salinity) your group will probably not be able to measure the salinity, in parts per thousand of the seawater at your field site. However, there are several activities that can be done with a sample of seawater collected from your field site to demonstrate salinity. For example:

a. Collect samples of water from a coastal site, from the mouth of an estuary, if nearby, and from a site further upriver. Put equal amounts of water from these three sites into three separate jars of the same size. (Fill the jars about ¾ full.) Pull a piece of masking tape along the outside of each jar running from the bottom of the jar to the rim. Mark where the water level is on the tape. Float a cork in each jar (all three corks should be exactly the same) and note the level of the top of the cork on the tape. Can you notice any difference? (Explanation: It may be difficult to see much difference, but the cork in the saltiest water *should* float the highest.)
b. Another activity which will demonstrate the effect of salts in water on living things is the following:

   Collect a few samples of seawater in jars with lids from around the field site and take them home. In one jar place a garden flower, in another jar place a land slug (such as the ones that attack many vegetables), in a third jar place a seaside plant (such as a beach rose, beach pea, seaside goldenrod). What happens in each case?

C. Geological Processes and Characteristics

Note the beach type of your field site. Is it rocky, sandy, pebbly, muddy or a combination? What kinds of geologic features can you see in the surrounding environs of your field site? Are there islands visible? Headlands? Coves? We highly recommend a visit to the Rachel Carson Salt Pond Area at New Harbor, Maine to study beach geology. An excellent guidebook, which will aid you in your study, has been prepared by Vandall T. King and Bruce W. Nelson, entitled: ***Guidebook to Geologic and Beach Features of the Rachel Carson Salt Pond Area, New Harbor, Maine.*** This guidebook is available through the Maine-New Hampshire Sea Grant Program, Marine Advisory Service, Publications, Coburn Hall, University of Maine, Orono, Maine 04469.

D. Biological Characteristics and Relationships.

Your groups can study both "Who Lives Here?" and "Who Lives Where?" by constructing a beach profile. This excellent activity is outlined in detail in the NNEMEP Unit, ***"Have You Been to the Shore Before?"***

A simple identification guide ***"Common Invertebrates of the Intertidal Zones of Northern New England"*** is available in the NNEMEP Unit, ***"Have You Been to the Shore Before?"*** Also included in that unit is "A Field Guide to Questions About Seashore Life" which is designed to help you, the leader, ask questions that will help your participants develop their observation skills regarding marine life.

If you cannot take a field trip to the shore to experience the marine environment first-hand, try to obtain a film on a marine topic to show to your group. There are many excellent ones available for lending by the Instructional Systems Center of the University of Maine at Orono. These are listed in the Filmography.

Section II
People and the Sea

In Section II of "What Is Our Coastal Future?" you and your group will be introduced to the many ways people use the sea for employment, as well as some of the beneficial aspects of the oceans to the planet Earth as a whole. Two readings provide background information on these two broad topics: "The Sea as a Provider" and "I Like It Here."

Uses of the Sea

Learning Objectives

From the background information contained in the reading entitled "The Sea as a Provider," the members of your group will learn the following:

1. The oceans and coastal zone provide many sources of employment for people. These sources include:
   a. The fisheries and related industries (boat building and repair, bait catching gear, gear construction and repair, etc.)
   b. Seaweed harvesting and processing for colloids.
   c. Transportation of goods and people.
   d. Mining of commercially important minerals, metals, elements, and compounds.
   e. Source of energy (outer Continental Shelf drilling for oil and gas; offshore coal reserves, wind power, wave power, tidal power, ocean thermal power)
   f. National defense (navy, air force, marines).
   g. Water dependent industries (power plants, oil refineries).
   h. Recreation (coastal tourism, boating, swimming, diving).
   i. Inspiration (sea literature, marine art, sea inspired music).

Indoor Demonstrations and Activities

1. Seaweed Cookery: Not only are seaweeds used for extracting colloids, which are used in many foods, but, in many parts of the world, the seaweed is eaten as a food itself. Try these tasty recipes, made with abundant Irish moss or kelp!

Blanc Mange I

1/2 cup packed Irish moss
1 qt. milk
1/2 cup sugar
pinch of salt
any fruit or flavor (e.g., 1½ tsp. vanilla, lemon, almond or maple extract, concentrated orange juice, etc.)
cheesecloth

Wash the algae several times in fresh water. Heat milk and Irish moss in a double boiler. Cook over boiling water for about 30 minutes, not more, stirring occasionally. Strain through cheesecloth and discard the Irish moss. Add sugar and salt to the milk and allow to partially cool. Any fruit or flavoring should be added as it begins to thicken. (Suggested: blueberries, raspberries, almond flavoring or honey.) Pour into molds and chill in the refrigerator for several hours. Can be served with cream.

Moss Cheese

1/3 cup of Irish moss
2 cups water
1 qt. sour milk or 2 cups soy milk
1 tsp. ground celery seed
1 cup stewed tomatoes, pureed
1 tbsp. parsley, minced

Boil Irish moss in water for 20 minutes. Cool. Mix with the sour milk or soy milk. Pour into muslin bag or two layers of cheesecloth to drain off whey. Empty solid cheese into bowl and beat in remaining ingredients. Pour into a shallow pan and cut in squares when set.

Irish Moss Salad

Irish moss
3 lemons
lettuce leaves
2 apples
1¼ cups celery, finely diced
3 tbsp. mayonnaise
walnuts

Wash some picked over Irish moss in hot water. Place in pan or bowl and cover it with the juice of three lemons. After several hours the moss will have dissolved, hardening everything into a yellow jelly. Place this in the refrigerator to chill a couple of hours. Arrange a few lettuce leaves in four chilled salad plates. Cut the moss mixture into cubes and place them in the center of the lettuce. Cut the apples into cubes and mix these with finely diced celery and mayonnaise. Distribute this among the four salads and top with walnuts.

Seaweed Sweet

4 cups of rings cut from fresh kelp
3/4 cup white vinegar
2½ cups sugar
1 tsp. whole cloves
1 tbsp. mixed pickling spice

Remove the outer skin of kelp with vegetable peeler and slice into thin rings or cut into long strips and then into rectangles. Soak the cut kelp in fresh water for 3 days, changing the water several times a day to remove the bitter tasting salts.

Place the spices in a cheesecloth bag and place in simmering vinegar and sugar for five minutes. Remove the slices and pour the hot syrup over the sliced kelp. Let stand overnight.

Next day drain off syrup, heat to boiling and pour over kelp again. Let stand overnight.

On the following day (sixth) remove syrup and heat to boiling. Place kelp slices in hot jars, cover with boiling syrup and seal, or store the pickles in a covered crock.

For dill seasoned pickles, handle the kelp in the same manner, but substitute your favorite dilling process for the above syrup.

2. Moods of the Sea
Your group might enjoy spending part of one meeting celebrating the sea in story, song, painting or photograph. Ask each member of the group to bring in a recording, poem, book, painting, photograph and/or any other work of art that depicts the sea. Spend some time listening to, looking at, and discussing the various contributions of the group members. Original creations are to be encouraged. The group might also like spending a little time on producing some marine art. Some suggestions: collages, paintings, photographs, sculptures using items found in the beach, poetry, etc. Instructions are included here for *gyotaku*, or fish painting — a Japanese art form:

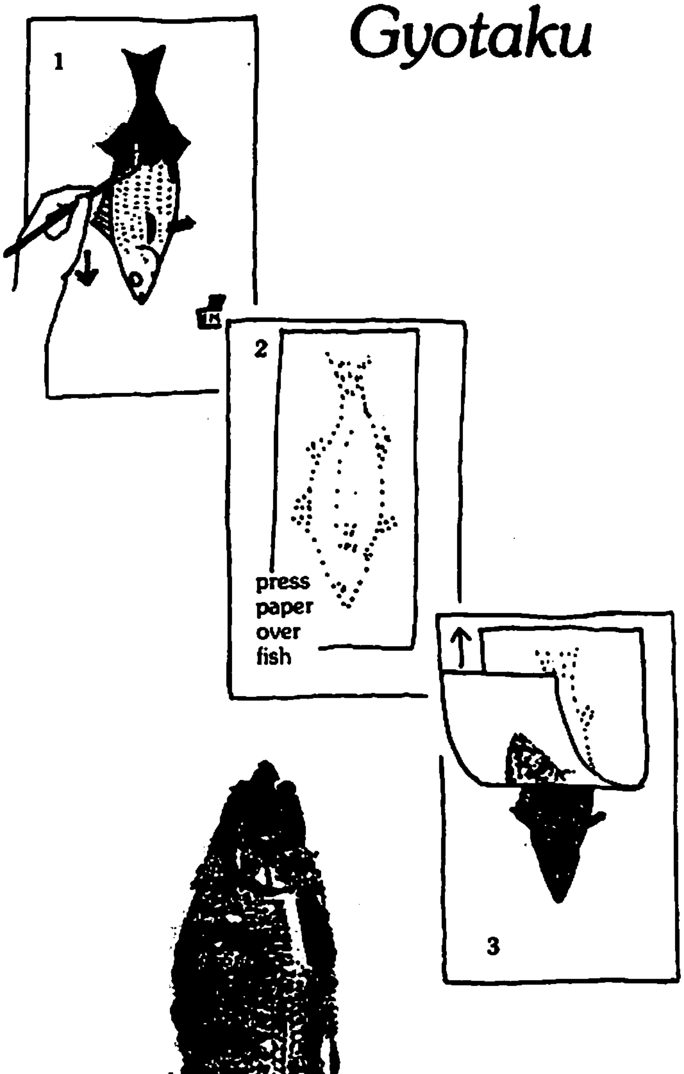
Equipment Needed:

- tempera paint
- newsprint (rice paper also works well)
- newspaper
- whole, fresh fish (preferably flounder)
- colored construction paper
- paintbrushes

Directions:

1. Cover desk top with newspaper.

Gyotaku



2. With your fingers or a paint brush, smooth a thin layer of the thickened tempera on the fish.
3. Place newsprint on the paint-covered fish. Holding the paper securely in place with one hand, rub over the entire fish with the other hand. Lift the paper from the fish very carefully. (The fish can be washed clean and reused.)
4. Mount the print on colored construction paper.

Variations

1. Prints can also be done on fabric, such as old sheets, unbleached muslin, etc. (T-shirts work great!)
2. A fish skeleton can be used to make the print instead of the entire fish.

3. Check the Filmography for films on Uses of the Sea. These would be listed under Section III.

4. Try to stimulate a group discussion on this topic by calling for questions from participants or by using the following suggestions:
   a. Can any of the activities that are done by people on or in the sea be done on land instead? If so, which ones? Is the land a reasonable substitute for the sea for certain activities, or is the sea a much better place for such activities?
   b. Which human uses of the sea demand a clean, unpolluted marine environment. Which activities could function perfectly well in a severely polluted marine environment? What difference would it make to the human population on earth if the oceans became environmentally damaged beyond repair?

Individual Research Projects

The following are but a few suggestions for activities that individual participants could do outside of class:

1. Locate a seafoods cookbook and try some of the recipes at home. Bring in samples for the rest of the group to try.
2. What is the most recent research on the energy sources of the sea? Are there experimental stations in existence for tidal power, ocean wind power, current power, wave power? If so, how successful have they been? (e.g. How successful is the OTEC station in Hawaii?)
3. Find out about some of the well known artists, musicians and writers from our northern New England region. How many, if any, of their works were inspired by the sea? If possible, bring in examples of poems, stories, paintings, musical compositions, etc. to share with the rest of the group.
4. Research some aspect of the maritime history of the northern New England region.
5. There are at least two enterprises along the northern New England coast that produce products for human use utilizing seaweeds. Find out more about these operations, including the procedures used in producing the products. Two such enterprises are:

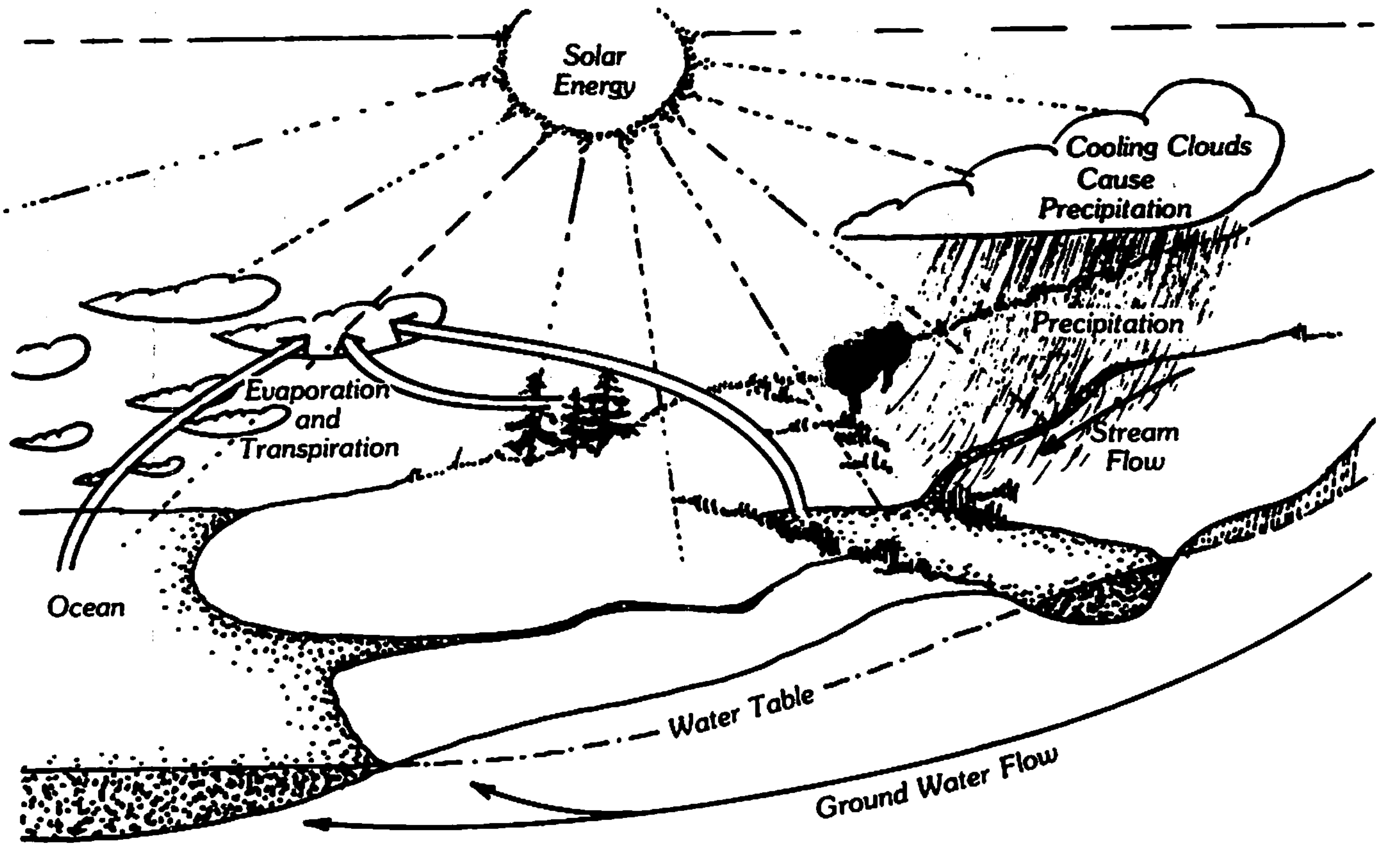
   Marine Colloids, Inc.
   A Divison of FMC Corp.
   Crockett Point
   Rockland, ME
   (207) 594-4436

   Atlantic Laboratories
   Waldoboro, ME
   (207) 563-5412

Field Activities

1. A visit to any portion of the coast of your state will serve as a good follow-up field activity for this section. What human uses of your coastal field site can you observe?
2. Go out to lunch or dinner with your group. How many items on the menu are made with seafood? How many different kinds of seafood are represented?
3. Visit a marine museum with your group. Three such museums in northern New England are listed below:
   1. Maine Maritime Museum
      Bath, Maine
   2. Penobscot Marine Museum
      Searsport, Maine
   3. Grand Banks Schooner Museum
      Boothbay Harbor, Maine
4. Take a trip to an art gallery. How many of the works of art are on marine themes?

Climate and Weather



Learning Objectives

The reading entitled "Because I Like It Here" deals primarily with the influence of the oceans upon global climate and local weather. As a result of studying the information contained within it, the group participants will learn the following:

1. Coastal areas are cooler in the summer and warmer in the winter. This is primarily due to the high *heat capacity* of water.
2. The presence of water on our planet makes it a habitable place for life as we know it.
3. Water moves around the earth in a circular path called the water cycle.
4. The water cycle is in balance globally (water leaving by evaporation = water returning by precipitation), it is not balanced locally (some areas receive more rainfall than other areas). This difference is due to the combined influences of solar heating, land masses and local wind patterns.

Indoor Demonstrations and Activities

1. The Water Cycle

Equipment Needed:

Gallon jar (usually available from institutions serving large quantities of food)
Tap water
Matches (wood safety matches work best)
Large rubber band
Large plastic bag (large sized baggies are fine)
Few ice cubes
Plastic wrap
Flashlight
Terrarium with plants, soil, small open container of water inside (optional)

As we learned from the background information, the water cycle involves water in its three states, liquid, solid and gas. The processes of evaporation (changes liquid water to a gas, water vapor), condensation (changes gaseous water to a liquid or a solid) and precipitation (the passage of liquid or solid water from the atmosphere to the earth's surface): These three processes can be demonstrated quite simply:

1. Evaporation: Measure a cupfull of water into an open bowl. Once a day for a few days measure the amount of water in the bowl using the same measuring cup. How much water evaporated each day? (For groups meeting once a week, use a larger amount of water to start with, say, one quart. Take measurements weekly.)
2. Condensation: Put a cupful of boiling water into an oven-proof dish. Cover the dish with plastic wrap. Place an ice cube on top of the plastic wrap. Watch the water droplets form on the underside of the wrap. After a short time, the drops should begin to fall from the plastic wrap — precipitation!
3. The formation of a cloud can also be shown with a simple demonstration:

   Take a very large glass jar (like the kind used for institutional mayonnaise or pickles). Put a small amount of water in the bottom, cover the top of the jar with a plastic bag with the bag extending into the jar.

   Secure the bag around the mouth of the jar with a rubber band. Lift one corner of the top of the bag and throw a lighted match into the jar. With the room darkened, shine a flashlight into the jar. Pull up on the jar *hard* and *fast*. You should be able to see a "cloud" form in the jar.

2. A terrarium also demonstrates the water cycle very nicely. A balanced, correctly constructed terrarium rarely needs outside

watering. A small bowl of water in the terrarium provides water to the atmosphere through evaporation. This evaporated water (water vapor) condenses on the cover of the terrarium at night when it is cool. This condensed water is in the form of little drops. When the drops become too heavy to remain on the terrarium lid, they fall to the "ground" as "rain" inside the terrarium. The soil and plants collect much of this rain and the excess runs into a little "pond." The plants, soil and pond all give off water through evaporation (and transpiration) and the cycle begins again.

3. Check the Filmography for films on weather and climate. These would be listed under Section II.

4. Try to stimulate a group discussion on this topic. Ask participants to write down any questions they may have regarding weather and climate or use the following suggestions:

a. Try to imagine what the climates and weather are like on Mars and Venus. Compare the "imaginings" of the group to what the climate and weather are here on earth. Theorize on how we would have to live if the protection our "world of water" affords us were suddenly to disappear.
b. If your group were going to take a trip to another planet in our solar system and could take along only ten items, what would these items be?
c. Scientists believe that life on earth began in the water. Why do you feel they feel this way?

Individual Research Projects

The following are but a few suggestions for individual research projects on the topic of climate and weather:

1. Research the weather patterns of northern New England. Find out what the prevailing winds are. What winds are dominant in summer? In winter? Do these winds blow onto land from the ocean or off the land? How much precipitation does our region receive? How does this amount of precipitation influence the type of vegetation we find growing in northern New England? What is the annual temperature range? What records exist for: high and low temperatures? Amount of precipitation? Wind velocities? Why does the coast of northern New England experience so much fog in the summertime?
2. How does the climate and weather patterns of our region affect the marine life of the Gulf of Maine? What species prefer the colder water of the northern section of the Gulf to the warmer water in more southern sections? How would a severe drought affect the marine life along our coast? How about excessive precipitation?

Field Activities

There are numerous outdoor activities that can be done on the topic of weather and climate. The following can be done anywhere outside. A trip to the coast is not necessary.

1. How Much Rainfall?
A simple rain gauge to measure the amount of rainfall can be made in the following way:

Equipment Needed:

Straight sided bottles or jars (such as olive jars or Alka Seltzer bottles)
Large sized cans (such as the largest sized Crisco or other shortening can)
Popsicle sticks or tongue depressors
Masking tape
Narrow ruler
Ballpoint pen
Small funnel

Procedure:

a. To make the scale for the straight sided jar gauge, take a popsicle stick or tongue depressor and mark off one quarter inch from the end. Using the stick as a guide, pour one quarter inch of water into a Crisco can.
b. Pour the water carefully from the Crisco can into the straight sided jar. The use of a funnel to do this is recommended to prevent any spillage.
c. Place a piece of masking tape along the side of the bottle and mark the level of the water on the tape. Label this mark as "one quarter inch."
d. To compute the other levels for the guage, simply measure the distance from the bottom of the bottle (on the inside of the bottle) to the "one quarter inch" mark on the tape. Double the measurement to find the "one half inch" mark and put it on the tape. Triple the first measurement to determine the "three quarter inch" mark and put it on the tape, and so on. For example, if the "one quarter inch" mark is one inch from the bottom of the jar (as measured on the inside of the jar with a ruler), then the "one half inch" mark will be two inches from the bottom of the jar. Label levels for 1/8 inch, 1/4 inch, 3/8 inch, 1/2 inch, 5/8 inch, 3/4 inch, 7/8 inch and 1 inch.
e. To collect rainfall, place the shortening cans outside just before a storm. Your group might want to place cans at different locations around the yard, for example, under a tree, beneath a bush, out in the open, behind a fence, etc. to determine if there are any variations in the amount of rainfall at different locations in a yard. Your group might be surprised!
f. After the storm is over, bring in the collectors and carefully, using a funnel, pour the rainwater from the cans into the straight-sided jar gauges and observe the amount of rainwater as indicated on the masking tape scale.

2. How big are raindrops?
To make a raindrop collector for this activity, you will need the following equipment:

Equipment Needed

Several shoe box covers or aluminum pie plates
Bag of finely sifted flour
Ruler
Flour sifter
Several pieces of cardboard or newspaper large enough to cover the lids or pie plates.

Procedure:

a. Pour the flour into the shoe box lids or pie plates and, using the ruler, smooth out the flour until it is level with the edge of the lid.
b. Cover the flour with the cardboard or newspaper.
c. While it is raining, don your rain gear and take out the collectors to the yard.
d. The members of the group might want to stand in different locations with their collectors, for example, out in the open, under a tree, next to a wall, etc. to determine if there are any differences in the size of raindrops at different locations.
e. On signal, have the group members expose their collectors to the rain for five seconds and then re-cover them and return indoors.
f. Allow the raindrops to dry and harden in the flour, and then, using the flour sifter, separate the raindrop pellets from the rest of the flour. Measure the sizes of the raindrops.

3. Rain and Erosion
To demonstrate the effect of rain on different types of soil, try the following simple activity.

Equipment Needed

Three one-quart cardboard milk containers
Stones (enough to fill each milk carton half-full)
White construction paper
Rubber bands
Magic marker (the waterproof kind)

Procedure:

a. Wrap each milk container with white construction paper and secure it well with the rubber bands.
b. Fill each carton half full with stones to weight it down.
c. With the magic marker, mark each face of the milk carton with a direction: north, south, east and west.
d. Before a rainstorm, place the "splash pillars" outside making sure that the marked faces are facing the correct direction. Put one pillar on a grassy lawn, another out on bare soil and another in a garden.
e. After the storm, bring the pillars inside and observe the results. Compare the splash marks showing on the white paper. Which pillar had the most soil on it? Which had the highest splash marks on it? On which side of each pillar did the most splashes occur? (from which direction did the rain come?) In what location did the soil erode the easiest. What is the effect of vegetation on soil erosion?

Section III Coastal Issues of Northern New England

Section III contains background information, demonstrations and other activities designed to teach your group about several of the critical coastal issues of northern New England. The broad issue categories that will be covered in this section are the following:

1. ***Fisheries Management and Development.***
2. ***Industrial, Commercial and Residential Development.***
3. ***Multiple Use Planning, Conflict Resolution, and Protection and Enhancement of Marine Resources.***

In each of these subsections, specific concerns such as fish product marketing, oil pollution, coastal access, residential development on the coast, tidal power generation, etc. will be discussed.

The background information for this subsection has been divided into two readings: Fisheries Management and Fisheries Development. We will first look at the specific learning objectives and some suggested demonstrations and activities for Fisheries Management.

Fisheries Management

Learning Objectives

As a result of studying the subsection on Fisheries Management, the program participants should learn:

1. The most common commercially important finfish, shellfish, worm, and crustacean species in the Gulf of Maine and the following information about each: habits and habitat, 1980 landings in pounds and dollars, commercial fishing methods used, spawning data, average size, and other facts.
2. Some of the "underutilized" species found in the Gulf of Maine for which larger markets need to be found, plus the following information for each: habits, and habitat, 1980 landings in pounds and dollars (where known), commercial fishing methods used, spawning data, average size, and other facts.
3. A comparison between the quantity of each species landed in 1980, the economic value of each to the entire state of Maine, and the price per pound paid for each to the individual fishermen.
4. Some detailed information about the most commonly used commercial fishing methods.
5. The basics of the so-called "200 mile limit law" (Public Law 94-265: "The Fishery Conservation and Management Act of 1976") and some of the conflicts that have arisen as a result of its passage, notably: resistance to government regulation by the industry; conflict between the U.S. and Canada as to the fisheries jurisdiction of each; inadequacy of management tools available to regulate the fisheries; the nature of the fishing industry (i.e. small independent businesses, widely dispersed, rapidly expanding).
6. Some of the most commonly used tools in fisheries management, notably: quotas; gear restrictions, limiting access to a fishery; closing of fishing grounds during spawning season; fish size restrictions, and the conflicts that have arisen over the institution of various of these methods.
7. The purpose of the New England Regional Fisheries Management Council and its accomplishments to date.
8. Other problems associated with trying to manage the New England fisheries, notably: the relationships between the various regulatory agencies (e.g. local, state, multistate, regional, federal, international) that deal with fisheries management; conflicts among different fisheries; conflicts between fisheries and other users of coastal land and water.
9. What is currently being done to solve the management problem, notably: baseline data research into the social and biological characteristics of the fisheries; attempts at consistency in the plans of various regulatory agencies; public hearings and legislative actions to help air differences among fishermen and between fishermen and other users of coastal areas.

Indoor demonstrations and activities

1. Check the *Annotated Filmography* for filmstrips and films with the biology, characteristics and management of fish and fisheries. These can be found under Section III of the Filmography.

2. If possible, try to obtain, from a fisherman or fish processing plant (e.g.) National Sea Products, Rockland) specimens of a variety of fish species. Try to get an example of some of the most popular commercial species like haddock, sardine (herring), blackback flounder, etc., and also of some of the less popular species ("underutilized species") like wolf-fish, monk fish, dogfish, etc. Include shellfish species like soft clam, mussels "wrinkle" (whelk), squid, etc. Set up a display of the specimens and have your group identify them. Afterwards, cook and sample each. The easiest way to prepare any finfish species is to saute in a little butter in an electric fry pan. Shellfish can be steamed in a large coffee pot or in a saucepan on a hot plate. Squid can be chopped, sauteed, and cooked a few minutes in spaghetti sauce. Several recipes for fish and shellfish species are included here. You may want to duplicate them for your group.

3. Section IV contains a role-playing game entitled "Goin' Fishin'?" which is appropriate for use by high school students and adults. The game is based on a public meeting concerning the conservation of New England's fishery resources and includes discussion of management of groundfish. Try it with your group! You will need between one and three hours to play.

4. Invite a fisherman in to speak with the group about his feelings regarding the growth of the fishing industry in northern New England and the attempts to manage the resource for future generations of fishermen.

5. Try to stimulate a discussion on this topic within the group by calling for questions or by using the following suggestions:
   a. What is the most important information that must be

obtained to enable us to better manage the fisheries in the Gulf of Maine?

b. Are there effective management tools that will protect fish stocks for future generations of fishermen while still enabling the present day fisherman to make a decent living? If so, what are they?
c. What are the impacts of interest rates, money supply, fuel prices, etc.? Fishery management?
d. How will the market respond to certain management decisions (e.g. to quotas, etc.)?
e. How will fisheries management effect the processing sector of the industry?
f. What should be the role of local government (e.g. town, county, etc.) in managing shellfish and anadramous fish resources?
g. What are the impacts of offshore oil and gas exploration and development upon the fisheries? How can the detrimental effects be reduced?
h. How can conflicts between fishermen and recreational boaters be minimized?
i. How can conflicts between commercial and sports fishermen be minimized?
j. How can conflicts between the different fishing methods be minimized? (e.g. between lobstermen and scallop draggers, etc.)

Individual Research Projects

Perhaps some or all of the members of your group would be interested in pursuing further some other topic related to Fisheries Management. These projects can be done on the individual's own time and then reported back to the rest of the group. The following are only a few suggestions:

1. Interview several people involved in the fishing industry: a fisherman, a fish processor (e.g. owner or manager of a sardine packing plant or fish processing facility), a fish market owner, fish eater, a fishery biologist (in the Appendix are listed several persons who would be able to answer questions pertaining to fisheries biology). Ask each as to his/her views on management of the fishing industry. Should it be done? What, in the person's opinion, is the best way to manage the fisheries? (e.g. quotas? net mesh size regulation? fish size regulations? etc.)
2. Contact the Maine Fishermen's Cooperative Association and determine what that organization's stand is on fisheries management. (Their address is: Maine Fishermen's Cooperative Association, P.O. Box 4812 DTS, Portland, Me. 04112. Mr. Ed Bradley is the organization's attorney.)
3. Contact the Marine Advisory Program at either the University of Maine or the University of New Hampshire and interview its director as to the most recent information regarding fisheries management plans for northern New England. The Marine Advisory Programs are the public extension arms of the UNH/UMe Sea Grant Programs:

Marine Advisory Program 30 Coburn Hall University of Maine Orono, ME 04469 (207) 581-2719	UNH Marine Program Marine Extension and Public Education NEC Administration Bldg. University of N.H. Durham, NH 03824 (603) 862-1255

4. Pick out an article on fisheries management from either the "National Fisherman" or the "Commercial Fisheries News" and report on its contents to the rest of the group. These two publications are both published in Maine ("National Fisherman" in Camden; "Commercial Fisheries News" in Stonington) and are widely available around the state.

Field Activities

1. If your group is unable to embark on field trips, several of the above suggestions can be incorporated into an effective out-of-class excursion. For example:

   Enlist the help of a local fisherman to take the group on a tour of the pier area of your community (or one nearby). Visits to a fishing vessel, fishing wharf, processing or packing plant (often these will conduct their own tours), fish market, etc. could be very enlightening, and fun, too!

Seafood Recipes

These recipes were taken from the Maine Seafood Calendar for 1982 which was prepared by the Marine Advisory Program, University of Maine Sea Grant Program, Coburn Hall, University of Maine at Orono. The recipes were contributed to the calendar by various restaurants around the state of Maine, or taken from magazines and cookbooks.

Oysters Brenville

12 large oysters in shell
1/2 pound crabmeat
1 pint cream sauce of medium consistency
4 oz. grated Gruyere or Swiss Cheese
Paprika and chopped parsley to garnish

Wash oysters and shuck, leaving oysters on half-shell. Sprinkle with crabmeat. Cover with cream sauce. Sprinkle grated cheese on top and add paprika and parsley for color.

Bake in a 350 degree oven approximately 1/2 hour or until cheese is melted and sauce is bubbling.

Garnish with lemon and serve immediately.

(Nickerson Tavern, Searsport, Me.)

Stuffed Squid Italienne

12 small squid
1 clove garlic
1/3 pound mushrooms, chopped
4 slices bread, crumbled
1 tbsp. parsley, chopped
1/4 tsp. oregano
6 tsp. olive oil
salt and pepper to taste

Clean, skin and wash squid. Cut off the tentacles and chop them very fine. Combine the chopped pieces with garlic, oil, and sprinkle lightly with salt, pepper, and chopped parsley. Bake the stuffed squid in a 375 degree oven for 45 minutes. Serve with lemon wedges.

(*The Uncommon Cookbook*, Phyllis Coggins, Ed. Maine Sea Grant, University of Maine at Orono)

Linguini with Clam Sauce

Sauce:
1 cup chopped or minced clams
1/4 cup butter
1/4 cup cooking oil
3 cloves garlic, minced
1/4 cup chopped fresh parsley
1/4 tsp. dried oregano leaves
1/4 tsp. dried basil leaves
1/8 tsp. pepper

8 oz. linquini, cooked and drained
grated parmesan cheese

Drain clams, reserving juice. Set aside. Heat butter and oil in 2 quart saucepan over medium heat until butter melts, about 3 minutes. Add garlic and saute 3 minutes. Stir in parsley, oregano, basil, pepper, and reserved clam juice. Cook over high heat 1 minute or until mixture comes to a boil. Reduce heat to low and simmer, uncovered, 5 minutes. Add clams and cook over medium heat 3 minutes or until hot. Serve over hot cooked linguini and sprinkle with cheese.

(*Farm Journal*, Patricia Ward, Food Editor)

Baked Salmon Tarragon

3 pounds Atlantic salmon, cut into steaks
1 cup sour cream
1/3 cup mayonnaise
1 egg
1/2 tbsp. tarragon
1 tbsp. parsley
1 tsp. sugar
1/2 tsp. salt
1/4 tsp. pepper
2 dashes Tabasco

Place salmon in flat baking dish. Combine all other ingredients, beating very well with egg beater. Spread sauce over salmon. Bake in preheated 400 degree oven until done, about 20 minutes. Serves 6-8.

(Lincoln House Country Inn, Dennysville, Maine)

Champagne Shrimps Mandarin

2 pounds fresh Maine shrimp (peeled)
1 shallot
1/2 cube butter
1 split champagne
3 oz. Grand Marnier
1 med. can Mandarin oranges, drained

Saute shrimps and shallot in butter for 3 minutes. Add 1 cup champagne and Grand Marnier and saute until flame dies. Simmer 3 minutes and add oranges. Cook 1 more minute until oranges are hot. Serve with rice or pasta.

(Central House, Bar Harbor, Maine)

Stuffed Flounder Florentine

1/2 pound mushrooms, sliced
1 clove garlic, finely chopped
2 tbsp. butter
1/2 pound fresh spinach
1/4 tsp. oregano
4 fillets of flounder
Juice of one lemon
6 oz. sliced mozzarella cheese

Saute mushrooms and garlic in butter about 5 minutes. Add spinach and cook about 1 minute or until spinach is barely wilted. Drain juices. Add oregano. Place 1/4 of the mixture in the center of each fillet. Roll fillet around mixture and place, seam side down, in greased shallow baking dish. Sprinkle with lemon juice. Cover each roll with slice of cheese. Bake in 425 degree oven until done, about 20 minutes. Serves 4.

(Lincoln House Country Inn, Dennysville, Maine)

Lobster Bisque

Saute 2 onions in 2 tbsp. of butter. Add the juice of one lemon, 1 tsp. Worcestershire Sauce, a little celery salt and paprika, 1 can of cut-up peeled tomatoes, 2 tbsp. chili powder, 2 quarts of heavy cream and 2 lbs. of steamed lobster. Heat and serve over broken toast with fresh cut chives as a garnish on top. Serve with a garden salad.

(5 Water Street, Machias, Maine)

Mackerel with Veronique Sauce

Sauce to cover broiled or poached fillet of mackerel:

Melt 1/4 cup butter and whisk in 3 tbsp. whole wheat pastry flour. Add 1½ cups milk or cream. Add 1/2 tbsp. minced onion, salt and white pepper to taste. Sprinkle with nutmeg. Cook to thicken. Add 1 cup seedless, peeled green grapes and serve over fish.

Maine Sardine Pizza

1 package pizza crust mix
2 cans (4 oz. each) Maine sardines
3 tbsp. salad oil
1 large clove garlic, minced
1 can (8 oz.) tomato sauce
4 tomatoes, sliced
2 sweet onions, sliced
2 green peppers, sliced
1 tbsp. minced parsley
1/2 tsp. salt
1/8 tsp. pepper
1 tsp. oregano
4 slices mozzarella cheese
Grated parmesan cheese

Prepare dough according to package directions. Pat into 12 inch pizza pan. Drain Maine sardines and mash 2 or 3 with 1 tbsp. salad oil, garlic and tomato sauce. Spread over pizza dough. Arrange tomato slices, onion, green pepper on sauce, and top with whole sardines. Combine parsley, seasonings and remaining oil. Drizzle over sardines and vegetables. Dot with mozzarella cheese. Bake 30-35 minutes at 450 degrees until crust is well browned. Sprinkle with Parmesan cheese. Serves 6.

(Maine Sardine Council, Brewer, Maine)

Eel Pie

1 small eel
1 tsp. onion, finely chopped
1 tsp. herbs, finely chopped
1 tsp. vinegar
1 tsp. parsley, finely chopped
salt and pepper to taste
pie pastry (enough to cover pie dish)

Wash and dry eel thoroughly. Remove all skin and bones and cut into cubes. Place in layers in pie dish, sprinkling each layer with salt, pepper, herbs, onion and parsley. Add water to three quarters fill dish and mix in vinegar. Cover pie dish with pastry and bake in hot oven (450 degrees) until pastry is set. Reduce oven to 350 degrees and bake 45 minutes to an hour. Serve hot or cold.

(The Uncommon Cookbook)

Baked Stuffed Scallops

5 pounds scallops, cleaned
3 cubes butter
2½ cups fine bread crumbs
6 tbsp. sherry
salt to taste
1½ cups cream

Melt butter in large skillet and add bread crumbs. Stir well and add sherry and stir again. Place half of scallops in two quart baking dish, salt lightly and spread half of crumb mixture over scallops. Repeat with remaining scallops and crumbs. Pour cream over all. Bake at 375 degrees for about 35 minutes. Serves 10-12.

(Lincoln House Country Inn, Dennysville, Maine)

Smoked Mussel Bisque

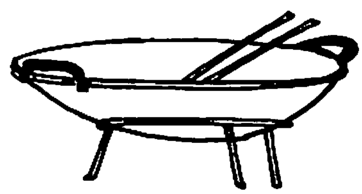
1 pound smoked mussels
1 med. onion, chopped
2 carrots, chopped
1 qt. half and half
1 pt. heavy cream
4 tbsp. butter
2 tbsp. flour

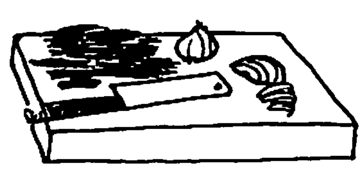
In saucepan: With 3 cups of water, boil until tender carrots and onions. Puree in blender with half and half. Set aside.

In large saucepan: Melt butter and add flour. Cook for 3 minutes. Don't brown.

Add: Puree mixture and cream and mussels. Whisk until smooth and simmer 10-15 minutes. Don't allow to boil. More cream may be added if too thick. Salt and pepper to taste.

(Central House, Bar Harbor, Maine)





Fisheries Development

Learning Objectives

As a result of studying this section on Fisheries Development, the members of your group should learn the following:

1. The fishing industry in northern New England is growing, thanks, in part, to the passage of the "200 mile limit law" and to an increasing worldwide demand for fish products.
2. The growth of the fishing industry in northern New England is, never-the-less, being hampered by several critical problems, notably: keeping fishermen informed of the latest innovations in harvesting technology; improving inadequate port and pier facilities; improving the marketing situation for fish products in the region.
3. There is some work being done to help solve these problems, but the "battle" is far from being won. Presently being undertaken are the following activities:
   a. Actions by the Marine Advisory Program (Sea Grant) Cooperative Extension Service, and the Vocational Technical Institutes to keep fishermen trained in and informed of the most recent technologies.
   b. Passage by voters in Maine of a $10 million dollar bond issue to build fish piers in the state.
   c. Formation of fishermen's cooperatives in Maine to help solve some marketing problems. Discussion of a fish auction in Portland.
4. There exist numerous marketing alternatives for fishermen which are designed to attack certain marketing problems. The program participant will learn about the following problems and alternative solutions:
   a. Problems: perishability of product, limited market access, low level of demand, lack of price and quantity information, lack of uniform products standards and descriptions, limited competiton, small scale of first buyer operation, supply variability, structure of harvesting industry, volume of imports.
   b. Alternative solutions: organized exchanges, forward contracting, vertical integration, group bargaining, marketing orders, marketing boards.
5. Marine aquaculture is an expanding industry in Maine. It faces many of the same problems as does the harvesting sector (fishermen):
   a. need for more biotechnical research.
   b. market development and coordination.
   c. improvement in credit and business climates.
   d. legal and institutional regulations and protections.

Indoor demonstrations and activities

1. Check the Filmography in the Resources Section of the Leaders/Teachers Guide. Under Section III of the Filmography, you should be able to find several films dealing with several "fish topics", including preparation and preservation of fish for consumption purposes.

2. Invite a home economist from your local Cooperative Extension office to come and speak with your group about the nutritional value of fish and to give a demonstration on how to prepare fish for eating. The marine education specialist from the Department of Marine Resources, Lorraine Stubbs, may also be able to do this. Contact her at:

Maine State Department of Marine Resources
State House Station 21
Augusta, Me. 04333
Phone (207) 289-2291

In New Hampshire, contact the

UNH Marine Program
Marine Extension and Public Education
NEC Administration Building
15 Garrison Ave.
UNH
Durham, N.H. 03824
Phone (603) 862-1255

and ask if there is someone who could come and speak with your group about fish preparation, preservation and consumption.

3. Invite someone from the Maine Fishermen's Cooperative Assocation or the Marine Advisory Programs (UNH/UMe Sea Grant) to come and speak with your group about the problems of marketing seafood in northern New England and what has been, or is being, done to help solve these problems. The Fishermen's Cooperative Association can be contacted at:

P.O. Box 4812 DTS
Portland, Me. 04112

The Marine Advisory Program of the University of Maine can be contacted at:

3rd floor Coburn Hall
University of Maine at Orono
Orono, Me. 04469
Phone (207) 581-2719

For the Program at the University of New Hampshire, see #2 of this section for the address and phone number. *Please note that the Maine Fishermen's Cooperative Assocation and the Marine Advisory Program, UMe, do not maintain regular speakers bureaus, however, they may be willing and able to send a speaker anyway, if asked. At the University of New Hampshire, trained marine education volunteers (called Marine Docents) do lead field trips and present programs on marine themes for schools and other groups. Contact Sharon Meeker, Coordinator, Marine Docent Program and the UNH Marine Program - Marine Extension and Public Education address given in #2. They may have a docent who would be willing and able to speak about marketing of fish products. If not, ask what programs are available.

4. There are numerous people who could speak with your group about the growth of aquaculture in Maine. Two suggestions are:

Dr. Edward N. Kastuck
Box 36
Tenants Harbor, ME 04860
(207) 372-6507

Mr. Sam Chapman
Marine Advisory Program
of the University of Maine
Ira C. Darling Center
Walpole, Maine
(207) 563-3146

5. Try to stimulate a discussion in your group by calling for questions from the participants or by using the following suggestions:
   a. What innovations in harvesting systems would reduce energy consumption?
   b. What onboard procedures would have the greatest effect on the keeping quality of fish?
   c. How can fishing be made more safe?
   d. How does the harvesting technique (e.g., dragging vs. hooking vs. gillnetting, etc.) affect the quality of the fish landed?
   e. How can quality be maintained in handling, transporting and marketing fish?
   f. What new products and processes would benefit northern New England's fishing industry?
   g. Are there environmental and social limits to the growth of aquaculture?
   h. What is the impact of an expanding aquaculture industry on the traditional fishing industry (eg. clamming, dragging, lobstering)?

Individual Research Projects

1. Find out about and report on the progress of fish piers around the state of Maine. Where will they be built? (Groundbreaking has already taken place in Portland for its pier!) How do the local fishermen feel about the pier? In what ways will it help their business?
2. Find out about and report on the progress of plans for a fish auction in Portland.

3. Find out about and report on fishermen's cooperatives in Maine. Where do they exist. How do the fishermen feel about them. In what ways has membership in a cooperative helped the business of individual fishermen?
4. Contact an economist who is interested in fisheries at either the University of Maine or the University of N.H. and ask about marketing alternatives for fishermen. Which ones would work most successfully in Maine and N.H.? Why? (At the University of Maine Department of Economics, Dr. James Wilson is a professor who has done a great deal of work on marketing alternatives for fishermen.) men.)
5. Speak with an aquaculturist about his business. How does he view the future of aquaculture? What are the mechanics of the various types of aquaculture (e.g. mussels, oyster, etc.)?
6. Interview several fishermen. What are the most crucial problems hampering the development of the fishing industry according to each person interviewed? What can be done, in their opinions, to help solve these problems?

Field Activities

1. Again, if your group is able to take field trips during the program, it would be worthwhile to visit the following places to enhance understanding of Fisheries Development:
   1. A fish processing plant (names and addresses can be found in the NNEMEP unit, *Do You Know Our Marine Fish?*).
   2. A marine aquacultural establishment (names and addresses can be found in the NNEMEP unit, *Is Our Food Future in the Sea?*).
   3. The Marine Trades Center of Washington County Vocational-Technical Institute in Eastport:
      Marine Trades Center
      Mr. Otto (Junior) Miller, Director
      W.C.V.T.I.
      Deep Cove
      Eastport, Maine

Industrial, Commercial and Residential Development

Cargo Port Development and Operation

Learning Objectives

As a result of studying the subsection on Cargo Port Development and Operations, the program participant should learn:

1. Most recent studies conclude that there does exist a large enough market for products from northern New England to warrant the development of cargo port facilities in the area.
2. Several factors are increasing the need for improved cargo port facilities in Maine and New Hampshire, including: the increase in the shipping of "neobulk" cargoes, the rapid increase in fuel prices, the move towards container "feeder operations."
3. In New Hampshire, Portsmouth is the favored site for cargo port development, while in Maine, three sites, in particular, have been considered for such development: Portland, Searsport and Eastport. Of these three, most studies favored Searsport as the most appropriate site for state supported port development. The reasons for this conclusion are given.
4. Each Maine site has its advantages and disadvantages as far as cargo port development is concerned. These advantages and disadvantages are given for Searsport, Portland and Eastport.
5. The development of cargo port facilities has several negative environmental impacts.

Indoor demonstrations and activities

1. Check the *Annotated Filmography* to see if there are any films that deal with Cargo Ports listed. If there are any, they would be listed under Section III.

2. Does your community or one nearby have plans for cargo port development? If so, contact the Town Manager regarding the status of these plans. What kind of port facilities will be built? How will they be financed? Why is the community being considered for this type of development (what features does the community possess that makes it appropriate for port development)? How will the negative environmental impacts be dealt with? How will port development affect the economy of the community (how many jobs will it create, etc.)?

3. Debate the pros and cons of renovating existing port facilities versus building all new facilities. Have the group divide into two sides and discuss this issue. (Members of the group need not debate on the side they *actually* favor. Try to find a few "devil's advocates" in the class who are willing to stand up for a side they do not necessarily believe in.)

4. Debate the pros and cons of the various sites chosen for cargo port development in northern New England. Are there other sites along our coast that group members feel might be more appropriate for such development than those mentioned in the background information?

5. The following questions can be used to help stimulate a discussion among the group on the topic of cargo port development:
   a. How can cargo potential be best identified for existing and proposed port facilities?
   b. What training programs are needed in the area of port management and operations?
   c. What kinds of information are needed in order to capitalize on the development of ports for natural resource based shipping?

Individual research projects

The following are just a few suggestions of projects that individuals in your group may be interested in pursuing on their own:

1. Research the history of shipping in northern new England. What kinds of products were shipped during the early days of the industry and where did they go? What caused the decline in shipping in northern New England. Why did some more southern ports continue to thrive (eg. Boston, New York, etc.)?
2. What are the detailed plans for the development of Sears Island (including port development and other types of industrial development)? Numerous studies are available on this subject.
3. What are the detailed plans for development of the port of Portland? To find out, call the Port Authority of Portland.
4. What are the detailed plans for the development of the port of Portsmouth? To find out, call the Port Authority of Portsmouth.

Field Activities

1. Take a field trip to an operating cargo port in your state (eg. Portsmouth, N.H., Portland, ME., Searsport, ME., etc.). What kinds of activities are going on?

Energy Development and Transportation

Learning Objectives

As a result of studying the information contained in the background reading on this topic, the participants in your group should learn the following:

1. The heavy industries most likely to site along the northern New England coast in the near future involve the development and transportation of energy, its raw materials and products.
2. There are numerous laws and agencies that have responsibility for regulating the siting of heavy industry along the coast
3. Numerous studies have been done regarding the siting of heavy industry along the northern New England coast

which make recommendations for specific communities which should be homes to heavy industry.

4. The concept of utilizing the tides to generate electricity has recently become very controversial in northern New England. This controversy is looked at in some detail.
5. One other heavy industry that is sited along the coast that is likely to expand is shipbuilding, notably Bath Iron Works.
6. The siting of heavy industry along the coast has numerous adverse environmental impacts associated with it.
7. There are many other types of industrial and commercial development, not necessarily located on the coast, that have impacts on the coastal environment.

Indoor demonstrations and activities

1. Check the *Annotated Filmography* to see if there are any films that deal with heavy industry siting, particularly industries concerned with energy development and transportation. If there are any, they would be listed under Section III.

2. Does your community or one nearby have plans for heavy industry siting (including energy related industries, shipbuilding, etc.)? If so, contact the Town Manager or Port Authority regarding the status of these plans. What kind of heavy industry is planned? Where in the community will it be located? How will the planned industry be financed (entirely private funds? entirely public funds? a combination of public and private funds?). What features does the community possess that makes it attractive and appropriate for the type of heavy industry planned? How will the negative environmental impacts be dealt with? How will the industry siting affect the economy of the community? The economy of the state?

3. In Section IV, you will find two activities concerning heavy industry siting along the coast: A Simulation Game entitled "EcoKill/EcoSave" and a role playing game entitled "Superport." Play these games with your group. They should prove to be interesting and fun learning experiences.

4. The following questions can be used to help stimulate a discussion within the group:
   a. How will alternative forms of energy be marketed (e.g. energy derived from tidal power projects, community run hydropower projects, etc.)?
   b. What are the opportunities and problems associated with the import and export of major bulk shipments of energy via the very deep harbors of Maine?
   c. How can the negative environmental impacts of heavy industry (e.g. oil spills, thermal pollution, hazardous waste disposal, etc.) be alleviated? (e.g. oil spill clean-up procedures, oil-eating bacteria, pre-cooling of thermal discharge, recycling of wastes, etc.) How successful are the various methods presently in use?

Individual research projects

1. Research the various laws, statutes and agencies that have responsibility for regulating the siting of heavy industry in your state. In what specific ways do these laws and agencies deal with the question of where heavy industry should be located along the coast?

2. Write a position paper on the recommendations of the various studies cited in the background information regarding the siting of heavy industry in Maine. Do you agree or disagree with the sites chosen by the studies? Why?

3. Research the history, and present controversy over the construction, of tidal power projects in Cobscook and Passamaquoddy Bays. What is your stand in the matter?

4. Find out more about the proposed expansion of Bath Iron Works into Portland. How would this expansion benefit the state of Maine and the city of Portland? What would be some of the negative impacts (both environmental and economic) of the proposed expansions? Report on the present status of the controversy over the state financed expansion of this private industry.

5. Research the three major oil spills that have occurred in Maine during the past twenty years. What scientific studies were done regarding the environmental impacts of these spills and what conclusions did these studies reach? What are the plans, in the states of Maine and New Hampshire, for dealing with oil spills in the future? What do these states do now in the event of an oil spill?

6. What is the current research regarding the effects of thermal discharge on the coastal environment that comes from the Maine Yankee Nuclear Power Plant? Are there other types of marine pollution associated with this plant (e.g. from the discharge of radionuclides, etc.)?

7. Research the problem of coastal pollution caused by inland activities (e.g. pulp-paper mills, agricultural practices, forestry, etc.). What is being done to help alleviate the negative impacts on the marine environment of these inland activities? What can be done in the future regarding this problem? What can be, or is being done, about the problems caused by out-of-state activities (e.g. acid rain)?

Field Activities

1. If possible, take a field trip with your group to a heavy industry already situated along the coast. Some examples are:
   a. The oil terminals of South Portland.
   b. The Maine Yankee Nuclear Power Plant, Wiscasset, Maine.
   c. The Seabrook Nuclear Power Plant, Seabrook, N.H. (under construction).
   d. Bath Iron Works, Bath, Maine.

Note: Some of these industries may not permit group tours of their facilities. You will have to call well in advance and check on their regulations regarding tours. If tours are not available, ask whether or not an industry representative would come and speak with your group on the following topics: How does the industry function (some details on its operations)? How many people does the industry employ? Why is the industry situated in the location that it is? How does the industry deal with negative environmental impacts associated with it? What are the industry's plans, if any, for the future?

Tourism and Recreation

Learning Objectives

From the background information on this topic, the participants in your group should learn the following:

1. Tourism and recreation are major industries in northern New England, ranking second in both New Hampshire and Maine in terms of gross revenues.
2. These industries suffer many of the same problems as the commercial fishing industry. The state government of Maine and New Hampshire, recognizing the importance of these industries, are attempting to solve these problems.
3. Two studies have been conducted regarding the problems of the tourism and recreation industries which make numerous recommendations.
4. The tourism and recreation industries have several negative impacts on the coastal environment.

Indoor Demonstrations and Activities

1. Check the Annotated Filmography to see if there are any films that deal with Tourism and Recreation (coastal) listed. If there are any, they would be listed under Section III.

2. What are the policies, regulations, plans, etc. of your community regarding the promotion/discouragement of tourism and recreation? Does your community, or one nearby, wish to encourage or discourage tourism and recreation? What types of tourism and/or recreational facilities exist in your community? What are the impacts of these facilities on the environment, social character and economy of your community? How can these impacts be minimized?

3. Organize a debate among your group members as to the pros and cons of highway billboards. Should they be left up, so as to benefit the businesses they advertise, or should they be removed because they represent an eye-sore?

4. Take a poll of your group: What coastal areas has each individual visited (make a list on the blackboard or on newsprint)? What did the individuals do when they visited these coastal areas? Tally up the results to determine what were the most popular activities among the individuals of your group who have visited coastal areas.

5. Stimulate a discussion within your group by calling for questions or by using the following suggestions:
   a. What would be the most effective way of packaging and promoting tourism in coastal areas? Have regional associations been beneficial in New Hampshire? What areas in Maine might be expected to benefit from regional promotion?
   b. What effects will the rising costs of energy have on the tourism and recreation industries? What strategies could be employed to maximize the benefits from changing vacation patterns (e.g. from travelling all over the state to staying in one spot within the state)?
   c. What are the most critical problems and needs facing the marina industry?

Individual Research Projects

The following are but a few suggestions for projects that individuals in the group might want to pursue on their own:

1. Research the outdoor recreation plans for your state. What are the specific recommendations made in these plans for improving the regional recreation picture, particularly for marine recreation?
2. Research the data contained in the 1973 study, *Tourism in Maine: Analysis and Recommendations* regarding the characteristics of tourists to that state. Report your findings to your group.
3. What is the current status of the "Billboard Law" in Maine? Has it successfully been carried out since its passage in 1978 or has it met with enforcement problems?
4. What was the function of the "Keep Maine Scenic" Committee (under the Maine Department of Conservation)? Why was it decommissioned in 1981?

Field Activities

1. Visit a tourist related or recreational facility that is situated along the coast. Interview the owner/manager. What kinds of activities are offered at the facility (e.g. if a marina, do they rent boats? sell fishing equipment and bait? etc.)? Are there any plans for future development of the facility? Is the owner/manager encouraged or discouraged about the prospects for the future? Why?

Cumulative Impacts of Development

Learning Objectives

As a result of studying the information contained in the background reading on this topic, the participants in your group should learn the following:

1. The cumulative impacts of development are the result of small, disconnected development projects which take place over a period of time.
2. Studies that have dealt with this issue recommend that there be increased planning efforts on the parts of state, regional and local governments to prevent the deleterious effects of "incremental development."
3. Planning efforts should take into consideration the "carrying capacity" of the land proposed for additional development.
4. Incremental development can destroy the "character" of an area or community.
5. Incremental development has many cumulative impacts which include serious degradation or depletion of coastal resources.

Indoor Demonstrations and Activities

1. Check the Filmography for any films related to this topic. If there are any, they would be listed under Section III.

2. Analyze your own community as to whether or not it suffers from "cumulative impacts of incremental development." If so, did this development occur rather suddenly or has it been over a period of many years? What, if anything, is being done to prevent any further incremental development? Does your town or community have any long term development plans? What is being done to alleviate the negative impacts on the environment, social character and economy of your community of this incremental development?

3. If your community is still relatively "undeveloped," is anything being done towards *planning* for any future development?

4. What kinds of incremental development do you see in your community and/or in the communities around you: industrial, commercial, permanent residential, summer homes?

5. Stimulate further discussions in your group by calling for questions from participants or by posing the following suggested questions:
   a. Have all the impacts of incremental development in coastal communities been negative? If not, what are some of the positive impacts?
   b. What development activities cause the most harm to the environment and to the community character as a whole? Which cause the least harm?
   c. Is the concept of "carrying capacity" appropriate for making human development related decisions? How can the carrying capacity of an area be determined?

Individual Research Projects

The following are but a few suggestions:

1. What statewide plans exist regarding long term development in your state? Contact your State Planning Office and find out.
2. Is there any research available regarding the use of the "carrying capacity" concept in developmental planning? Contact the Sea Grant office at the University of Maine or the University of New Hampshire and inquire.
3. Compare the development plans of your own community (if there are any) with the plans of another similar community. How do the plans differ? How are they similar?

Field Activities

1. If your community does have certain plans for development, visit the sites intended for this development. Try to visualize what the area will look like after development.

Multiple Use Planning, Conflict Resolution, and Protection and Enhancement of Marine Resources

Learning Objectives

The participants of your group should learn the following from this subsection:

1. In order to deal with the many problems that face our coast now and will face it in the future, emphasis should be placed on multiple use planning and conflict resolution, with the protection and enhancement of our marine resources kept in mind.
2. There are several conflicts that would be directly influenced by the strategy described above (multiple [illegible] regulatory authorities, conflicts between authorities and users of the coast, conflicts among users of the coast.
3. There are numerous agencies in both Maine and New Hampshire that have responsibility for dealing with these conflicts. The agencies and other means for working towards solutions to these problems have not been as successful as they might otherwise be if all efforts are coordinated.
4. As far as protection and enhancement of marine resources is concerned, more planning work needs to be done in [illegible] areas of shoreline management, waste disposal and [illegible]

Indoor Demonstrations and Activities

1. Check the Filmography for any films related to this topic. If there are any, they will be listed under Section III.

2. Analyze your own community or another community of your choice as to whether or not the concepts of multiple use, conflict resolution and protection and enhancement of marine resources are being included in any development plans for the area. Do the plans (if any exist) allow for a multiplicity of uses of coastal areas (e.g. industry, residences, recreation, etc.)? Are efforts being made to avoid conflicts between various regulatory agencies, between regulatory agencies and the public, among the different users of the coast (e.g. are public hearings and educational efforts being undertaken? are different agencies concerned with the same problem working together?, etc.)? Are the protection and enhancement of marine resources being considered (e.g. what is being done to minimize the negative environmental impacts of the proposed development? etc.)?

3. Section IV contains "Guidelines for Conducting a Case Study of Your Community." Consult these guidelines or make up a community and have your group become the "Planning Board" for your fictitious community. An example is given in Section IV.

4. Stimulate further discussion on this topic with the following suggested questions:

  a. Where are the prime areas for conflicts due to overcrowding or lack of access? In what areas could more access be provided? What role can the private sector play in the access problem?
  b. What effect will major new development projects have on the present and future projected access needs? How does the multiple use concept fit in with regard to recreational access?
  c. How can beach users be distributed to avoid crowding problems?
  d. Should the boundaries of state waters for the purposes of resource management be redefined? Why?
  e. Can and should the Federal Government delegate marine resource management authority to state and local agencies? Why?
  f. Are there harbor management practices which would minimize conflicts between fishermen and recreational boaters?

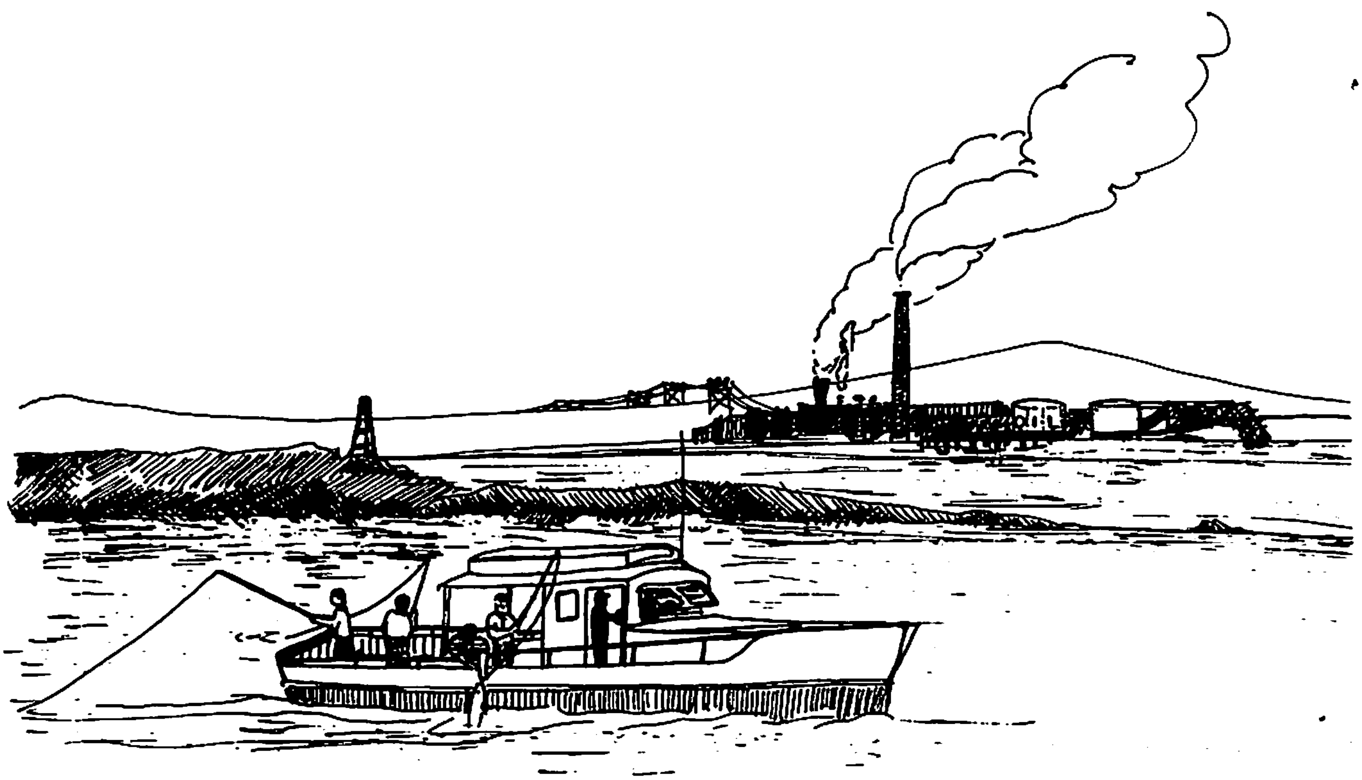
Individual Research Projects

The following are but a few suggestions:

1. Research the activities or status of the Coastal Zone Management Program in your state. What has the program accomplished to date?
2. What are the policies in your state, if any, regarding dredging, shoreline management, and waste disposal in the marine environment?
3. Find one example of how public hearings were used to educate and air differences of opinion on a coastal issue in your state. Report on the proceedings and results of the hearing(s).

Field Activities

1. Take a tour of the waterfront of your community or of a coastal community of your choice. How many different uses of the waterfront can you and your group find? Is there any evidence of conflict between any of the uses? What uses are missing? Would these missing uses be appropriate for the waterfront of your community? Why or why not?



Section IV
Community Case Studies and Educational Games

In Section IV, you will find several activities that are designed to further illustrate some of the concepts covered in the first three sections of the program or that will help to tie together all the information gleaned from the program. Included in this section are the following:

1. *Guidelines for conducting a case study of your community.*
2. *Role-playing game: "Goin' Fishin' "*
3. *Simulation game: "EcoKill/EcoSave"*

You will also find in this section an Annotated Filmography *of audiovisual materials available through the University of Maine and elsewhere. A list of other instructional units published by the Northern New England Marine Education Project will inform you of where you can expect to find extensive resource sections containing suggested books, etc., helpful persons, and places to visit.*

Guidelines for Conducting a Case Study of Your Community

One of the purposes of this program is to encourage the participants in your group to take a careful look at their own communities from a coastal management standpoint. The following outline of activities is but a suggestion as to how a community case study might be conducted:

I. Ecological Features of the Community

A. What is the normal tidal range at the waterfront of the community?

B. How high are the spring tides?

C. What degree of wave energy does the waterfront experience (high, medium, low)? Is the waterfront fairly well protected from storm waves or does it suffer wave damage frequently?

D. What are the current patterns in the nearshore waters of the waterfront? Are there strong tidal currents due to the presence of a fairly large river in the vicinity of the community? Are there longshore currents running parallel to the shore? Are there rip currents in the vicinity of the waterfront?

E. What is the salinity of the water near the community? Is the community fairly well upstream on a river (low salinity)? Or is it located out on a coastal peninsula, facing open waters of the Gulf of Maine (high salinity)?

F. What types of beaches exist in the community (rocky, pebbly, sandy, mostly mud flats)? Are there sand dunes in evidence? What is the general condition of the beaches (badly eroded, or in good shape, basically)? If the nearby beaches are sandy, what is the most likely source for the sand sediments (riverborne, reworked glacial deposits, local bedrock erosion, remains of animal shells and skeletons)?

G. What topographic features exist offshore in the vicinity of the waterfront (ledges, islands, deep basins, banks, etc.)?

H. Are there productive clam and worm flats in the vicinity of the waterfront or somewhere in the community? Is lobstering done in the offshore waters of the community? What other forms of marine life, if any, are harvested in the community (whelks, seaweed, crabs, etc.)? Are there any aquacultural enterprises in the community?

II. Uses of the Coastal Sections of the Community

A. How is the community's coastline utilized? Are there commercial fishing enterprises in the community that have onshore facilities associated with them (piers, docks, processing plants, freezing facilities, fish markets, off loading apparatuses)? How extensive are the onshore facilities for the aquacultural enterprises, if there exist any, in the community? Are there other marine product industries located in the community (seaweed processing, offshore or coastal sand and gravel mining, etc.)? Are there any heavy industries sited along the coast of the community (oil terminals, oil refineries, power plants, shipbuilding enterprises, coal storage yards, etc.)? Are there any cargo port operations located in the community? Are there any tourist and/or recreational facilities located along the shoreline of the community (coastal campgrounds, marinas, bathing beaches, hotels, motels, sport fishing boat rental stations, charter boats, etc.).? Are there any waterborne passenger services (ferries, water taxis, etc.) located along the waterfront of the community? Are there any military installations situated along the coast in the community (naval yards, old forts, etc.)? Are there any Coast Guard stations and/or lighthouses in the community? Is there extensive residential (permanent and summer home) development along the coast of the community? What kinds of light industry and commercial developments exist along the shoreline of the community (boatbuilding businesses, restaurants, garment and shoe factories, etc.)? Is the community located on a river or estuary on which there is significant development upstream (major cities, pulp and paper mills, large agricultural areas, major areas of lumbering activities, etc.)? Are there marine research facilities located along the shoreline of the community? What other uses can be found along the coast of the community?

III. Management of the Shoreline and the Marine Resources of the Community

A. Fishery resources:

1. Does the community have any regulations regarding the harvesting of fish, shellfish and crustaceans (e.g. restricting clam flats to use by town residents, etc.)?
2. Does the community have any zoning ordinances that would affect the siting and operations of aquacultural enterprises?
3. Does the community have any regulations and or zoning

ordinances affecting the siting and operations of seafood processing and/or storage facilities?
4. Does the community have any regulations affecting the marketing of seafood?

B. Heavy industry siting:
1. Does the committee have any regulations and/or zoning ordinances regarding heavy industry siting and operations along its coastline? (Including road construction, waste storage and/or disposal, dredging, filling of wetlands, etc.)

C. Cargo port development and operations:
1. Does the community have any regulations regarding cargo port development and operations (including road construction, dredging, filling of wetlands, etc.)?

D. Tourism and recreation:
1. Does the community have any regulations and/or zoning ordinances regarding the siting and operations of tourist and recreational facilities?

E. Light industry, other commercial and residential development
1. Does the community have any regulations and/or zoning ordinances regarding these activities along its shoreline?

IV. Planning

A. Does the community have any plans for the future of its shoreline? What activities does it plan to encourage? What activities does it plan to discourage or prohibit?

Resources available to help your group with its community case study

There are numerous reports, persons and agencies that can help your group conduct its study. Some of these are listed below:

Reports

Many reports that are available on various aspects of coastal issues, coastal planning and coastal management have already been listed in the references sections for each background information reading contained in this program. Many other reports are available through the various agencies listed below. The Coastal Program of the Maine State Planning Office is a veritable goldmine of technical and planning reports on a variety of topics. It would be beyond the capabilities of this program to list them all here. The Coastal Program publishes updated lists of all its publications. If you are interested, write or call them and ask that a recent list be sent to you.

Persons

Probably the persons who would be of the greatest assistance to you and your group in conducting a community case study are the community's officials, including:

1. Town selectmen
2. Town manager
3. Town or city planner
4. Directors of special planning groups (e.g. regional planning commissions, waterfront redevelopment projects, etc.)
5. The mayor's office.

It is beyond the scope of this program to give the names, addresses, and telephone numbers for the town or city officials of *all* coastal communities in northern New England. Consult your local telephone directory.

Agencies

There are several agencies at state level that should be able to provide information on various state policies, regulations, etc. that have an effect on the plans and activities of the coastal communities of that state. In Maine these agencies are:

The Maine State Planning Office
State House Station
Augusta, Maine 04333
(207) 289-3261

The Coastal Program and The Critical Areas Program
Maine State Planning Office
State House Station #38
Augusta, Maine 04333
(207) 289-3154 (Coastal Program)
(207) 289-3155 (Critical Areas Program)

The Coastal Program has an extensive library of material on coastal issues, coastal resources, and coastal planning which it lends or gives away. A list of "Publications Related to Coastal Resource Management" is available by writing or calling Joyce Gerardi at the Coastal Program office. In addition it has produced maps for the entire coast of Maine that contain such information as fish and wildlife resources of each area, topography, land cover types, slopes, etc. A map set for your area can be obtained from the Coastal Program office. Refer to the map code and legend found in the Appendix of this guide to determine what the section number is for your community. Maps must be ordered according to section number.

The Critical Areas Program investigates and registers natural features of state significance. It also has available inventories and reports about each of these areas. For more informatin, call the Critical Areas Program.

State of Maine Department of Marine Resources
Lorraine Stubbs, Marine Science Educator
State House Station #21
Augusta, Maine 04333
Telephone (207) 289-2291

The DMR has the ability to work with teachers and schools in setting up programs and planning curriculum. Speaker service with slide presentations can be tailored to your groups' interests and needs. Hands-on materials and answering questions are part of the presentation. Publications for use by educators which are free of charge, are abundant in the DMR library, as are many technical reports for background material or intensive study projects. The department will also arrange for visits to aquaria or research labs. The highly-knowledgeable and skilled Lorraine Stubbs is responsible for these diverse and high-quality services.

State of Maine Department of Conservation
Bureau of Parks and Recreation
Information and Education Division
State House Station #22
Augusta, Maine 04333
Telephone: (207) 289-3821

The Bureau of Parks and Recreation will send information on State Parks and Memorials, many of which make excellent seashore field trip sites. Only one state park maintains a year round, full-time naturalist — Wolf Neck Woods State Park in Freeport. The services of talented naturalist Kate LeRoyer are available to you at the Park. An outdoor guided nature walk on intertidal zone ecology is a specialty of the interpretive program. To contact the park directly, call (207) 865-4465.

Land Use Regulation Commission
State of Maine Department of Conservation
State House
Augusta, Maine 04333
(207) 289-2631

Office of Energy Resources
55 Capitol Street
Augusta, Maine 04333
(207) 289-2196

Bureau of Public Lands
State House
Augusta, Maine 04333
(207) 289-3061

Maine Department of Environmental Protection
State House
Augusta, Maine 04333
(207) 289-2811

Branch Offices:
a. *P.O. Box 1274, 634 Main St., Presque Isle, Me. 04769*
(207) 764-3737
b. *31 Central St., Bangor, Me. 04401*
(207) 947-6746
c. *Portland Main Office, 17 Commercial St., Portland, Me. 04101*
(207) 775-6587
d. *Portland Oil Polluton Control Division Office*
17 Commercial St., Portland, Me. 04101
(207) 773-6491

Bureau of Land Quality Control
State House
Augusta, Maine 04333
(207) 289-2111

Bureau of Water Quality Control
State House
Augusta, Maine 04333
(207) 289-2591

Atlantic Sea-Run Salmon Commission
State House
Augusta, Maine 04333
(207) 289-3371

Maine Department of Transportation
Bureau of Planning
State House
Augusta, Maine 04333
(207) 289-2251

Maine Land and Water Resources Council
State House
Augusta, Maine 04333
(207) 289-2212

If you and your group cannot conduct a case study of an actual community, make up a community! Half the group could be responsible for describing the community and the other half could act as the community's planning board and devise plans for the community, keeping in mind the various planning and management concepts and strategies learned in this program.

For example:

Community Z has the following characteristics:

1. It is situated at the head of a large bay which is bordered to the east and west by a large peninsula of land.
2. It has a natural deep water harbor.
3. The bay has very few islands and ledges compared with other sections of the coast.
4. The tidal range is 10 feet. The spring tidal range is 14 feet.
5. There is no major river running through the community and no longshore current patterns.
6. The community has extensive productive clam and worm flats and an abundance of rockweed along its shoreline.
7. The community has very poor and thin top soil underlain by hardpan clay.
8. The community has some clean, protected coves along its coastline.
9. The community has a small population. Most of the population is employed as lobstermen, clammers, or wormers. There is one dragger fisherman who owns his own wharf. Existing industrial/commercial development consists of one campground on the shore, a shorefront restaurant, a small boatbuilding enterprise, a lobster pound, and a public boat launch ramp. Twenty percent of the population is unemployed.
10. There are only a few summer homes in addition to the permanent residences.

What kinds of coastal activities and development should be planned for this community? What activities should be severely restricted or prohibited? Why?

Role Playing Game: "Goin' Fishing?"

*A Public Meeting Concerning the Conservation of New England's Fishery Resources**

*Developed by the Education Department of the Federal Reserve Bank of Boston in cooperation with the New England Aquarium.

Introduction:

In a short time, this room will become the scene of a public meeting concerning the management of New England's fishery resources. Participants have received descriptions of the role each will play in the public meeting. Before we begin, I'd like to discuss the background of the Fishery Management and Conservation Act of 1976, which established a nationwide program of fishery conservation after years of overfishing by foreign fleets threatened the existence of fish stocks around the U.S. coasts.

The 200-mile limit law, as it is commonly called, gives the U.S. exclusive authority to manage and conserve fish in a coastal area which extends 200 miles off the shores of the U.S. Foreign fishing is strictly limited in this zone to those species and that portion of quotas that U.S. fishermen cannot use. Foreign nations must now apply for permits to fish within the "U.S. economic zone" which specify where and when they can fish and what and how much they can catch.

In addition to restricting foreign fishing, the 200-mile limit law establishes a system for the regional control of fishing. Eight regional fishery management councils are charged with the responsibility of developing management plans for the fisheries in their areas. Members of the councils include commercial and sports fishermen, processors, and state and federal representatives of fishery management agencies.

They develop plans for the conservation of fishery resources that also take into account the social, economic, consumer, and recreational needs of the region.

The plans, prepared by the councils with the advice of fishermen, scientists, and economists, are submitted to the Secretary of Commerce for approval and implementation. The fishery management plans (FMP's) may govern the amount and types of fish that can be taken and the times and places fishermen may fish. The various regulatory tools open to the council include: setting quotas on the amount of fish that may be caught; limiting the number of people allowed to fish; closing certain seasons or areas to fishing; and restricting types of gear.

Under the 200-mile law, all groups which use or have an interest in fishery resources — such as the commercial fishing industry, recreational fishermen, seafood consumers, and environmentalists — must be included in policy decision-making. For example, the council must hold a public hearing when considering a policy decision so that all concerned groups have an opportunity to express their views. All monthly Council meetings and committee meetings are open to the public.

The 200-mile limit law has had a considerable impact on the New England fishing industry. It has also generated considerable controversy since it regulates not only foreign fishermen, but American fishermen as well. This role play, a simulation of a New England Fishery Management Council meeting, will illustrate some of these conflicts.

Today's public meeting concerns how the catch of cod, haddock and yellowtail flounder will be regulated during the next fishing quarter. The local fishing industry depends heavily on these species — also known as groundfish. Groundfish have long been traditional favorites with seafood consumers, and as a result, groundfish stocks have been depleted over the years. Since the FCMA went into effect the population of groundfish has increased significantly, but not as much as some people would like.

During the current quarter, the Council's plan placed strict quotas on groundfish catches. As a result, the quotas were filled before the end of the quarter, and all fishing of these species was closed by the Department of Commerce until the next quarter — the one coming up, for which the plan is now being reviewed. The closures, of course, resulted in some hardship to the fishing industry.

The question before the Council is whether or not to increase the quarterly quota for this next period, to allow more opportunity for fishermen who say the fish are plentiful or to maintain the existing quarterly quota, to allow for more rapid rebuilding of the stocks, which the scientists claim is necessary. Alternatives to the quota system to protect the fish stocks and the fishing industry should also be considered.

One final word before beginning the hearing: Do not limit yourself to discussing only those matters which are strictly within the Council's jurisdiction. The role play will be enriched if the discussion during the hearing is not confined to narrow bounds. So feel free to bring up relevant issues — such as recommending tariff increases on the imported fish — which the Council may not possess the authority to implement itself but can adopt as a recommendation.

The Council membership represents the broad range of members' interests.

Eight people are scheduled to comment on the groundfish issue at this morning's meeting. The Council Chairman will call upon each one of them to testify. After each witness has spoken, the rest of you will have an opportunity to comment, and Council members may ask questions. After the testimony, the Council will take several minutes to formulate a decision on what the Council's next step will be as a result of these discussions.

***Mark Hanson** — Council Chairperson*

It is your responsibility to ensure that the meeting runs smoothly, and that all have an equal opportunity to express their views. You believe strongly in the need for conservation, but you also want to develop regulations that protect the interests of all concerned. You listen carefully to the variety of opinions voiced so as to devise a plan which balances the need for conservation with the economic, recreational and consumer needs of the community.

You will meet with your council members after the meeting to decide what direction the council will take as a result of the testimony presented. You will vote only if necessary to break a tie.

***Alice Rogers** — Council Member*

You are the publisher of a magazine for recreational fishermen entitled *Ocean Sport*. You are also a member of the fishery management council.

As a council member, your primary responsibility is to prevent the depletion of groundfish stocks. In doing so, however, you must also consider the economic and social needs of the fishing industry and the general public.

During today's meeting, you will solicit comments about the needs of the citizens who are concerned enough about the groundfish issue to attend. After the meeting, you will meet with the other council members to decide what direction the council will take as a result of the testimony.

***John Hubbard** — Council Member*

You are a *retired state conservation officer* and a member of the fishery management council.

As a council member, your primary responsibility is to prevent the depletion of groundfish stocks. In devising a plan to do so, however, you must also consider the economic and social needs of the fishing industry and the general public.

During today's meeting, you will solicit comments about the needs and opinions of the citizens who are concerned enough about the groundfish issue to attend. After the meeting, you will meet with the other council members to decide what direction the council will take as a result of testimony.

***Manuel Motta** — Council Member*

You are the *president of a fishermen's cooperative association* and a member of the fishery management council.

As a council member, your primary responsibility is to prevent the depletion of groundfish stocks. In devising a plan to do so, however, you must also consider the economic and social needs of the fishing industry and the general public.

During today's meeting, you will solicit comments about the needs and opinions of the citizens who are concerned enough about the groundfish issue to attend. After the meeting, you will meet with the other council members and decide what direction the council will take as a result of the testimony.

***William Pierce Bright** — Council Member*

You are the *lawyer for an association of New England seafood processors* and a member of the fishery management council.

As a council member, your primary responsibility is to prevent the depletion of groundfish stocks. In devising a plan to do so, however, you must also consider the economic and social needs of the fishing industry and the general public.

***Sally Marsh** — Witness*

A *seafood consumer*, you attend the meeting to voice your concern about the high- and ever-rising prices of cod and haddock, which are great favorite of yours. As a vegetarian, you depend on fish as a source of protein. You feel that the consumer suffers from the quota system by paying a higher price for the artificially limited supply of fish. Although you are unsure of the best way to regulate the groundfish catch, you feel that an attempt should be made to keep prices reasonable by increasing the available supply.

Also you feel that it makes economic sense to buy imported fish since it is cheaper than domestic fish.

***Joanne Stein** — Witness*

You have been asked to attend this meeting by the *sporting club* of which you are president. Club members have no complaint against quotas, per se, but they do resent the recent closing of cod and haddock fishing. You remind the council that the economics of many New England towns depend on the tourist industry, which in no small measure is made up of recreational fishermen.

You propose that the quotas be continued, but set at a higher level to enable those who fish for sport to do so without encountering any further closures.

***Benjamin Gonsalves** — Witness*

A *commercial fisherman* for the past 20 years, you were delighted when the 200-mile law was passed. Thinking that hard times were finally over, you borrowed money to buy a large, modern fishing boat, which you'd long dreamed of owning. During the current fishing quarter, however, you have encountered financial disaster, thanks to the council's unfair quota system. You don't know how you are going to meet this month's payments on the new boat. You don't think the quota system can work because there are too many boats in the water competing for the same limited groundfish catch.

You think the quotas unfairly restrict "highliners" like yourself, those who have always been the most successful fishermen in their ports. Your costs for fuel, bait, and grub for the crew are getting out of sight, so you need to fill the hold with fish when you go out on a trip in order to make ends meet. Even before you leave the dock with your crew, you've invested $6,000-$8,000 in fuel and other expenses.

Fish are cyclical, you argue, so you have to take them while they're there.

***John Parisi** — Witness*

The president of an *environmental protection agency*, you believe firmly in our responsibility to conserve natural resources for future generations. You actively support the strongest conservation measures proposed at the meeting. Nonetheless, you are also sensitive to the needs of those employed in the fishing industry. The problem, in your opinion, is that the New England fleet depends too much on groundfish. There are some 200 other species in the water — such as whiting, squid, and pollack — which still exist in volume since they have not been traditional favorites with seafood consumers. You propose that a tax be levied on groundfish catches, and the revenue gained be used to pay subsidies to fishermen who harvest underutilized species. In addition, you feel that profitable foreign markets may be found for species that the American consumer will not buy.

Squid, for example, is very popular in Italy. You recommend that the Department of Commerce provides technical assistance to the fishing industry in breaking into foreign markets.

***Mark Brown** — Witness*

You dropped out of college two years ago because the freedom of a *fisherman's* life appealed to you. Not only does the quota system threaten to destroy this freedom; it is also completely unnecessary. Now that the foreign ships have pulled out, stocks of cod and haddock are at the highest level ever for the past ten years.

However, you feel large vessels take a disproportionate share of the catch. Not only are they able to catch more, those boats can go farther offshore and stay at sea for several days on the rich fishing banks of Georges Bank. Your fishing, on the other hand, is restricted to relatively protected inshore areas within several hours steaming time from port. Nonetheless, your average work day is 16 hours long.

You feel more attention should be given to the small boat fisherman, in the form of preferential quotas or government loans for vessel construction or improvement. Requiring larger mesh sizes would help you compete with large boat fishermen (who have the horsepower to haul small mesh nets against the water resistance).

You would hate to see the independent fisherman disappear the way the small family farm has vanished from our landscape.

***Maria Taylor** — Witness*

A marine scientist, you are a member of the Scientific and Statistical Committee that advises the council. You are concerned about New England's depleted fish stocks, especially cod, haddock and yellowtail flounder. Your data indicates that it will be at least five years before groundfish stocks reach their optimum level. You recommend therefore that the quotas be continued, although at a slightly higher level. In addition, you propose further conservation measures. You feel that spawning grounds should be closed to fishermen and that the mesh of their nets be increased so that younger fish can escape. Spawning seasons should also be closed.

***Theresa Gomez** — Witness*

You own one of the largest *fish processing* companies in New England. Although your business in the last several weeks has suffered along with that of the fishermen, you support rather than oppose conservation. You recognize that conserving fish may have short-term costs, but in the long run the entire fishing industry will benefit if fish stocks are allowed to replenish themselves.

In addition your processing facilities cannot handle undersized fish. Therefore it is to your advantage to encourage the harvesting of larger, adult fish.

You have long thought that the industry should diversify its harvest, so you recommend that the government support a marketing campaign to encourage consumers to shift their tastes and buy more underutilized species.

***John Holmes** — Witness*

You are a *fresh fish dealer*. Your business suffers when the fishing season is closed. Also, you find it hard to compete with fresh and frozen fish imports from Canada where prices are subsidized by the government. You recommend, therefore, that a tariff be placed on imported fish to improve the competitive position of the domestic market.

You also would like to see the government spend more money promoting underutilized species to the public.

Simulation Game: "EcoKill/EcoSave"

Introduction

Welcome to **EcoKill/EcoSave**, a simulation game developed by the staff of Northern New England and Marine Education Project. The game was created by Edward Hodgdon and has been adapted for use in ***What is Our Coastal Future?*** by Gail Shelton and Connie Holden:

The main purpose of **EcoKill/EcoSave** is to demonstrate how the particular *site* of an industry influences environmental pollution. The game concerns the "Northern New England Bugbear Company" which has eight factories located on different sites in a coastal community. The accompanying map shows the locations of the eight factories. Each factory produces four related products, Product A, Product B, Product C and Product D. The manufacture of each of these products has a different effect on the environment as does the location of the factory producing these products. Data Sheet II shows the "EcoKill" and "EcoSave" values for each product at each site. The number of "EcoKill points" shown refers to the relative amount of environmental damage caused by the particular product manufactured at a particular site. For example, at site #1, Product A causes 10 points worth of environmental damage (EcoKill points), Product B causes 100 EcoKill points, Product C, 20 EcoKill points, and Product D, 5 EcoKill points. These same products, A, B, C, D produce, respectively, 40, 400, 100, and 20 points worth of environmental damage at Site #4, and so on. "EcoSave" points, on the other hand, refer to the amount of money that must be spent to clean up the pollution at each location caused by the manufacture of each product. This value is compounded by other factors at the site, such as other nearby industries or residential centers, etc. As you can see, by looking at the chart, at some sites, the production of a certain product produces so much pollution that it cannot be cleaned up, hence the initials N.A. ("not applicable" or "None Available.")

The object of the game is really open-ended. It is up to the players to decide who is the "winner" in the end. They may, for example, decide that the winner is the person who has amassed the largest income at the end of twenty rounds, without regard to the number of "EcoSave" points that person has allocated toward pollution abatement. Or, they may choose the player who has a combination of high income and high "EcoSave" points. Or, they may even choose the person who has the highest number of "EcoSave" points, without regard to the income he/she has accumulated. The players should not be presented with these alternatives at the beginning of the game. In fact, it is preferrable to simply ask at the end of the game, "Well, who won?" and see what system they choose without having knowledge of the various alternatives available. The purpose of leaving the game "object-less" in this way, is to enable the players to develop their own views regarding profits and pollution.

EcoKill/EcoSave consists of the following players: a referee, 8 players (or 8 teams of players), one for each site. We suggest that the referee read over the rules in advance of actually playing the game. During the explanation of the rules to the players, it will be helpful if the referee hand out a copy of "Summary of the Rules for Players" to each player or team of players. There is also an example and two figures that should help the referee explain the rules. The figures can be put on a blackboard or on an overhead transparency.

Before the game begins, the referee asks the players to rate themselves, on a scale of one to one hundred as to their "ecological consciousness." Each player writes down the value chosen on a slip of paper, along with his/her name and gives it to the referee. Teams of players should decide on an average value for the "ecological consciousness" of the team. The players should not let each other know how they rated themselves. In fact, refraining from collaboration throughout the game is an important aspect! Players should keep their strategies secret, and give out information only when the referee calls for it

To start the game, the referee gives the dice to a player who rolls the dice. Each player then has a turn at rolling the dice. The person with the highest roll gets first choice of location for his/her factory (see attached map). The player with the next highest roll gets second choice and so on. In the case of two or more players rolling the same value, have them roll again until each has a different value. The referee should then distribute Data Sheet I on which the player should record her/his site number. (See Example and Figure I).

Data Sheet I — Site # 4

Round # (1)	Sales / Prod Choice (2)	Total EcoKill Pts (Site total) (3)	Strategy EcoKill Pts (Prod total) (4)	Total EcoSave Pts (Site total) (5)	Strategy EcoSave Pts (Prod total) (6)	Income (7)	Debts (8)	Loans (9)	Balance $100,000 (10)
1	6 / A,C	560	140	63	58	4920	738	—	109,18[illegible]
2									
3									
4									
5									
6									
7									
8									
9									
10									

Figure 1

The player who had *last* choice of sites then rolls the dice. The value that comes up on the dice is the "sales" for his/her factory. This value should be recorded on Data Sheet I under the column labeled "sales" for Round 1 (see Example and Figure 1). Then proceeding clockwise around the group, each player (or each team) rolls the dice and records the value under "sales" on his/her Data I sheet. (Note that on Data Sheet I, every player starts off with a balance of $100,000.) The referee should note whether or not any player rolls a double. This is for future reference. The referee should write down the player's name and what double he/she rolled. Do not tell the players you are doing this!

The referee then distributes Data Sheet II. This table contains the various "EcoKill" points (amount of damage done to environment) and "EcoSave" points (monetary amount required to clean up the pollution) for each of the four products manufactured at each site. For example, at Site #1, Product A creates 10 EcoKill points worth of damage which requires 5 EcoSave points worth of money to clean up. Product B at Site #4 creates 400 EcoKill points worth of pollution, a situation so bad that only an exorbitant amount of money can clean it up (is labelled N.A.). A factor that needs to be considered when dealing with EcoKill and EcoSave points is that a factory owner *must* allocate the EcoSave money shown for each product he/she wishes to produce at his/her factory.

With this information and the data contained in the chart, the factory owner (or team of owners) can play her/his strategy for the game depending on her/his goal: to make money, to save the environment, or to do a little of both. Again, we emphasize that the players are not to be made aware of these alternative goals; they should be left on their own to decide for themselves.

Players should examine the EcoKill and EcoSave points for the various products at their respective sites and decide whether to manufacture one, two, three, or all four products. (They need not manufacture all four, but rather have the choice of which ones to produce. They must choose *at least* one product.) After the players have made their choice of products, they should write down their product choices in column 2, under "sales" (see Example and Figure 1). They should then add up the total number of EcoSave points involved in their choice. For example, the owner of the factory at Site #8 wishes to maximize his profits with as little regard for the environment as possible. We can see that Product B has a high EcoKill value which means that it produces environmental damage that cannot be cleaned up at any price. Thus, the EcoSave point value for Product B at Site #8 is zero. Product C has a high EcoKill point value but also has a high EcoSave point value. Product D has a relatively low EcoKill value, but a practically non-existent EcoSave value and Product A has a bit higher EcoKill value, of products, the money oriented owner can discover the blend that yields the lowest EcoSave value (and therefore the greatest savings to him/her):

Site #8

A+B+C+D+	=	Total EcoSave Points of 20+0+150+1	= 171
A+B+C	=	Total EcoSave Points of 20+0+150	= 170
A+B	=	Total EcoSave Points of 20+0	= 20
A	=	Total EcoSave Points of 20	= 20
B	=	Total EcoSave Points of 0	= 0
C	=	Total EcoSave Points of 150	= *150*
D	=	Total EcoSave Points of 1	= 1
B+C+D	=	Total EcoSave Points of 0+150+1	= 151
B+D	=	Total EcoSave Points of 0+1	= 1

and so on...

Thus the factory owner at Site #8 can choose among the various products, a combination that helps him/her best achieve his/her goal. The money oriented manufacturer may choose to produce Product B alone. With an EcoSave value so high, the factory would go bankrupt if required to pay it, a situation which would be against the free enterprise system, or perhaps Product B *and* Product D (because it's economically safer to diversify) for a total EcoSave allocation of 1 point, or whatever. The referee should note, at this point, that the more products a factory produces, the higher its income. This should not be pointed out to the players, however, as it is one purpose of the game that they figure such things out as they play the rounds.

The environmentally conscious manufacturer might choose not to produce Product B at all, and produce all other products including C to prove that she/he is willing to put money into pollution abatement. Players can choose any combination of products they wish depending upon what they hope to accomplish.

Once the players have figured out their strategies, they should record the following data on their Sheet I: (see Example and Figure 1)

1. Total # of EcoKill points for the site (see Data Sheet II).
2. Number of EcoKill points resulting from players strategy. (Total for products chosen.)
3. Total # of EcoSave points for the site (see Data Sheet II).
4. Number of EcoSave points resulting from player's strategy. (Total for products chosen.)

Next, the referee distributes Data Sheet III. This sheet is a computer print-out of a program that incorporates the EcoKill points and the EcoSave points for each product at each site and the value of the "sales" as determined by the roll of the dice.

These factors are related by the following equation:

$$\text{Income} = \$10{,}000 \times \text{Sales} \times \frac{\text{EcoKill} - \text{EcoSave} + \$1{,}000 - 1}{1{,}000}$$

To save the players from having to compute their income for each round using this equation, our computer has produced the table shown on Data Sheet III. To find his/her income for a particular round, the player simply:

1. Looks for his site number at the head of each block of columns.
2. Goes across to the Product he/she chose to manufacture. (If he/she chose to manufacture more than one, find the income for each Product chosen, and then add the individual incomes together for a total income. To determine income, see #3 below.
3. Go across the column labelled "Sales" until the value for that round is located. Go down that Sales column until it intersects with the Product row. The value shown at that intersection is the income for that product. If more than one product is chosen, find the income for each product chosen and add them together. (See Example and Figure 1).

The player should then record his/her total income in the column labelled "Income" on Data Sheet 1.

Finally, the referee should inform players that the federal government has the authority to levy fines on any factory which fails to comply with air and water quality control standards. The referee should not tell the players that the fines are levied strictly by chance (depends upon the roll of the dice as explained below) nor should she/he divulge the amounts for the fines until a player incurs one.

Fines are administered when a player rolls a double on his/her "Sales" roll. The amounts for the fines are listed below:

If the player rolls a double:	*Then his/her fine is:*
1	10% of real income
2	20% of real income
3	30% of real income
4	25% of income if first offense 50% of income if second offense 75% of income if third offense 99% of income if fourth and higher offenses*
5	A summons to court. This means that the player loses one turn. (He/she cannot sell anything for one turn — does not roll the dice for a "sales amount" for one turn. His/her income for that turn is carried over from the previous turn.)
6	Player is jailed. This means that the player loses three turns. On the second offense, player is ordered to shut down his/her plant until the end of the game.

*(Note: The odds of a player rolling a double 4, four times in ten rounds, is slim indeed.)

NOTE: All fines are reduced if the player has allocated EcoSave Points. The amount the fine is reduced depends upon the number of EcoSave points allocated and/or upon the EcoKill value of the products being manufactured. A player's fine is reduced by 1/2 if he/she has allocated 1/2 of the total EcoSave points available to that player, or is not manufacturing Product B (the worst polluter of the four products). The fine is suspended if player has allocated *all* the EcoSave points available *and* is not manufacturing Product B.

The player is exempt from a summons (double 5) and jailing (double 6) if he/she has allocated 75% to 100% of the EcoSave points available and is not manufacturing Product B. If the player has allocated 75%-100% of the EcoSave points or is not manufacturing Product B (but not both), then he/she is exempt from the summons (on a double 5) but must face the summons on a double 6 and lose one turn.

Fines should be calculated and recorded on Data Sheet I under the column labelled "Debts." Players should figure out their balance for the round by substracting debts (fines) from income. Once the balance is obtained, round 1 is over. (See Example and Figure 1) The referee then calls for a corporate report and each factory owner must tell her/his balance. The referee might want to record these amounts on a chart or on the board (See Figure 2).

If a player comes up with a negative balance for a round, he/she has two choices:

1. Declare bankruptcy and drop out of the game, or
2. Borrow money from the referee. The player can borrow up to $10,000 at 10% interest. The amount of the loan should be listed as income in the round that it is taken and the interest listed as a debt in the *next* round and all succeeding rounds. The loan *must* be paid back before the end of round 10, but can be repaid on any round the player so chooses.

Round 2 (and all following rounds) begins with each player rolling the dice to get a sales value for his/her factory. The game ends after ten rounds, at which point the players decide upon the winner.

Listed below are some points you and your groups should discuss after the game is over:

1. Would a tax on each type of product according to its polluting capability be an effective means of enforcing anti-pollution legislation?
2. How does the location of the industry effect the environmental damage it can do?
3. How does the location of the industry effect the costs of cleaning the pollutant up and why?
4. What is the role of the federal government? Should the federal government have a role in determining the site of the industry? Should the industry be allowed to operate in a Supply and Demand mode?
5. How effective was the 'threat' of federal intervention in stopping players from polluting? In the first part of the game; later on?
6. Tally the total EcoKill Points, and the total EcoSave Points and corrolate this with the individual student's rating of his/her "ecological consciousness." How are they different and why?
7. Discuss the difficulties that industry locating itself on Sites 1 and 2 would have/did have in accumulating 1/2 of the total EcoSave points in each round and how this might lead to a 'polluting' attitude by that industry. What could be done to avoid this situation?
8. What would be the effects of running this game for a long period of time, allowing the players to figure out the fining structure of the federal government? How could this change the game?
9. Discuss why EcoKill points contribute to an industry's income. Introduce the concept of "hidden costs." What are they and how are they used by industry?

The rules for players are summarized in the following pages. Note that it would be helpful to have several hand-held calculators for doing the computations involved in determining income and fines.

Referee Data Sheet

Round #	Site #	[illegible]	(From Col 4 Data Sheet I) Product EcoKill Points	(From Col 6 Data Sheet I) Product EcoSave Points
1	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
2	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
3	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			

End of Game	Site #	Total Product EcoKill	Total Product EcoSave	EcoSave EcoKill	Eco. Con.
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				

Figure 2

Summary of the Rules for Players

1. Rate yourself according to "ecological consciousness" on a scale of 1 to 100. Write down your rating on a slip of paper, sign your name, fold the paper, and give to the referee. Teams should decide on an average "ecological consciousness" value.

2. Look at the map of sites of the individual factories of the "Northern New England Bugbear Company, Inc." Roll your

dice. The player with the highest roll gets first choice of site; the player with second highest roll, second choice, etc. Record your site number on Data Sheet 1.

3. The player who had last choice of site begins the game by rolling the dice. The value on the dice is his/her "Sales" which should be recorded on Data Sheet 1 for round 1. Proceed clockwise around the room, with each player (or team of players) rolling the dice to obtain his/her "Sales" value.

4. Referee should then distribute Data Sheet II. Find your site number and study the "EcoKill" and "EcoSave" points for each of the four products (A,B,C,D) at your site. EcoKill points refer to the amount of environmental damage done by the manufacturer of that product at that site. EcoSave points refer to the amount of money necessary to clean up the pollution. Where the value N.A. is listed, the pollution is so bad that the amount of money required for abatement is exorbitant. For all practical purposes, N.A. = 0. With this in mind, decide upon a strategy for your factory. You can choose one or more products to produce, but you must allocate the EcoSave points for whatever products you choose. Remember that EcoSave points cost you, as a manufacturer, money. Write down your product choices in the space below the *Sales* column.

5. When you have decided which products to produce (you must produce at least one), add up the total number of EcoSave points involved in the choice and record it on Data Sheet I. Also record the *total* number of EcoSave points available for the site (see Data Sheet II) and record that value on Data Sheet I. Do the same for EcoKill points.

6. Then go to Data Sheet III. Find your site #. Go across to the products you wish to manufacture. (If you chose more than one product, find the income — as explained below — for each product and add together the separate incomes for a total income.) Then locate the value of your sales in the section of the chart labelled "Sales Value." At the intersection of the column for "Sales" and the row for Product will be the value of your income for that product. For more than one product, add the separate incomes. Record your total income on Data Sheet I.

7. Note that players can be fined for failure to comply with air and water quality standards. Fining is up to the discretion of the referee. If you are fined, the amount of the fine is recorded under "Debts" on Data Sheet I.

8. Finally, players should determine their balance by subtracting any debts from their incomes. (Note that every player starts off with a balance of $100,000.) If a player ends up with a negative balance, he/she can borrow money from the referee up to $10,000, at 10% interest compounded on every round. The loan should be recorded as "income" during the round it is taken out and the interest should be recorded as a "debt" during the next round and in all succeeding rounds until the loan is repaid. The loan must be repaid before the end of round 10. Once each player has a balance recorded for that round, it is time to move on to the next round.

9. The game ends after 10 rounds.

Examples illustrating how to play "EcoKill/EcoSave"

1. Suppose the player (or team of players) chooses site #4 from map. He/she writes #4 in the space provided for site # on Data Sheet I. (See Figure 1)

2. Suppose a player rolls a double 3 on the dice. Then his/her "Sales Value" is 6. This value should be recorded on Data Sheet I in column 2 for round 1 (upper half of the space). See Figure 1. The referee should make a note to him/herself that this player rolled a double 3. This is for future reference. Do not tell the players that this has any significance.

3. Suppose the player chooses to manufacture Products A and C at his/her site. He/she should write "A & C" in column 2 for round 1 (lower half of space). See Figure 1.

4. The player should fill columns 3, 4, 5 and 6 for round 1 by referring to Data Sheet II. For example:

a. The total EcoKill points for site # 4 is: 40 (for Prod. A) + 400 (for Prod. B) + 100 (for Prod. C) + 20 (for Prod. D). Total = 560 (this total can be found in the second to the last column on Data Sheet II) This figure is written in column 3 (See Figure 1).

b. The "Strategy EcoKill Points" refers to the total number of EcoKill Points of the products chosen. Since this player chose to manufacture Products A and C, the following value is written in this column (column 4):
EcoKill Points for Prod. A = 40
+ EcoKill Pts. for Prod. C = 100
Total EcoKill Pts. for Products = 140 (See Fig. 1)

c. The "Total EcoSave Points" refers to the total for that site (site #4). Look in the very *last* column on Data sheet II for this total for site #4:
8 (for Prod. A) + 0 (for Prod. B) + 50 (for Prod. C) + 5 (for Prod. D) = total EcoSave Pts. for site #4 = 63
Write this value on Data Sheet I, column 5. See Fig. 1.

d. The "Strategy EcoSave Points" is the number of EcoSave Pts. for the products chosen. This is figured in the following manner:
EcoSave Pts. for Prod. A = 8
+ EcoSave Pts. for Prod. C = 50
Total EcoSave Pts. for Products = 58
Write this value on Data Sheet I, column 6. See Fig. 1.

5. To find this player's income for Round 1, go to Data Sheet III. Find the chart for site #4 (site numbers form the headings for the various charts). Go to the far left hand column marked "sales value". (Only the left hand charts have a sales value column. This column should be used for the right hand charts also.) The sales value for this player was "6." Go across from the sales value of "6" to the columns for the various products for site #4. The numbers given are the incomes for the various products. The income for Product A (with a sales value of 6, at site #4) is $1920. The income for Product C (with a sales value of 6, at site #4) is $3000. Add these two incomes together for a total income of $4920. Write this figure in column 7 of Data Sheet I for round 1. (See Fig. 1)

6. Column #8 "Debts" on Data Sheet I is for fines. Since this player rolled a double 3, he/she will be fined. The amount of his/her fine should be 30% of his/her income:
Income = $4920
x30%   x. 30
Fine = $1476

However, this player chose not to manufacture Product B, plus he/she has allocated more than half of the total available EcoSave points, so his/her fine is cut in half.
Fine = 1476 ÷ 2 = $738

Note: Do not tell players how fines are allocated, figured or why some are cut. Let them try to figure that out on their own. You may want to tell this player simply that he/she is being fined, but for reasons known only to you, the fine has been cut in half.

The amount of the fine should be recorded in column 8 on Data Sheet I (See Fig. 1). This amount should be subtracted from the total income. Total income now equals $4182.

7. Each player starts off with a balance of $100,000. Thus at the end of round 1, this player will have an income (or balance) of:
starting balance = $100,000
+ income (minus fine) + 4,182
Balance $104,182
at end of round 1

This figure is written in column 10 on Data Sheet I. (See Fig. 1)

8. Suppose this player had chosen a different site # and a different set of products to manufacture and had ended up with a *negative* income of greater than $100,000. This player may wish to borrow money from the referee so he/she can continue in the game. Suppose his/her income before borrowing is $101,000. When subtracted from his/her starting balance of $100,000, this leaves an ending balance of -$1,000. The player may borrow up to $10,000 from the referee. Suppose he/she borrows this full amount. Then, the player must write $10,000 in column 9 ("Loans") and the figure $ 9,000 in column 10 ("Balance"). Thereafter, the player must record the value $1,000 in column 8 ("Debts") for every round that the loan goes unpaid. (10% of $10,000.) If the player pays off some of the loan in each round, the debt becomes 10% of the remaining amount of the loan. The entire loan must be paid off before the game ends or the player will be considered bankrupt.

Annotated Filmography

The following films are available from the Film Rental Library Instructional Systems Center, Shibles Hall, University of Maine, Orono 04469. There is a rental charge for groups outside the University system.

Section I: Basic Coastal Ecology

The Beach: A River of Sand. L-374, 14 min. Color.
From an elementary analysis of the currents produced by waves (documented by underwater photography) and the calculations of the accumulation and depletion of sand (produced by jetties), the discovery is made that the most pronounced movement of sand on a beach is usually along the shore. The beach is actually a moving river of sand between the land and the water. (AGI Basic Science Program.) EBF 1966.

Birds of the Sea. S-60, 11 Min. Color.
Photographed on the headlands, cliffs, and islands of the Atlantic coast, this film introduces us to a wide variety of birds that live near the sea. Shown are gulls, terns, skimmers, pelicans, eiders, gannets, murres, and puffins. COR 1965.

Challenge of the Oceans. L-239, 29 Min.
An exciting motion picture on oceanography presenting current views of the character and dynamics of oceans, explaining the scope and objectives of current oceanographic exploration and problems confronting the oceanographer. (Planet Earth Series) MH 1961.

Crustaceans. M-82, 13 Min.
This film explains the value of crustaceans as a source of food and livelihood for man. Describes the appearance, habitat, and behavior of the fairy shrimp, cypris, a crustacean plankton, barnacles, crabs, lobster and crayfish. EBF 1955.

Cry of the Marsh. M-1028, 12 Min. Color.
Presents in a powerful and emotional manner the poetic beauty of marsh life, then the terror and awesome finality which results when man diverts a marsh into other purposes. Suitable for science, art, and social studies, and the humanities. Maine Fish and Game 1969.

Life Between Tides. M-797, 11 Min. Color.
Presents a film discovery of intertidal life, showing the rich variety of animals and plants on a stretch of shoreline on the coast of the state of Washington. Points out the relationships among plants and animals and their marine environment. EBF 1963.

Echinoderms and Mollusks. M-1556, 15 Min. Color.
Underwater photography reveals many species of echinoderms and mollusks in their natural habitats. We examine the development of a sea urchin egg under magnification and study the reproductive system of the clam. In the radial body plan of the echinoderms and the bilateral body plan of the mollusks, the two main types of evolutionary development of animal structures are seen. COR 1968.

Echinoderms: Sea Stars and Their Relatives. M-825, 17 Min. Color.
Describes the characteristics of the echinoderm body plan and how it adapts for locomotion, respiration, digestion, and reproduction. Examples of the five classes are shown. Laboratory experiments using sea urchin eggs are shown. Biology Program Unit III. EBF 1962.

Endless Sea. L-509, 29 Min. Color. $13.25.
Two-thirds of our planet is covered by the sea, yet it remains largely a mystery we have only just begun to investigate. In this film, we sail and learn with the CSS Hudson, a Canadian oceanographic vessel, one of the few designed for sea study. The film enables us to see more than most men do. Microphotography shows the beautiful infinite world of plankton. Beneath the sea, we explore the rich pastures of the continental shelf and beyond to the soaring undersea mountains and the abyss of the great deeps. The experience is exhilarating — the inexhaustible sea at last vulnerable to man's abuse — and we emerge from it with a rapture clouded by concern. LCA 1973.

Food Cycle and Food Chains. S-1005, 11 Min. Color.
Animation and live action photography illustrate several examples of food chains, almost all of which depend ultimately on green plants. The film relates these food chains to the larger concepts of the oxygen-carbon dioxide and the nitrogen cycles and to the unending pattern of life, growth and decay known as the food cycle. COR 1963.

Fish, Moon and Tides: The Grunion Story. M-901, 14 Min. Color.
Grunion is the only fish that spawns on land. Fertilized eggs are photographed hour-by-hour to show the development of the transparent egg. Actual heartbeats, blood circulation and movements of the embryo are clearly viewed. Animated drawings explain how the spawing of Grunion is related to ocean tides and the moon. Bailey 1964.

Life In The Sea. S-501, 11 Min. Color.
This film describes the interrelationship of plants and animals in providing a chain of food and maintaining a delicate balance of life. EBF 1958.

Life Story of the Oyster. M-799, 11 Min. Color.
Demonstrates how the free-swimming oyster larva develops into an adult attached to objects in shallow waters of the ocean. Shows the place of this well-known mollusk in the marine food cycle. EBF 1963.

Life Story of the Sea Star. M-802, 11 Min. Color.
Illustrates the life cycle of the sea star and shows the adaptations of its body for life in the difficult environment of the intertidal zone. Demonstrates the characteristics the starfish has in common with the brittle star, the sea urchin, and the sand dollar. EBF 1963.

Maine Waterfowl Story. M-859, 24 Min. Color.
Produced by Maine Fish and Game, this film documents the work being done in Maine on migratory waterfowl. Has some excellent scenes of different waterfowl species. Documents the year round program on waterfowl research and management and closes with some excellent scenes of different kinds of Maine duck hunting. MFG 1957.

Marine Biologist. M-706, 14 Min. Color.
Presents an intimate portrait of scientists at work, permitting the viewer to discover why men and women devote their lives to the study of living things of the sea. EBF 1963.

Marine Life. S-531, 11 Min., Color.
Underwater photography shows how big fish hunt for victims while the small fish seek safety. Photographed at Marineland, Florida. EBF 1952.

Marine Animals and Their Foods. S-530, 8 Min.
This film demonstrates the interrelationship of marine animals and their surroundings by showing various sea animals and the five general types of food on which they depend. COR 1949.

Mission Oceanography. M-278, 8 Min., Color.
Traces the beginning of oceanographic research to the latest developments in this field. The information gathered from oceanographic research is analyzed and the film shows what the benefit is from this analysis. An excellent film showing this ever expanding field of study. Amer. Pict. Serv., 1966.

Mollusks. M-267, 14 Min., Color.
Discusses the five classes of mollusks, picturing their physical characteristics, reproduction processes, feeding habits and ways of protection themselves. EBF 1955.

Plankton and The Open Sea. M-702, 19 Min., Color.
Demonstrates the importance of the minute plankton organisms to marine food chains. Typical forms of plankton are shown. Photomicrography and laboratory experiments show how plankton are studied at sea, in floating laboratories, and in shore-based laboratories. (Biology Program — Unit II) EBF 1962.

Plankton: Pastures of The Ocean. S-438, 10 Min., Color.
Photomicrography shows plankton, the conglomeration of plants and animals in the upper levels of the sea, which is the vast food source for all marine life. Not only do viewers come to recognize the diatoms and dinoflagellates which form the base of the food pyramid in the sea, but they also see the microscopic animals and larvae which feed on planktonic plants. EBF 1965.

Plankton To Fish: A Food Cycle. S-121, 10½ Min., Color.
Experiments with a miniature ecosystem in an aquarium illustrate the food chain as a continuous cycle, with each type of living thing depending on the others. Observing the effects of varying the fish population reveals what happens when the balance is upset. COR 1974.

Restless Sea. L-498-499, 58 Min.
A complete story of oceanography. Produced by Walt Disney. NET-T 1964.

Seacoasts: First Film. S-472, 10 Min., Color. $7.25
There are many kinds of seacoasts. Some are sandy, some are rocky. Some consist of tidal marshes. All coasts are battered by the rise and fall of the sea. So seacoasts are constantly changing. A great variety of animals live in the tidal area. BFA 1973.

Shoreline Sediments. XL-46, 44 Min., Color.
The film shows how a shoreline forms. This is done by explaining how a beach is formed when sand and rocks move back and forth on the beach. Pebbles are shown on an ocean beach wearing away. Coastal and storm beaches are also talked about. Tides and how they form sand patterns are illustrated. The marsh shore is brought out, too. Finally, the narrator summarizes the contents of the film. Edinburgh University.

Tides of the Ocean: What They Are and How The Sun and Moon Cause Them. M-908, 16 Min., Color.
Shows the many ways in which man has made use of the range of ocean tides. Animated drawings help explain, not only the why of ocean tides, but many other concepts important to an understanding of our earth and its position in the solar system. Educational Consultant Joseph L. Reid, Jr., Assoc. Research Oceanographer, Scripps Institute of Oceanography, La Jolla, CA. Bailey 1964.

Waves On the Water. M-714, 16 Min., Color.
By using large experimental tanks, wave refraction (waves approaching shore bend to conform to coast line) is explained. Documentary evidence is presented proving that the seismic sea waves which crossed the Pacific Ocean in April 1964 were directly associated with an underground earthquake that took place near the Aleutian islands. (AGI Basic Science Program) EBF 1965.

Section II: People and The Sea

Climates of the United States. S-963., 11 Min., Color.
This film surveys the climatic regions of the United States and shows how these regions are determined by such geographic factors as latitude, large bodies of water, ocean currents, altitude, and winds. COR 1962.

Fish Cookery With Savoir. M-28, 14 Min., Color.
Unique in presentation. Monsieur Henn Savoir, special emissary of providence, an imaginary and imaginative master of fish cookery, gives pertinent aid to the perplexed chef. NOAA.

Marine Biologist. M-706, 14 Min.
Presents an intimate portrait of scientists at work, permitting the viewer to discover why men and women devote their lives to the study of living things of the sea. EBF 1963.

Marine Scene with Herb Olsen. M-973, 19 Min., Color.
One of the fifty-eight living painters chosen for representation in the historic "200 Years of Watercolor Painting in America" exhibition at the Metropolitan Museum of Art, Herb Olsen knows well and paints beautifully the many moods of the sea. In this film he demonstrates his indirect method of creating images of fog, his technique for creating illusions of solid forms in space, and the careful texturing of a paint surface to enhance the intimacy of the foreground. This film is part of the Watercolor Painting Series. PERS 1973.

Take A Can of Salmon. 14 Min., Color.
Several salmon recipes are prepared. Recipe booklet of the same name available from Supt. of Documents, Govt. Printing Office, Washington, D.C. 20402. NOAA.

Winslow Homer in Maine. L-618, 28 Min., Color.
This film shows the last years of Winslow Homer's life which were spent in Prouts Neck, Maine. The film shows the paintings done at this time, and gives a background of each one. Some excellent photography has been taken of the rugged Maine coast. Very good for all age groups. WCBB 1971.

Section III: Coastal Issues of Northern New England

Note: Not all of these films deal with northern New England specifically, but they do concern coastal issues.

Alone In My Lobster Boat. M-1337, 16 Min., Color.
This film is the salty tale of Timmy Bradford, age twelve, of New Harbor, Maine. Like many residents of this snug little 300-year-old town of 700 people, Timmy's main interest is lobstering. As the film builds up to the boy's first solo voyage among the lobster traps, the viewer shares Timmy's native knowledge of his seacoast environment and of its way of life. Xerox.

Energy Sources of the Future. M-433, 15 Min., Color.
Examines the need for new and better ways to provide for ever-growing energy needs. Focuses on new trends and ideas for the production of energy: extraction of oil from shale; gasification of underground coal; production of energy from nuclear fission and fusion; use of solar heat; control of the power of the tides. Discusses ecological, social and economic problems which must be considered before new energy sources can be utilized. MH 1974.

Flavor of Maine. M-1425, 14 Min., Color.
Supplements the films "It's the Maine Sardine" and "Sardines from Maine Downeast Style." Artistically depicts the whole Maine sardine industry. Three methods of capture, processing and various methods of serving are pictured. NOAA.

Food From the Sea. S-1086, 11 Min., Color.
Aboard ship, colorful live action sequences along with diagrams and illustrations help to give young viewers an understanding of purse seining, the method used to take fish from the sea. Once ashore, we see the cooking, packing and labeling operations. Bailey 1966.

Fresh Out of Water. M-135, 14 Min., Color.
Tours a modern cannery. The fish move from the ocean to the cannery to the consumer. Explains different types of seafood and nutritional values of seafood. Commercial Fish Inc. 1957.

It's the Maine Sardine. M-203, 20 Min., Color.
The prize winning film about the Maine sardine fishing industry, showing the methods of capturing and processing Maine sardines. Maine Sardine Packers Assoc., 1949.

Lobstermen, The. M-584, 22½ Min.
Documentary of Maine lobster fishermen. They bait, set, and repair lobster traps, navigate their boats, market their products, and then relax at the country store. Narration is the conversations of the fishermen as they work. They decribe their gear, navigation methods, designs of lobster traps, and personal feelings and experiences. Filmed in Corea, Maine. CP 1954.

Mrs. Peabody's Beach. L-147, 24 Min., Color.
A teenager discovers an apparently deserted beach which is ideal for surfing — but soon learns that the owner, Mrs

Peabody, will permit surfing only if the boy helps her develop it as a profitable business. This leads to a practical course in the laws of supply and demand, capital investment and depreciation, diminishing returns, and other aspects of basic economics. WD 1970.

Outboard Fisherman. L-56, 30 Min., Color.
Depicts fishing for lobster, catfish, scallops, shad, clams, oysters, and crabs from an outboard motorboat. U.S. Dept. of Wildlife, 1956.

Preservation of The Maine Environment. XL-91, 45 Min., Color.
This film, narrated by Gary Merrill, shows the Environmental Protection Agency in action cleaning up Maine rivers and streams that are polluted. The film discusses the importance of screening new industries coming into the State of Maine. Excellent film for Maine groups. DEP 1968.

Salmon Story. S-685, 11 Min., Color.
Portrays the life cycle of the salmon and calls attention to steps taken to assure a continuing supply of this important fish food. Shows the "purse seine" method of catching salmon and follows the catch from the sea to the cannery. EBP 1950.

Sardines From Maine: Downeast Style. 12 Min., Color.
Chiefly an informational type film for acquainting the reviewer with the Maine sardine. USFWD 1957.

Seafood. AA-68, 15 Min.
This film presents a general picture of the fishermen who fish for clams and crabs and the subsequent processing and packing of these shell fish for public consumption. AFL-CIO 1959.

Shellfishing. S-705, 11 Min.
Survey of the oyster, crab, clam and lobster fishing industries of the East Coast. Preparing oyster beds, planting and dredging for mature oysters; luring crabs to nets with baited lines, planting and harvesting clams, and catching lobster. Preparation for market. EBF 1938.

Shipbuilders. AA-69, 15 Min.
This film provides a good over-all view of the shipbuilding industry from the drawing board to the launching of a new ocean liner. AFL-CIO 1959.

Other Sources

The northern New England Marine Education Project has recently published eight marine-oriented instructional units on various themes. These units are:

"*Have You Been to the Shore Before?*"
"*What Adventures Can You Have In Wetlands, Lakes, Ponds and Puddles?*"
"*How Do People Use Lighthouses and Navigational Charts?*"
"*Is Our Food Future in the Sea?*"
"*Do You Know Our Marine Fish?*"
"*Do You Know Our Marine Algae?*"
"*What Are the ABC's of Marine Education?*"
"*What is Our Maritime Heritage?*"

These units contain numerous activities and have extensive resource sections that include lists of organizations, persons, places to visit, books, and other references, etc. Since it would be redundant to duplicate the resource sections of these units into this program (to say nothing of making "*What Is Our Coastal Future?*" much longer than it already is!), we suggest that you write or call:

Northern New England Marine Education Project
206 Shibles Hall, College of Education
University of Maine
Orono, ME 04469
Phone (207) 581-7027

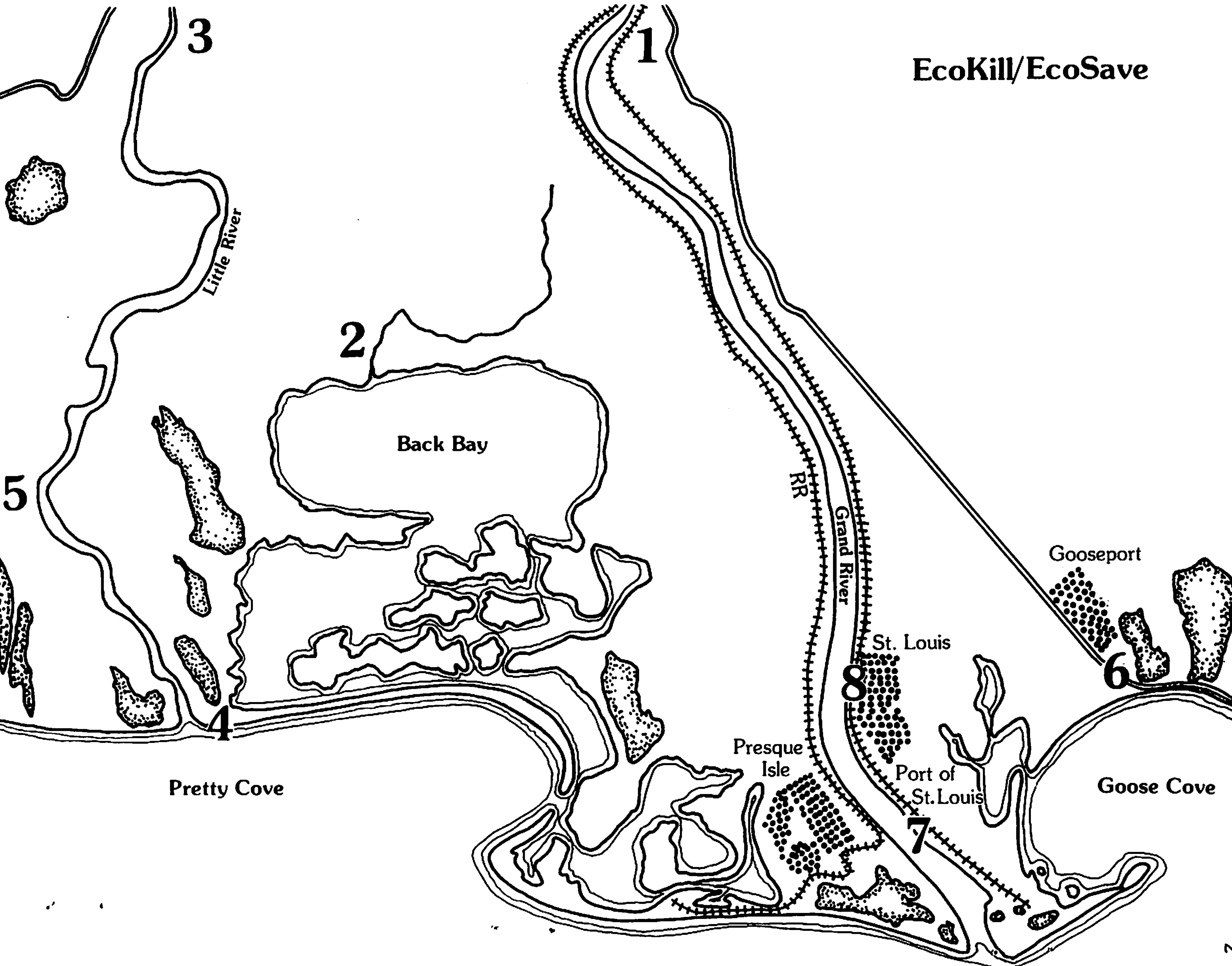
and request that a copy of one or all of these units be sent to you. They are supplied at $3.50 each.

Introduction to the Background Information Readings for "What Is Our Coastal Future?"

The readings contained in this pocket provide fairly detailed background information on the various topics and subtopics covered in the program. How these readings will be used by various groups will depend on the goals, interests and intentions of the individual instructors and program participants. Because this program "What Is Our Coastal Future?" has been designed for use by a wide variety of groups, the background information on topics provided, is intentionally detailed: thus groups that are especially science oriented or already informed on coastal issues will find the extra detail helpful, while groups seeking only an introduction to these topics may wish to omit a great deal of the detail. The readings have been written as simply as possible so that instructors with little science and/or management backgrounds can understand them.

It is up to the instructor as to how he/she wishes to use background informational readings. He or she may want to use them as a base for the preparation of lecture notes, supplementing the lectures with suggested readings from other sources. Or, he/she may want to duplicate the readings for the program participants to read as background for a more detailed lecture or basis for discussion.

In summary, the goal of "What Is Our Coastal Future?" is to provide an adequately detailed program that will appeal to a wide variety of groups at all levels of knowledge and understanding of the topics presented. It is hoped that instructors will use whatever portions of the program they see appropriate for their particular groups.


EcoKill/EcoSave
1
2
3
4
5
6
7
8
Little River
Back Bay
RR
Grand River
Gooseport
St. Louis
Presque Isle
Port of St. Louis
Pretty Cove
Goose Cove

Referee Data Sheet

Round #	Site #	Balance	(From Col. 4 Data Sheet I) Product EcoKill Points	(From Col. 6 Data Sheet I) Product EcoSave Points
1	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
2	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
3	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
ETC.				

End of Game	Site #	Total Product EcoKill	Total Product EcoSave	EcoSave/EcoKill	Ecol. Con.
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				

Data Sheet I

Site #: ____________________

Col. # 1 Round #	2 Sales / Prod. Choice	3 Total EcoKill Pts. (Site total)	4 Strategy EcoKill Pts. (Prod. total)	5 Total EcoSave Pts. (Site total)	6 Strategy EcoSave Pts. (Prod. total)	7 Income	8 Debts	9 Loans	10 Balance $100,000
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Data Sheet II

Location	Product A EcoKill Points	Product A EcoSave Points	Product B EcoKill Points	Product B EcoSave Points	Product C EcoKill Points	Product C EcoSave Points	Product D EcoKill Points	Product D EcoSave Points	Total EcoKill Points EKP	Total EcoSave Points ESP
1	10	5	100	400	25	20	5	20	140	445
2	20	6	200	300	50	30	10	10	280	346
3	30	7	300	N.A. 0	75	40	15	6	420	53
4	40	8	400	N.A. 0	100	50	20	5	560	63
5	50	9	500	N.A. 0	125	60	25	4	700	73
6	60	10	600	N.A. 0	150	70	30	3	840	83
7	70	15	700	N.A. 0	175	100	35	2	980	117
8	80	20	800	N.A. 0	200	150	40	1	1120	171
	Product A		Product B		Product C		Product D		Totals For EcoKill and EcoSave	

Data Sheet III

Site No. 1

Sales Value	Prod. A	Prod. B	Prod. C	Prod. D
2	100	-6000	100	-300
3	150	-9000	150	-450
4	200	-12000	200	-600
5	250	-15000	250	-750
6	300	-18000	300	-900
7	350	-21000	350	-1050
8	400	-24000	400	-1200
9	450	-27000	450	-1350
10	500	-30000	500	-1500
11	550	-33000	550	-1650
12	600	-36000	600	-1800

Site No. 2

Sales Value	Prod. A	Prod. B	Prod. C	Prod. D
2	280	-2000	400	0
3	420	-3000	600	0
4	560	-4000	800	0
5	700	-5000	1000	0
6	840	-6000	1200	0
7	980	-7000	1400	0
8	1120	-8000	1600	0
9	1260	-9000	1800	0
10	1400	-10000	2000	0
11	1540	-11000	2200	0
12	1680	-12000	2400	0

Site No. 3

Sales Value	Prod. A	Prod. B	Prod. C	Prod. D
2	460	6000	700	180
3	690	9000	1050	270
4	920	12000	1400	360
5	1150	15000	1750	450
6	1380	18000	2100	540
7	1610	21000	2450	630
8	1840	24000	2800	720
9	2070	27000	3150	810
10	2300	30000	3500	900
11	2530	33000	3850	990
12	2760	36000	4200	1080

Site No. 4

Sales Value	Prod. A	Prod. B	Prod. C	Prod. D
2	640	8000	1000	300
3	960	12000	1500	450
4	1280	16000	2000	600
5	1600	20000	2500	750
6	1920	24000	3000	900
7	2240	28000	3500	1050
8	2560	32000	4000	1200
9	2880	36000	4500	1350
10	3200	40000	5000	1500
11	3520	44000	5500	1650
12	3840	48000	6000	1800

Site No. 5

Sales Value	Prod. A	Prod. B	Prod. C	Prod. D
2	820	10000	1300	420
3	1230	15000	1950	630
4	1640	20000	2600	840
5	2050	25000	3250	1050
6	2460	30000	3900	1260
7	2870	35000	4550	1470
8	3280	40000	5200	1680
9	3690	45000	5850	1890
10	4100	50000	6500	2100
11	4510	55000	7150	2310
12	4920	60000	7800	2520

Site No. 6

Sales Value	Prod. A	Prod. B	Prod. C	Prod. D
2	1000	12000	1600	540
3	1500	18000	2400	810
4	2000	24000	3200	1080
5	2500	30000	4000	1350
6	3000	36000	4800	1620
7	3500	42000	5600	1890
8	4000	48000	6400	2160
9	4500	54000	7200	2430
10	5000	60000	8000	2700
11	5500	66000	8800	2970
12	6000	72000	9600	3240

Site No. 7

Sales Value	Prod. A	Prod. B	Prod. C	Prod. D
2	1100	14000	1500	660
3	1650	21000	2250	990
4	2200	28000	3000	1320
5	2750	35000	3750	1650
6	3300	42000	4500	1980
7	3850	49000	5250	2310
8	4400	56000	6000	2640
9	4950	63000	6750	2970
10	5500	70000	7500	3300
11	6050	77000	8250	3630
12	6600	84000	9000	3960

Site No. 8

Sales Value	Prod. A	Prod. B	Prod. C	Prod. D
2	1200	16000	1000	780
3	1800	24000	1500	1170
4	2400	32000	2000	1560
5	3000	40000	2500	1950
6	3600	48000	3000	2340
7	4200	56000	3500	2730
8	4800	64000	4000	3120
9	5400	72000	4500	3510
10	6000	80000	5000	3900
11	6600	88000	5500	4290
12	7200	96000	6000	4680

Section I: Basic Coastal Ecology

Introduction

Before considering some of the critical coastal issues of northern New England, it is important to come to a basic understanding of some of the ecological principles, processes and characteristics of marine environments, in general, and the Gulf of Maine, in particular. While the information presented in the background readings for this section may seem very detailed, it really only barely scratches the surface of what is known about the oceans and the Gulf of Maine. And actually, compared with what is *not* known about the sea, the body of knowledge presently possessed by humankind about things marine is miniscule.

The following topics are presented in this section:

1. Physical Processes
   a) Tides
   b) Waves
   c) Currents
2. Chemical Characteristics
   a) Salinity (the chemical composition of seawater)
3. Geological Processes and Characteristics.
   a) Sediment transport (movement of materials)
   b) Beach dynamics
   c) Bottom topography of the Gulf of Maine
4. Biological Characteristics and Relationships
   a) Some plants and animals of the Gulf of Maine (Who lives here?)
   b) Some habitats of the plants and animals of the Gulf of Maine (Who lives here?)
   c) Some relationships between the plants, animals and their environment in the Gulf of Maine.

It is hoped that, through the study of this section, program participants will better understand how the ecological characteristics and processes of the Gulf of Maine affect the lives of the citizens living along its shores.

Background Information: Tides

The alternating rise and fall of sea level is called a tide. In our area, the tide rises and falls twice every day. Actually, we mean a *lunar* (moon) day, which is a little longer than a *solar* (sun) day. A lunar day is 24 hours 50 minutes while a solar day, which is what our clocks go by, is 24 hours. This means we have two high tides and two low tides in every 24 hour 50 minute time period. This type of tide is called a *semi-diurnal tide* (one tide every half-day). In other areas of the world, for example, in the northern part of the Gulf of Mexico and in southeast Asia, there is only one high tide and one low tide every lunar day. These are known as *diurnal*, or *day* tides. In yet other areas, the tides are *mixed* which means that the heights of the high and low waters are unequal (i.e., one high tide might be 8 ft. high and the second high tide that day might be 5 ft. high. Or, one low might be 3 ft. and the second low, 1 ft.). The reasons for these differences in tides around the world are complicated. Basically, however, the type of tide an area has depends on: 1) the declination of the moon and 2) the size and shape of the basin where one is measuring the tide. These will be discussed in later paragraphs of this reading. Let us first discuss the question: What causes tides?

The earth is a solid globe, whose surface is almost three quarters covered with water. This globe is turning on its axis in space, making one revolution every 24 hours. The continents are like islands "floating" in the global sea. Try to picture the earth as a solid ball within a watery envelope, which has floating in it a few blotches of land. Imagine an orange suspended in a round tank of water that is only slightly larger than itself. The orange is spinning inside the tank. The earth is like the orange being spun around inside the water tank. The water tank (i.e., the oceans) are carried along as the orange (i.e., the earth) spins. Now picture that the orange and the watery tank are magnetic and that the moon and sun are magnets out in space. What happens when something magnetic is put next to a magnet? If the magnet were strong enough it could attract the magnetic substance to it even from quite a distance. This is similar to how gravity acts on bodies in space. The sun and moon have an attraction for the earth (and the earth for the sun and moon, too) that tend to pull all these bodies toward each other. But, fortunately, the pull is not strong enough to cause the sun, moon and earth to collide with each other. Another force, created by the spinning of the earth and moon, help keep them in their places by counteracting the pull of gravity. What happens when you swing a plastic bucket tied to a rope around and around you and then let go of the rope? Does the bucket fly towards you or away from you? This force, called centrifugal force, tends to cause the spinning earth and moon to pull away from each other and from the sun, while at the same time, they are being pulled towards each other by gravitational attraction, keeping them all in balance.

Now, getting back to the orange in the tank: what would happen if you put a magnet very near the orange in the tank, assuming that the water in the tank *and* the orange are both magnetic? Because the water is liquid and flows easily as compared to the solid orange, it will move first.

This is precisely what happens to the ocean water on earth. Since it moves more easily than the solid earth beneath it, it responds more readily to the gravitational attraction of the sun and moon. It moves enough for us to notice it. This movement of the oceans in response to the gravitational pull of the moon and the sun are the *tides*.

Even though the sun is much *larger* than the moon (400X larger), the moon is much *closer* to the earth than the sun (400X closer). This closeness more than counteracts the size difference and causes the moon to have twice the influence on earth's tides as the sun. In other words, the moon is 2X more powerful than the sun in producing tides.

However, the sun and moon acting together have important effects on the earth's tides. When the sun and moon are in line with the earth (either on the same side or on opposite sides) the effect is greater on the tides. When this happens (either on a full moon or new moon), we have high tides that are higher than usual and low tides that are lower than usual (called *spring* tides). When the sun, moon and earth are at right (90 degree) angles, then the effect is lessened because the sun and moon are acting against each other. In this case, the *high* tides are *lower* than usual and the *low* tides, *higher* than usual. (These are called *neap* tides.) See Figure 1.

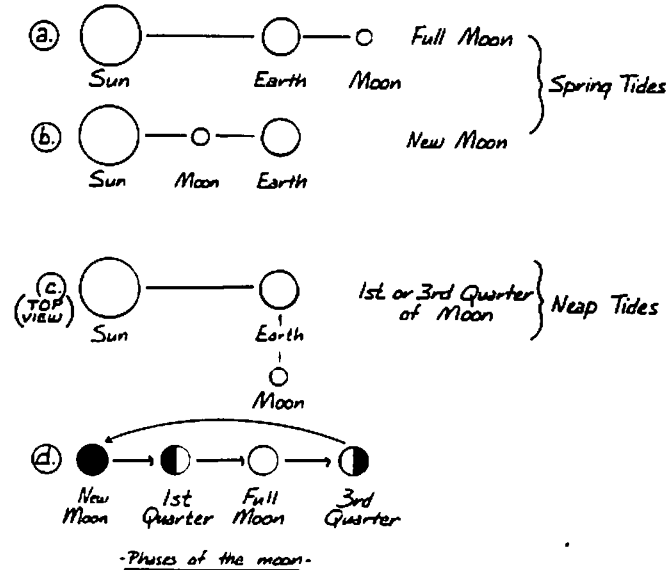


FIGURE 1

To summarize, the tides on earth are the result of the gravitational attraction of the moon and sun for the earth. This attraction causes the water to "bulge" out from the earth's surface as the moon and sun "pass by." Since the influence of the moon is greater than that of the sun, the moon can be considered to be the main cause of the tides. As the moon "passes" over the earth (actually, it only appears that the moon is passing through the sky; this illusion is caused by the rotation of the earth), the "bulge" of water follows it. So different places on earth have high tides at different times, depending on the "position" of the moon over the earth.

It is easy to see why there would be a bulge of water on the same side of the earth as the moon. But a bulge also occurs on the side of the earth *away* from the moon. Why do you suppose this is so? Remember that the spinning earth is under the influence of centrifugal force that pushes the earth out into space. This force is equal at all points on the earth. It also causes the waters of the earth to move. Look at Figure 2. You can see that on the side of the moon, the centrifugal force is *less* than the gravitational attraction of the moon. But on the side away from the moon, centrifugal force is *greater* than the gravitational attraction. It is mostly centrifugal force then that causes the bulge of water on the side of the earth away from the moon.

If you look at tide tables in your local newspaper, you will notice that the tides do not occur at the same time each day. This is because the tidal cycle runs on "lunar time" and our clocks run on "solar time." Recall that the lunar day is 24 hours 50 minutes, while the lunar day is 24 hours. The two "clocks" are "out of step" with one another. Since the lunar day is 50 minutes longer than the solar, the tides will be *about* 50 minutes later each day. (Actually, the time difference is *about* 40 minutes. This is because the "bulge" of water on earth is not *directly* beneath the moon. Rather, the bulge is pushed forward by the rotation of the earth and tends to be slightly *ahead* of the moon.) Also when the sun and moon are not aligned as shown in Figure 1 (in a straight line or at 90° angle) but are in intermediate positions (for example, sun, moon and earth at 50° angle) the sun influences the moon's tidal bulge in such a way as to warp it slightly. This warping causes the tides to occur a little earlier (*less* than 40 minutes) or a little later (*more* than 40 minutes) than expected.

Let us now turn to the question of why some places on earth have only one high and one low tide per day (diurnal tide) and why other places have mixed tides (highs and lows of unequal heights). As you know, the earth tilts on its axis as well as rotates. It tilts towards the sun about 23° during our summer and away from the sun about 23° during our winter (See Figure 3). The earth is, at the same time, tilting towards and away from the moon, causing the moon's position to appear to move from

FIGURE 2

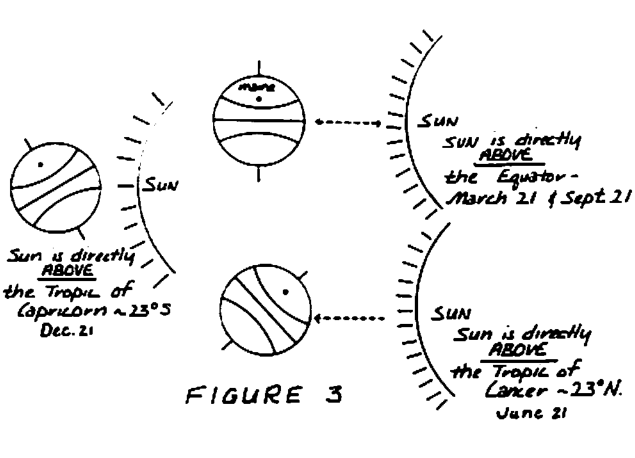


FIGURE 3

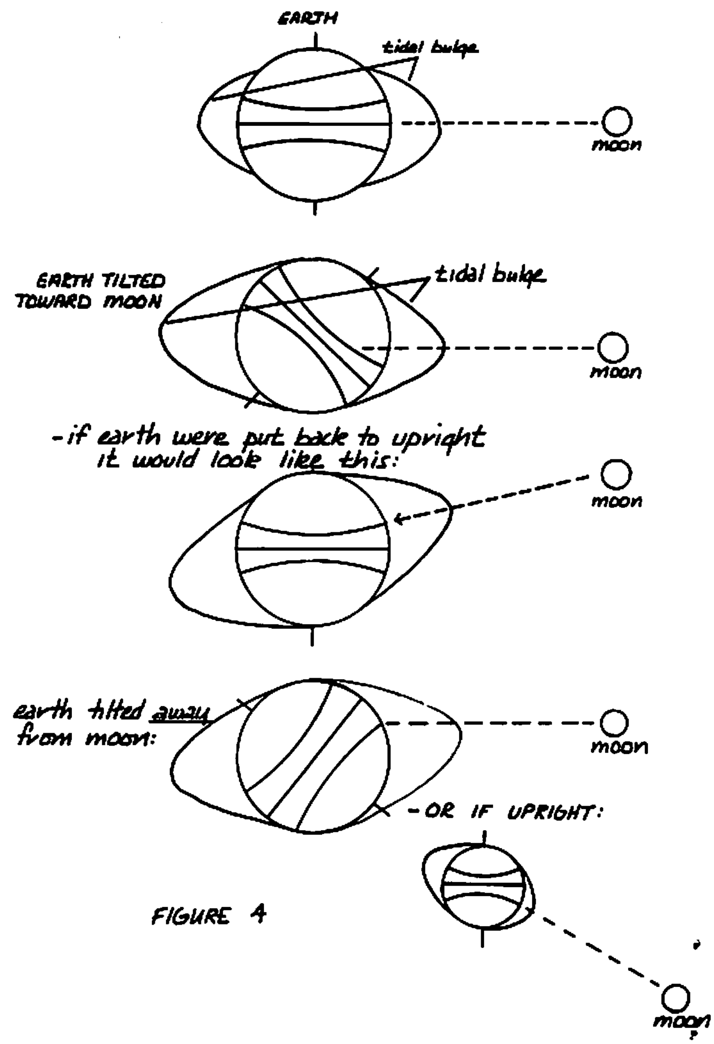


FIGURE 4

the equator to 28.5° north or south of the equator. This shift causes the tidal bulge also to move above and below the equator (See Figure 4). The Atlantic Ocean is not as greatly affected by this shifting of the tidal bulge, because it is smaller than the Pacific and has less water to be pulled outward, hence our tides (and western Europe's tides) remain *about* equal throughout the year. However, in the Pacific Ocean where there is much more water to be affected, the shifting of the bulge does cause a noticeable result and the west coast of our country experiences mixed tides (See Figure 5).

The sizes and shapes of bays and gulfs have a great effect on the tides of an area. For example, the Bay of Fundy, between New Brunswick and Nova Scotia, is fairly wide and deep at its mouth (87 miles wide and 280 feet deep) but gets shallower and narrower as one moves inland. Funnel shaped bays such as Fundy tend to increase the tidal range (tidal *range* is the difference in feet or inches between high and low tide). This occurs because the wide mouth allows a great deal of water to enter. This water gets squeezed as it moves up the bay, causing the energy in the tide to increase and making the high tide *very* high at the upper end of the bay. The tidal range in the Bay of Fundy is about 50 feet at its maximum. This means that you would have to have a 50 foot ladder going down off the side of your wharf in order to get to your boat at low tide. At high tide, the ladder would be completely under water. This funnel-effect also occurs in Maine's bays, though to a somewhat lesser effect, accounting for the fairly large tidal range along most of the coast of Maine. In other areas, like Great South Bay off Long Island, New York, the tidal range is very small (about 18"). This is because the bay is almost completely enclosed by islands. The only entrance for ocean water is through a few narrow inlets. These inlets let in so little water that over the entire bay, the tide rises and falls very little.

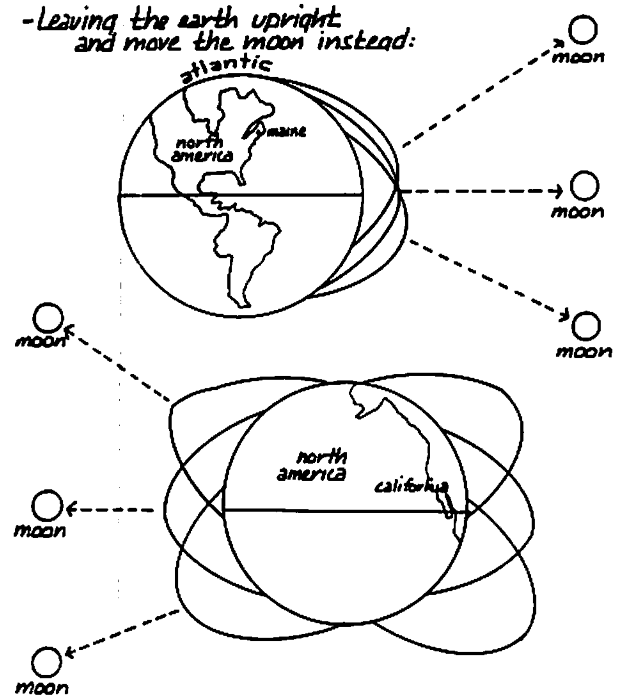


FIGURE 5

The shape and size of basins may also help determine why an area has diurnal tides rather than semidiurnal tides. The coast of Southeast Asia is on the western shore of the South China Sea. This sea is semi-enclosed, bordered to the south, east and northeast by Indonesia, the Philippines and Formosa, and mainland China. While there are openings between these island countries that allow water into the South China Sea, it is so restricted by land masses that it takes practically half a day for the high tide to reach the shores of Southeast Asia and the other half for it to receed to low tide. The situation is exactly the same in the Gulf of Mexico which is bordered by southern-central United States to the north, central America to the west, Florida to the east, and the Caribbean Islands to the south.

How do tides affect our lives here in northern New England? For the fisherman who must unload his catch by hand onto a wharf, it is much more convenient to arrive at high tide. Imagine coming into dock at low tide and having to hoist or carry buckets of fish up from the boat some eight or ten feet *below* the dock! To those fishermen who offload fish using the vacuum-chute apparatus (e.g., sardines) or via cranes, the time of the tide is less of a crucial factor. Obviously, the clam digger and worm harvester are entirely dependent on the tides. An important reason why soft clam and worm harvesting are such important industries in our area is because the large tidal range exposes such vast areas of flats. In other sections of the coast, where the tidal range is comparatively small, soft clams and worms are not harvested commercially, rather hard clams (Quahogs) and oysters, which are "dug" primarily by rakes from boats are more important.

The large tides in northern New England are also of historical significance. The coast of Maine is ideally suited to shipbuilding, not only because of the abundance of lumber, but also because huge ships, of over a hundred feet long, could be built and launched far up river away from the ravages of the open sea. Practically every little town along Maine's major rivers has a history of shipbuilding, and many of these are amazingly far upstream (eg. Cherryfield, Harrington, Thomaston, Wiscasset, Bath, Ellsworth, Bucksport). Indeed, the design and construction of vessels is affected by tidal ranges. Boats that will be left high and dry at low tide, only to be floated again on the high, must be able to withstand this stress. Boats with very deep keels will fall over on their sides when left stranded by the low tide and will be swamped by the return of the high!

The tide plays an important role even away from the shore. In some areas the tidal currents are so strong, that they seriously affect coastal navigation and the speed of the current must be taken into account when charting a course. The National Ocean Survey has prepared charts for certain heavily used boating areas that provide information on the speed and direction of the tidal currents. Using these charts, the mariner can quickly consider the effect of the tidal current on his desired course.

An important economic application of the energy contained in tides is the generation of electricity. In the past "tidal power" has been used successfully in this country to turn flour and lumbar mills and, at present, is being utilized abroad (eg. The Rance River in France) to produce electricity. This is an important issue in our area as two tidal power stations are under serious consideration for the Bay of Fundy and several others are proposed for the Cobscook-Passamaquoddy Bay region. This issue will be addressed further in Section III of this program.

These are but a few of the many ways that tides affect our daily lives here in northern New England. Take some time with your group to discuss further the importance of the tides.

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Background Information: Waves

Waves are surface water in motion. This motion is generated by either the wind or by geophysical pressures such as earthquakes under the ocean floor or along the coast. Wind generated waves are the most common type and occur when wind blowing over the surface of the water creates a frictional drag which causes the water to "hump up." The size of a wind wave depends upon several factors: (1) the speed of the wind; (2) the length of time the wind blows; and (3) the *fetch* or expanse of open water over which it blows. Storm waves may reach a height of fifty feet, caused be a wind velocity of 70 miles per hour blowing over a fetch of 500 miles. The highest wave on record was observed in the north Pacific by an officer aboard the U.S.S. *Ramapo*, who on February 7, 1933, measured the wave to be 112 feet high! This monstrosity had been caused by winds that were blowing between 60 and 80 knots over a fetch of several thousand miles.

The average wave consists of the following parts: (See Figure 6):

1. The *crest* of the wave is the highest point to which the water rises.
2. The *trough* of the wave is the lowest point to which the water falls.
3. The *height* of the wave is the distance between the crest and the trough.
4. The *wavelength* is the distance between successive crests.

Generally speaking, the wavelength of the average sea wave is between 20 to 30 times the wave height (i.e., a 5 foot wave is between 100 and 150 feet in length).

Another useful characteristic of waves to know is its *period*. The period is the time it takes for successive crests to pass a fixed point. In other words, if you watched a wave crest wash over a rock and then kept track of the time until the next wave crest washed over the same rock, the time intervening would be the period of the first wave. On the average, the period of most waves ranges between 2 and 10 seconds.

If you watched gulls or bottles or some other object floating in the water, you would notice that they more or less stay in one

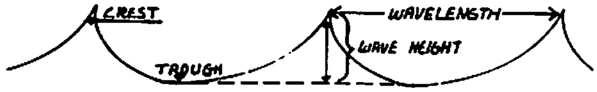


FIGURE 6

spot, moving up and down as the waves pass beneath them, but making very little progress forward or backward. The waves don't seem to push them along as might be expected. Why? This is because the wave form passes through the water without causing the water itself to move forward. Think about what happens when two people hold a rope, one on each end, and one person shakes the rope gently. A "wave" or ripple moves down the rope from the person who did the shaking towards the person who is holding the other end. However, the *entire rope* did not move toward that person. This is essentially what happens with waves in the water. Each molecule of water in a wave actually moves in a circular motion. The molecule moves forward in the circle as the crest passes it, and backward to complete the circle (it is rotating clockwise) as the trough passes. You might say at this point "But things *do* move on the surface of the ocean. Bottles with messages are carried to foreign lands! Aren't these things carried by waves?" The answer to this very good question is "No. They are carried by *currents*, not waves." Currents will be discussed later on. The circular motion of the water molecules decreases with depth to a point where it practically does not exist. This is why animals and other objects on the bottom are rarely disturbed by waves on the surface.

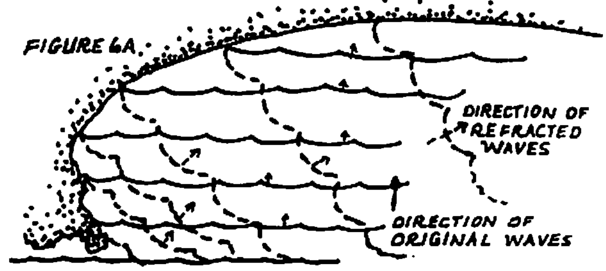
When the depth of the water becomes shallower, as over a bank or shoal, or nearing the coast, the trough of waves begins to "feel" the ocean bottom. This "feeling" of the bottom creates a frictional drag which tends to slow the trough of the wave down. The crest, however, continues at the speed it has been travelling and begins to move ahead of the trough. The crest becomes steeper and steeper and "peaks up" as it moves ahead of the slowing trough. The circular motion of the water molecules becomes distorted and eventually the wave crest becomes unstable and crashes headlong over itself. This actually happens when the depth is so shallow that not enough water is available to fill the growing crest. If you have ever watched breaking waves closely, you will notice a hollow beneath the foaming crest of the wave that forms just before the waves actually break. This is the "tunnel" that surfers ride in and is formed as water is "sucked" up into the crest. The breaking of waves is really a scientific occurrence. That is, it depends upon a very specific depth of water relative to the wave height. When the water depth is only slightly greater than the wave is high (precisely 1.3 times the wave height) the wave breaks. This means that waves that are 5 feet high will break in water that is about 6½ feet deep.

Ocean waves do other interesting things besides travel through the water and break upon coastlines. They also *reflect, refract* and *diffract*. When a wave encounters a vertical obstruction, it reflects back on itself with little loss of energy. This is an important concept to understand when one is considering constructing a breakwater. Breakwaters should be located in water that is too deep for breakers to form because very little energy will be expended upon it by nonbreaking, reflecting waves. Breaking waves on the other hand will likely demolish the breakwater in a relatively short time.

Diffraction occurs when a train of waves suddenly encounters a steep-sided island or other obstruction arising abruptly from the depths. As the waves pass the island, they diffract sideways into the "lee" or "shadow" of the island. Again, wave diffraction must be taken into account when constructing a breakwater because some of the wave energy will be refracted by the end of the breakwater into the so-called protected waters.

If these same waves had approached the island over a gently sloping underwater topography, the result would have been different than that described above, because of wave *refraction*. As mentioned, when a wave enters water shallow enough to "feel" the bottom, it is slowed down. The waves in the shallowest water (but not shallow enough to cause them to break) move the slowest. The wave front, which consists of several wave crests moving in a more or less horizontal line toward the shore is travelling over differing depths as it approaches the island. Thus, since the wave front is slowed down more by shallower water in one spot than at another spot not quite so shallow, the crests tend to bend, and the wave fronts tend to become roughly parallel to the underwater contours. Picture a straight line of people marching down a level street. Suddenly they encounter a part of the street where there are some small hills over which some of the people must march. The hills will slow these people down and the line is no longer straight as it moves down the street. Wave refraction acts in a similar way causing a once straight wave front to be bent until it almost parallels the shoreline. See Figure 6A The ultimate effect of refraction is to concentrate wave energy against projecting headlands (and breakwaters!). As the old sailor's saying expresses the situation, "The points draw the waves." Thus, over a long period of time wave refraction will wear away headlands eventually causing a straight shoreline to be built.

FIGURE 6A



Finally we should mention waves that are generated by earthquakes, underwater explosions, volcanic eruptions and landslides. These waves have long erroneously been called "tidal waves," although they have nothing to do with tides. The correct term for such waves is the Japanese word "tsunamis" (pronounced soo-ná-me). These waves are the "killer waves" of so many horror films, and destructive they are! However, this is true only when they strike the shore. While still at sea, they are barely perceptible. Generally speaking, they are very long and very low. The period of a tsunamis may be a thousand seconds, its wavelength as much as 150 miles, but its height, only a foot or two in *deep water*. It may move at a speed of 472 miles an hour!

It is when these waves move into shallow water that they become spectacular in the worst sense of the word. These extremely long, low and fast waves have been carrying enormous amounts of energy with them from the point of their generation, and this energy is unleashed upon shorelines. The tsunamis do all the things that other waves do, that is, reflect, refract, diffract and break, but since the energy contained in a tsunamis is so much greater than the "normal run-of-the-mill" wind wave, the effect of a tsunamis upon the shoreline is quite different indeed from that of the "normal" wave! For example:

August 13, 1868 — South Peru (now North Chile), USS *Wateree* carried a quarter mile inshore by a wave with a maximum height of seventy feet. Receding wave uncovered Bay of Iquique to a depth of twenty-four feet and then returned with a forty-foot wave, covering the city of Iquique.

June 15, 1896 — Northeast Japan. Sea waves nearly one hundred feet high at head of bay; elsewhere, ten to eighty feet. 27,000 lives lost along 320 kilometers of coast; 10,000 houses swept away.

March 16, 1926 — Palmerston Island, Cook Group. Island submerged and natives lost their means of sustenance.

November 21, 1927 — Chile, Aysen River region. Sea invaded land along twenty-five miles of coast. Boat *Mannesix* with crew flung into treetops of forest.

November 18, 1929 — Newfoundland, Burin Peninsula. A wave from the Grand Banks earthquake swept up several narrow inlets to a height of fifty feet, destroying villages and causing heavy loss.

Tsunamis are most common in the Pacific Ocean where a "tsunamis warning system" now exists. However, as noted above, in 1929, an earthquake on the Grand Banks caused a "tidal wave" in Newfoundland so we here on the east coast cannot be *too* complacent about tsunamis!

We have already discussed two of the many ways waves can affect humans: in the building of breakwaters, and the destructiveness of tsunamis. What are some other reasons why waves are important to us?

In a state such as Maine where a large number of people depend upon the sea for their livelihoods, consideration of waves cannot be taken lightly. Storm waves can be dangerous to those out on the water in small vessels as well as to those along the shore. Newspapers, magazines and news reports on the radio and television frequently tell about fishing boats and cruising yachts that were swamped, capsized or "pitch-poled"*, by storm waves, or of how piers, wharves and coastal dwellings suffered extensive damage from wild, rampaging waves. In this day and age of rapid communications, much of the loss of life due to storm waves can be averted, but property damage is inevitable and many fishermen and sailors continue to be killed by freak storms that escaped notice by even the most highly skilled of weather forecasters of today.

We cannot underestimate the destructive potential of ocean waves, but can waves also be used to our advantage? As we have mentioned, even "ordinary" sea waves contain large amounts of energy. Can this energy be captured in some way to be used in the generation of electricity? In Great Britain, research is being conducted as to the feasibility of such an idea. At the University of Edinburgh, Scotland, a system of large, free floating concrete generators has been designed, which employ moving vanes capable of capturing up to 90% of the energy available in sea waves. These devices could be used successfully in the North Sea where wave energy is very high. The gulf of Maine, especially in the area of the Grand Banks, has wave conditions very similar to the North Sea. Might not this "wave power" system someday be used to generate electricity for northern New England and the Canadian maritimes?

**pitch-poling occurs when a large wave comes up from behind a vessel, causing it to somersault "heels over head" so to speak (stem over bow) leaving the vessel upside down in the water.*

We have also learned that waves often proceed in particular patterns, especially around land. Anthropologists have found that ancient Polynesian and Micronesian sailors utilized wave patterns, notably *refracted* wave patterns, to navigate to various Pacific islands. Could it be possible that fishermen off the fogbound coast of northern New England used this same method to navigate to shore back in the days before radar, Loran and other electronic navigational aids?

Again, we have covered only a few ways that waves influence our lives here in northern New England. Take some time with your group to discuss this further.

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Background Information: Currents

Currents are horizontal water movements which are caused by a number of factors. Some currents are temporary and are caused by local wind and water conditions. Other currents are permanent features of the world's oceans and are the products of global atmospheric and oceanic states.

Currents can exist at all depths of the ocean: at the surface, midway between surface and bottom, and on the bottom. Surface currents have been studied extensively since the early 1800's and a wealth of information exists that describes these water movements. Surface currents are primarily caused by the wind, however this picture of "wind blowing over water, causing water to move," is actually more complicated than it sounds.

Let us start with a rotating sphere. This rotation, coupled with a pattern of rising and falling air causes wind patterns on earth. Air in the lower atmosphere that is in contact with the earth's surface is warmed by heat radiating from the earth. This air rises away from the earth's surface into the cooler upper atmosphere. Here the air is cooled and begins to fall back to earth whereupon entering the lower atmosphere it is again heated and begins to rise. This alternating rising and falling of the air creates regions of high air pressure (when air is sinking towards earth) and of low air pressure (when air is rising away from the earth). Areas in between tend to be regions of variable air pressure. Air tends to move in a counterclockwise direction around a high pressure zone and in a clockwise direction around a low pressure zone. This moving air gives rise to the familiar wind patterns on earth (the Trade Winds, the Prevailing Westerlies, the Polar Easterlies, etc. — see Figure 7), which in turn drive the major east-west currents (the North Equatorial Current, the South Equatorial Current, the North Atlantic Current, the West Wind Drift, etc. — see Figure 8).

The currents that flow north or south (the Antilles Current, the Gulf Stream, the Canary Current, the Brazil Current, and Benguela Current, etc.) are called "boundary currents" and are formed when the easterly or westerly flowing currents are obstructed by continental land masses and their flow is directed either northerly or southerly along the continental margins. The four currents together, one flowing from east to west, one flowing north, one flowing from west to east and a fourth flowing south form a circular system called a *gyre*. There are two gyres in the North Atlantic: the Northern Subtropical Gyre

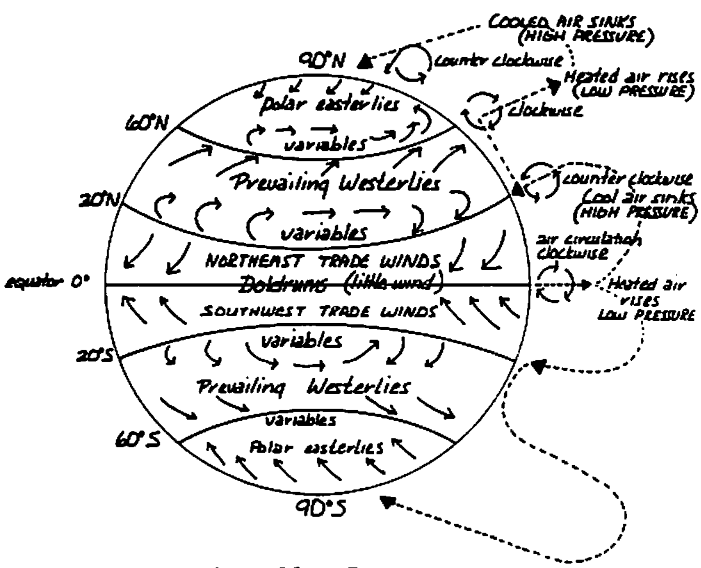

FIGURE 7

and the Northern Subpolar Gyre. In the South Atlantic, there is only one gyre: the Southern Subtropical Gyre. There is no Southern Subpolar Gyre because there are no large land masses south of the southern tips of South America, Australia, and Africa, that would obstruct the flow of the West Wind and East Wind Drifts. The East Wind Drift flows eastward *around* the Antarctic Continent and the West Wind Drift flows westward between the East Wind Drift and the continents of South America, Australia and Africa.

These currents are more or less permanent features of the world oceans. From time to time, one or another of these currents may shift position for reasons that are not clearly understood. For example, on rare occasion, the Gulf Stream sometimes extends farther north than usual, reaching into the Georges Bank, bringing warm water with it and disrupting the

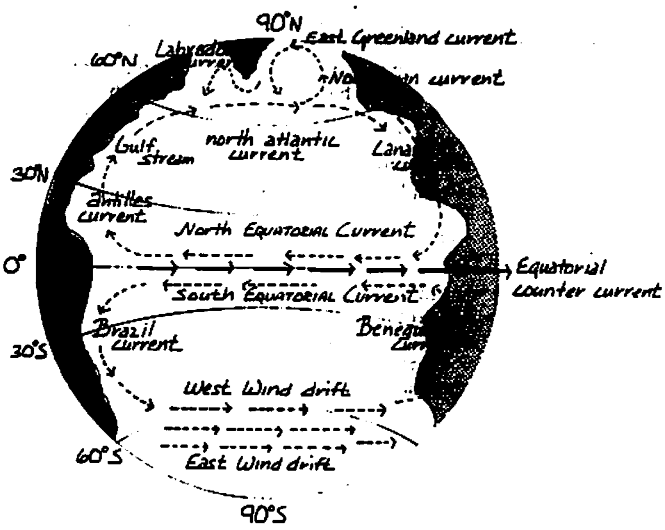

FIGURE 8

cold water fisheries located there. Likewise, in the southern hemisphere the flow of the Peru current is disrupted every few years, with disastrous results. The Peru Current is a cold current and essentially acts as a boundary against the warmer waters to the north of it. However, every now and then, a tongue of higher temperature water extends farther south than normal into the region where the Peru Current usually flows. This influx of warmer water wreaks havoc on the anchovy fishery there as well as causing heavy rainfalls which damage the nearby landbased guano harvesting areas. This event usually occurs around Christmas time every few years and is thus called "El Nino," The Child. Again, the reasons for the occurence of "El Nino" are only theorized.

Surface currents are not restricted to the surface film of the ocean that interfaces the atmosphere. Actually, surface currents extend to depths of 300 to 650 feet (100 or 200 meters). The open ocean east-west currents such as the North and South Equatorial Currents travel at speeds of 2 to 4 miles per day (3 to 6 kilometers per day), while the north-south flowing currents along the western boundaries of gyres (e.g., the Gulf Stream, the Kuroshio Current) move much faster, at speeds of between 25 to 75 miles per day (40 and 120 km/day), and extend to depths of 3,300 ft. (1,000 meters) or more.

The Gulf Stream, an important current off our coast, is often erroneously thought of as a stream of hot water flowing through surrounding colder waters. Actually it is the boundary between the warm Sargasso Sea, which is located in the Atlantic approximately midway between Florida and the northwest coast of Africa, and the colder waters to the north. It just happens to be moving faster than either the waters of the Sargasso Sea or the colder northern waters and thus appears to be a separate body of water akin to a river, but it really should not be thought of as such. The Gulf Stream is important in that it carries warm water into the North Atlantic. The waters of the Gulf Stream do not remain long enough in temperate climates to become influenced by the local temperature conditions as do the slower east-west flowing currents. The Gulf Stream waters pretty much maintain the temperatures they had at their origin and they carry these temperatures up into the North Atlantic to just south of the Grand Banks where the "Stream" becomes the North Atlantic Current. The climate of land areas that border the route of the Gulf Stream is moderated quite markedly. It is the influence of the Gulf Stream waters that explains why Great Britain, which lies on approximately the same latitude as Labrador has much milder weather than Labrador which has the cold Labrador Current flowing down from the north along its shores. In the northern New England area, the Gulf Stream has very little effect upon the climate because it flows south of the seaward edge of the Gulf of Maine. By and large, the Gulf of Maine, marks the beginning of the cold northern water masses which are so effectively separated by the "Stream" from the more moderate waters of central and southern New England. Indeed, this fact is very important to the fisheries of the region as cold water is more biologically productive than warm water. (This will be discussed further in a later sub-section). The most important fisheries of the world (e.g., the Gulf of Maine, the west coasts of North and South America, etc.) are primarily located in regions of cold water.

We have spent quite a bit of time here discussing surface currents and their corresponding causes, the prevailing winds. Before moving on to other kinds of currents, it should be mentioned that surface currents do *not* flow in exactly the same direction as the winds that cause them. Actually, the water is deflected to the right of the direction of the wind in the northern hemisphere and to the left of the wind in the southern hemisphere. This occurrence is caused by the rotation of the earth towards the east and is called the *Coriolis effect* (pronounced Core-o-lis). The magnitude or size of the effect varies over the earth's surface because as one moves away from the equator towards the poles, the speed of rotation of any point on the surface *decreases*. Think of a circular race track with five race cars on it. The car nearest the inside of the circle does not need to travel as fast as the car on the outside of the circle because it actually has less distance to go in order to complete one trip around the track. Because the earth is a circle in three dimensions, a similar situation exists. A person walking around the earth at the equator where the earth's circumference is greater, would have to travel *faster* than a person walking around the earth at the poles, where the circumference is smallest in order for both people to return back to their starting points at the same time. Thus, the earth needs to rotate faster at its equator than at its poles in order for all points on it to complete one rotation all at the same time! Thus, a parcel of water travelling eastward along the equator is moving at the same speed as the earth's rotation (about 1,050 mph or 1,670 km/hour). If this parcel were to travel north, it is also moving eastward, with the rotation of the earth. However, it tends to move eastward *at the same speed* it had at the equator (which was also the same speed as the earth's rotation *at the equator*. As one moves away from the equator, any point on the earth's surface is rotating slower than any point on the equator. For example, the city of New Orleans which lies 30°N latitude is rotating at 935 mph (1450 km/hr). Thus a parcel of water in the ocean that has travelled from the equator to a latitude of 30°N is moving eastward at a speed of 1,050 mph while the surface of the earth at that point is moving eastward at 935 mph. Clearly, the parcel will be moved to the east of its intended northward path (see Figure 9). Thus, the earth's ocean waters (and objects on the surface of the ocean) will be deflected by the Coriolis Effect *away* from a north or south path. Objects on land, like you in your car travelling north or south, are not affected by the Coriolis because they are being carried along at the same speed as the earth's rotation at that point. This is due to the fact that

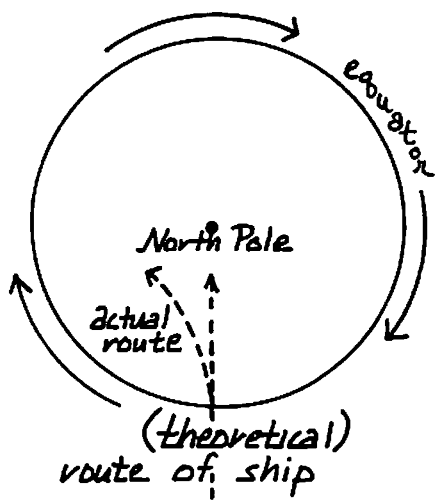

FIGURE 9

land is rigid and does not "flow" the way water does. The Coriolis Effect then plays its most important role in influencing the movements of large bodies of flowing water.*

How do ocean currents affect the lives of northern New Englanders? We have already discussed the importance of cold currents to the fisheries of an area and how the intrusion of a warm current into a cold water area can bring disastrous consequences. Another influence comes about as the result of the speed and direction of the major ocean currents. Major travel lanes for wind and fossil fuel powered vessels alike generally take advantage of favorable winds *and* ocean currents. It is much more difficult to travel from the United States to Europe via a mid Atlantic route, say from the Caribbean to Africa where both the winds and ocean currents flow *from east to west*, i.e., *against* the traveller all the way, causing the petroleum powered ship to burn more fuel and the sailing vessel to be sailing into the wind. The north Atlantic route, on the other hand (while presenting an increased risk of icebergs, to be sure), takes advantage of the prevailing westerly winds (blowing *from* the west towards the east) and the easterly flow of the North Atlantic Current (the extension of the Gulf Stream in the north Atlantic) which is moving at speeds between one half and one knot an hour (approximately one half to one mile an hour). While this does not seem like a great deal, it makes a difference when one is travelling for many days or weeks, being helped along by the current's flow. Looking at Figure 8 can you guess where the best route for a return trip from Europe to the United States might be located?

Thus far, we have been discussing *open ocean* currents. What about the currents in near shore bodies of water such as the Gulf of Maine, the Gulf of Mexico, the Mediterranean Sea, the Red Sea, the Caribbean Sea, etc. In these areas, the current configurations become much more complicated due to the influence of the nearby land masses. In the Gulf of Maine, the surface currents tend to flow in a counterclockwise direction (just opposite to the flow of the open ocean currents in the Northern Hemisphere). This flow is most pronounced in the spring but becomes weak and diffuse in the fall. The outer edge of the Gulf of Maine gyre flows at rates of up to about 7 miles per day (13 km/day). It takes a parcel of water about 3 months to complete a trip around the gyre. (See Figure 10)

Four factors appear to account for the counterclockwise circulation:

1. 35,310,000,000 cubic feet of freshwater (35+ billion), from major rivers enter the Gulf. This abundance of near-shore water flows downhill due to gravity. The Coriolis Effect causes this downhill flow of water to swing to the right (south-westward along Maine coast).
2. The strong tides within the partially enclosed basin of the Gulf and the rotation of the earth results in a counterclockwise direction of the currents.
3. The St. Lawrence River adds an immense quality of cold, low salinity water in the northern part of the Gulf, which strengthens the counterclockwise circulation.
4. Deep water flowing along the continental shelf off Nova Scotia meets the Northeast Channel. Due to the Coriolis Effect, the flow is deflected to the right or northwestward into the Gulf.

The Gulf of Maine is not affected much by either the Gulf Stream or the Labrador Current. The Gulf Stream flows south of the Gulf of Maine some 200 miles (360 km) away from the seaward rim of the Gulf. The "Stream" is more or less barred from entering the Gulf by the shallowness of the Georges Bank, by the westward-flowing water on the south edge of Georges Banks, and by the density differences between the Gulf Stream waters and Gulf of Maine waters.

The Labrador Current is even more removed from the Gulf of Maine being separated by Nova Scotia, Newfoundland and the Grand Banks. Occasionally however, cool waters off the coast of Labrador mix with waters of the Scotian shelf (off Nova Scotia) and enter the bottom of the Gulf through the Northeast Channel.

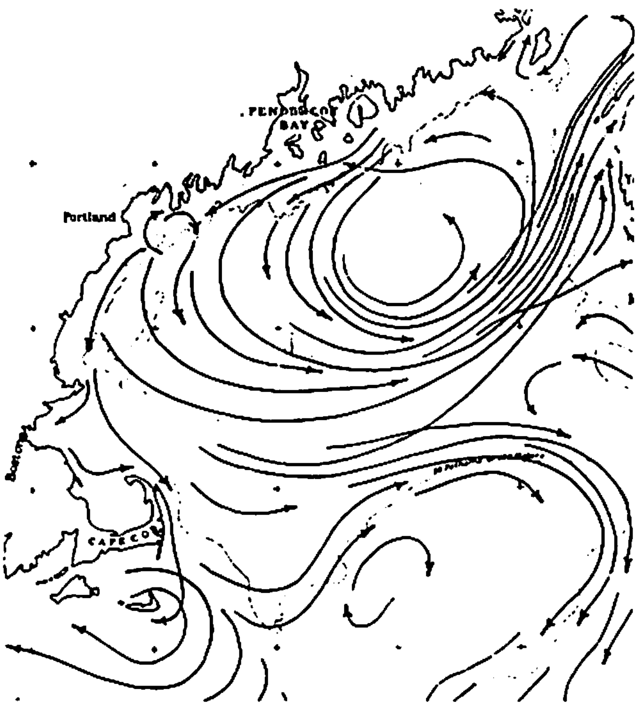

FIGURE 10

What does all this mean to shore dwellers of the Gulf of Maine? If you examine Figure 10, you will readily see that the currents *along shore*, flow primarily from eastern Maine (Lubec) southward to Cape Cod. The *offshore* current flow is basically northeastward to Nova Scotia where the flow splits, with some water continuing northward into the Bay of Fundy and the rest completing the circle and swinging back southwesterly. This means that as the rocky headlands of eastern Maine (e.g. East and West Quoddy Head, etc.) are eroded by wave action, the sediment is caught up in the circulation pattern and is transported southward where much is deposited along the southern sandy beaches of Maine, New Hampshire and Massachusetts. Were the circulation pattern reversed, eastern Maine would be receiving sediments eroded from the beaches of Ogunquit, Wells, Hampton, N.H., Cape Cod, etc.!

Not only sediments are carried southward along the Maine coast. Most of us are aware of the proposal of the Pittston Company to build an oil refinery at Eastport. A major oil spill in that area would end up affecting the *entire* coast of Maine (and probably, to some extent, also New Hampshire and Massachusetts) thanks to the dominant current pattern in the Gulf of Maine. Thus, the prevailing currents of an area should be important considerations in discussions about onshore industrial development.

Finally, it should be mentioned that ocean currents contain enormous amounts of energy. Recent research into the feasibility of harnessing some of this energy for use by humans indicates that it can be done with a minimum of adverse environmental impacts. Huge turbines could be moored well below the surface of the ocean in areas of fast moving currents and the resulting electricity generated within these turbines could be transported to shore. Already two separate research groups have experienced with different designs for turbines. The areas most suited to the production of electricity by ocean

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**footnote: The Coriolis Effect also influences the flow of water beneath the surface which is contained in the surface current. (Recall that a surface current can extend to depths of more than 3,000 ft.) Water tends to move more or less in layers. Thus the layer right at the very surface is deflected by Coriolis from the direction of the wind. The layer just beneath the surface layer is deflected from the layer just above it. This deflection continues down to the very base of the current where the bottom is actually moving in a direction directly opposite to that of the top layer. (See Figure 9.)*

current "power plants" are those where fast moving currents pass fairly close to shore, notable, the Gulf Stream off Miami, Florida, the Kuroshio Current off Japan, the Benguela Current off the west coast of Africa, and the Peru or Humboldt Current off Peru. However, this is not to say that other areas of the world could not become potential receivers of ocean current energy, once the "bugs" in this presently experimental system are all worked out. Ocean currents, then, present another source of renewable energy, which could possibly be developed as our nonrenewable sources (oil, gas, coal, etc.) continue to dwindle.

These are just a few important influences that currents have upon our lives in northern New England. Take some time with your group to discuss some other ways in which ocean currents affect the lives of people living in coastal states.

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Background Information: Chemical Composition of Seawater

Of all the substances found in seawater, the most common is H_2O: water. Water makes up nearly 97% of the entire composition of seawater. Other substances, generally referred to as "salt" only make up between 3.3% and 3.8%.

Water is a material unique to our planet so far as we presently know. It has some very important properties: (1) it can exist in three states, liquid, solid (ice), and gas (water vapor or steam) and all three of these states can be found simultaneously in nature; (2) its molecules, which consist of one atom of oxygen and two atoms of hydrogen are aligned in such a way as to hold a strong attraction for each other. It is this strong attraction that enables insects to walk upon its surface and permits one to float a needle atop a glass of it; (3) it is *less dense* when in its solid state which occurs at 0°C, than at a certain higher temperature (4°C). This is the reason that ice floats on the surface of lakes and ponds enabling creatures to live through the winter in the liquid water below; and (4) it is practically a universal solvent, dissolving more substances than just about any other solvent. It is this fourth property that accounts for *seawater* being "salty." It contains, in solution, most of the solid and gaseous elements found on the land (See Table I).

How do these elements get into seawater? Rivers and streams erode away rocks that line their bottoms and banks and carry these substances, in very small amounts per river, to the sea. Rain also dissolves minerals from the earth's surface and washes them into the rivers and streams. All the many rivers of the world that empty into the oceans contribute their share to the total element or "salt" content of the sea.

In Table I, we have divided the components of seawater into four groups: *major* constituents, *minor* constituents, *trace* constituents, and dissolved gases. The major constituents, which we see from Table I, are chlorine (as chloride), sodium, sulfur (as sulfate), magnesium, calcium, potassium, carbon-oxygen-hydrogen (as bicarbonate), bromine (as bromide). (Oxygen and hydrogen will be considered to be constitutents of *sea salt* only as they contribute to the makeup of bicarbonate (HCO_3); they are important components of *water*, H_2O.) These major constituents exist in more or less constant proportions throughout the world's oceans. The salinity of the oceans ranges between 33 parts or grams salt per 1000 parts or kilograms seawater (written 33 0/00) and 38 0/00 (read as 38 parts per thousand) with the average being 35 0/00. This range is very small, so it can be reasonably concluded that the relative amounts of the major components vary very little from place to place.

This is not necessarily true of the *trace* elements nor of the substances associated with living things. (Called "nutrient elements," these include carbon, oxygen, nitrogen, phosphorus, manganese, iron, cobalt, copper, zinc, silicon, and boron.) The nutrient elements vary in concentration from place to place depending on the amount of sea life, both plant and animal, in different locations. Most sea life is concentrated in the top hundred meters of the open ocean and from this part of the water column (area of water from surface to bottom), the nutrient elements are taken from the water and utilized by plants for growth. The plants are eaten by small sea animals, the small sea animals are eaten by larger sea animals and so on. This process is called a *food chain* or *food web* and will be explained in greater detail in a later subsection. Most of the food chain exists in the upper layers of the ocean, however, part of it takes place in the depths as excreted material and dead organisms sink to the bottom. Here deep sea scavengers consume some of this organic material, but mostly it is attacked by decay bacteria who break down the large organic compounds back into nutrient elements. Thus, this process causes the surface waters to lose their nutrient elements and the bottom waters to become enriched with these substances. The nutrient elements must be returned to the surface in order for life to continue there and this occurs in varying degrees throughout the oceans. Basically, nutrients can be returned to the surface waters from the depths by three processes: (1) convection, which occurs when surface waters are cooled in the autumn and sink, being replaced by warmer waters below. This process helps return nutrients to the surface in shallower areas; (2) tidal turbulence: in areas where tides are large, mixing of the bottom and upper waters takes place; (3) upwelling, which is the most important process in the transfer of nutrients from the depths to the surface. This occurs most commonly along the west coasts of North and South America and along the Equator in the open ocean. Along the coast, upwelling occurs when the wind tends to blow parallel to the shore causing the surface waters to be moved away from the shore. This water is replaced by subsurface water which brings with it nutrients from the depths. Along the Equator, upwelling is caused by the change in direction of the Coriolis effect. Recall that the Coriolis effect causes water currents to be deflected to the right in the northern hemisphere and to the left in the southern hemisphere. At the Equator, surface water that is virtually "parting" away from the Equator is replaced by water from below bringing nutrients with it. In areas of upwelling, sea life is very abundant. This explains why fishing is such an important industry along the west coast of Canada, United States and South America.

In the Gulf of Maine, there are two important areas of upwelling where marine life is abundant: off the southwestern coast of Nova Scotia from Cape Sable Island to Yarmouth, the wind blows parallel to the shore and causes the surface water to flow northward. The inshore flow of the bottom waters thus greatly enriches this area with nutrients. Also, there is a pronounced band of upwelled water stretching from Grand Manan Island southwesterly to just beyond Schoodic Point. Both of these areas are characterized not only by enriched surface waters, but also be cooler summer temperatures than the surrounding waters.

Of course the two largest rich fishing areas off of our coast are the Grand Banks which lies southeast of Newfoundland and Georges Bank, located along the southeastern boundary of the Gulf of Maine. These and other banks are extremely shallow compared with surrounding waters and nutrients lying on the bottom are easily made available to the surface waters by convection, tidal and wave turbulence.

The presence of "salts" in ocean water causes some of the physical characteristics of seawater to be very different from fresh water. For example, salt water freezes at much lower temperatures than fresh water. Recall that fresh water freezes at 0°C. (32°F.), but it is *most dense* at 4°C. (about 38°F.). Salt water, at salinities greater than 28 0/00, on the other hand, begins to freeze at the same temperatures at which it is also most dense. (Salt water of a salinity of 28 0/00 is most dense *and* begins to freeze at -1.3°C. or -29.7°F.) At this point, you are no doubt tempted to ask: "Why does ice in the sea float? If seawater is actually its *most dense* when it begins to freeze, then sea-ice should *sink*!" This indeed would be the case if sea-ice water were made of *saltwater*. In actuality, what happens is that *freshwater* is frozen right out of the seawater, leaving the salts behind in the surrounding ocean water. Thus, seawater cannot freeze solid, except under conditions of continuous extreme cold. Fresh water *will* freeze at 0°C, which is why we can make ice cubes in our freezer and why shallow puddles are completely turned to ice after a few nights 0°C. Freezing seawater on the other hand causes fresh water to be removed as ice, but leaves an increasingly saltier and saltier brine behind. Of course it requires even colder temperatures to freeze the remaining brine. Thus it is exceedingly unlikely that the oceans would *ever* freeze solid.

Gases dissolved in seawater are an important aspect of marine chemistry (see Table I). These gases enter the oceans at the interface between the sea and the atmosphere. Turbulence created by wind and waves at this interface aids the dissolving of the gases by the water. Thus the water at the surface of the ocean tends to be *saturated* with atmospheric gases which means that it holds as much of the gases that it can hold, and that the amount of gas entering the water equals the amount leaving during the same period of time. The total amount of gas that can be dissolved in the surface seawater (i.e., the saturation point) is determined by the temperature and salinity of the water. In general, increased temperature and/or increased salinity *reduces* the amount of gas that can be held by a parcel of water at the surface. Colder waters and/or less saline waters can be held by a parcel of water at the surface. Colder waters and/or less saline waters can contain *more* dissolved gases. (Of these two factors, temperature is more important.) This chemical characteristic has important implications for life in the sea. Because colder and/or less salty water can contain more gases, such water is also going to be able to support more sea life. Plants need carbon dioxide in order to photosynthesize (produce their own food) and animals need oxygen to "breathe" (animals in the sea extract oxygen from the water through their gills or skin). Thus colder waters and less salty waters are going to be richer in sea life. This explains why the world's greatest fishing areas are located in cold climates or areas influenced by cold currents.

There is one important exception to the above rule and that is that *cold, bottom* waters tend to be oxygen poor and carbon dioxide rich. This is because little plant life exists at great depths because of the lack of sunlight (also needed for photosynthesis) and oxygen is not being produced. Instead, any animal life which exists beyond the depths to which plants usually extend, uses up the available oxygen. This explains why the bottom waters of very deep areas are practically devoid of animal life. What types of animals that do live on the bottom of deep water areas generally are slow moving or attached and do not have large oxygen requirements.

Carbon dioxide entering the surface waters from the atmosphere plays an important role in what is called the "seawater buffer system." Carbon dioxide gas enters the water and is dissolved to form an acid (carbonic acid). This acid is fairly unstable and breaks down to form bicarbonate (HCO_3) and carbonate (CO_3). This series of reactions that make up the buffering system help regulate the acid-base balance of the oceans. Acids (like vinegar, acetic acid; orange juice — citric acid; carbonic acid, sulfuric acid, nitric acid, etc.) and their "opposites," called bases (for example, ammonia, and baking soda are common bases) can be measured by a scale called a pH scale. A pH value of 1-6 indicates that a substance is an acid (the *lower* the number, the *stronger* the acid). A pH value of 7 indicates that the substance is neutral (neither acid or base) and a pH value of 8-14 indicates the substance is a base (the *higher* the number, the *stronger* the base). Ocean water is normally slightly basic (pH = 8) and the reactions of the buffering system help keep it that way. What this means is that fairly large amounts of carbon dioxide can enter the ocean waters without making much of a change in the acid-base balance (the pH) of the ocean. If it were not for the series of reactions discussed above, which comprise the "buffer system," the amount of carbon dioxide that normally enters the oceans would make the ocean water increasingly more acidic and eventually unfit for sealife. In addition, this carbon dioxide "buffer system" helps to neutralize other acids that enter the marine environment. Thus, "acid rain" and snow have less of a devastating effect on saltwater environments than on fresh water environments thanks to the buffer system present in ocean waters.

Within the Gulf of Maine, there are several factors at work which affect the salinity of surface waters: ice formation, and evaporation, which raise salinities by removing fresh water, and tend to occur in winter and summer, respectively, and atmospheric precipitation, river and stream run-off, and melting ice, which tend to lower salinities by diluting Gulf waters with fresh water and occur in spring and fall. Also of great importance is the degree to which the surface waters are mixed with deeper waters. As mentioned, in the spring and early summer surface waters in the southern part of the Gulf are diluted by great fresh water run-off from the land. The surface waters here also tend to be warm at this time of year and because the deeper waters are colder, a stable *thermocline* is established across which only minimal mixing occurs. The thermocline is an area of the ocean that occurs generally between the depths of about 100 meters and 1500 meters in which the temperature decreases steadily from the warm surface value (usually around 25°C) to the colder deeper value (about 3°C). The thermocline is usually formed in late spring when the upper waters of the Gulf are warmed by the increased intensity of the sun's rays while the deeper waters, beyond the reach of the sun's warmth, remain cold. The area in between where the temperature drops sharply is the thermocline. Thus, in summer, nutrients are not brought up to the surface from depths in the southwestern Gulf of Maine (Cape Elizabeth, Maine to Cape Ann, Massachusetts) and this area tends to have the warmest and the least salty surface waters in the Gulf. The northeastern section of the Gulf near Nova Scotia, on the other hand, is basically unstable and the thermocline is only poorly formed, thus mixing from the depths takes place. Here surface waters are cooler in summer, having been chilled to a greater extent in winter than more southerly Gulf waters. In addition, this area receives an injection of somewhat warmer, salty *deep* water through the Northeast Channel near Nova Scotia. These two factors combined create a situation where the difference in temperature between the surface waters and deeper waters is not as great as in more southerly waters and more mixing between surface and depth can occur. Because of this mixing, these waters are the saltiest parts of the Gulf. In general then, we find saltiness increasing in the Gulf as we move northeastward.

A word should be mentioned about estuaries. Estuaries are areas where the fresh water of rivers meets and mixes with the salt water of the oceans. Here we find a rather wide range of salinities ranging from very low (10 o/oo) near the head of the estuary to much higher (20 o/oo) at its mouth. Organisms living in an estuary must be able to tolerate this wide range of salinities and are termed *euryhaline* (eury = wide or broad; haline = salt). As the river flows out to the sea, the less dense fresh water flows over the heavier salt water, creating a "wedge" effect. This wedge can be very stable or can be broken up by mixing, especially in areas where tides are great. Nevertheless, the wedge, combined with the decreased flow of the water as the narrow river meets the wide sea, causes the river to deposit its sediments all across the bottom of the estuary. These sediments are composed of all the essential elements needed for biological activity and in estuaries where tidal mixing brings these substances to the surface, conditions are very rich indeed for plant and animal life. Estuaries also tend to be shallow and therefore receive light and heat almost to their bottoms which further enhances productivy. In addition, it has been found that estuarine bacteria produce important substances like Vitamin B_{12} which further enrich conditions for life.

What importance is the chemistry of Gulf of Maine waters to us as citizens of northern New England? As we have seen, the chemical composition of seawater largely determines what kinds of plants and animals live in it. Most organisms normally found in fresh water cannot survive in salt water and vice versa (although there *are* notable exceptions). And within the marine environment itself, the amount of "salt" in the waters of different areas plays a major role in what lives there. For example, some creatures like the various snails, small fishes like mummichogs and many crabs can withstand a wide variety of salinities, while others, like the oyster, can exist only within a very small range.

The amounts of the "nutrient elements" in seawater is a very important factor determining how much and what kinds of sea life exists where. We mentioned that areas within the Gulf of Maine where *up-welling* occurs, bringing nutrients from the bottom to surface waters, are richer in marine life than other areas. On the other hand, *too many* nutrients can have an adverse affect on the marine ecosystem, creating a system called "eutrophication." When rivers draining farm lands or pass cities that discharge domestic sewage, encounter the sea, they contain high amounts of agricultural fertilizers and organic material. These fertilizers encourage the growth of plant life in estuaries and sometimes cause blooms where plant life becomes so prevalent that it literally "chokes out" any animal life in the area. This happens when the excess plant life dies and is decomposed by decay bacteria. The bacteria require large amounts of dissolved oxygen so, hence, the area becomes oxygen deficient and cannot support other animal life.

Finally, as we have alluded above, the amounts of dissolved gases, particularly oxygen, in seawater, is crucial to the existence of marine life. In addition, the seawater buffer system, created by certain chemical reactions involving dissolved carbon dioxide, helps maintain the proper pH or acid level of the oceans.

It is crucial that we understand something about the chemistry of seawater and its importance to life in the sea *and* on land. Daily, chemical and radioactive substances, human and animal wastes and other materials are dumped, intentionally and unintentionally, into our marine environment. What the impact is on the marine ecosystem and what the ultimate effect will be on us as citizens of northern New England is, at present, largely unknown. Two things appear likely, however: one is that continued alterations to the chemical balance of our coastal environment will probably have negative, rather than positive, consequences and, two, the voters of northern New England can and should play a role in the decision making process regarding our marine resources, but they must first be informed.

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TABLE I
Elements in Seawater

Major constituents (more than 20 grams of the constituent per *ton* of seawater)

Constituent	*Chemical Symbol*
Chlorine	(as chloride, C1-)
Sodium	(Na)
Sulfur	(as sulfate, SO_4=)
Magnesium	(Mg)
Calcium	(Ca)
Potassium	(K)
Carbon	(as bicarbonate, HCO_3-)
Bromine	—as bromide, Br-)
Hydrogen	(as bicarbonate, HCO_3-, as a component of water, H_20, and as a dissolved gas)
Oxygen	(as a bicarbonate, HCO_3-, as a component of water, H_20, and as a dissolved gas)

Minor constituents (between 1 gram and 20 grams of the constituent per *ton* of seawater)

Constituent	*Chemical Symbol*
Strontium	(Sr) — is sometimes considered a *major* constituent
Boron	(B) — is sometimes considered a *major* constituent
Fluorine	(as fluoride, F-) — is sometimes considered a *major* constitutent
Silicon	(Si) — is sometimes considered a *trace* constituent

Dissolved gases (in part)

Gas	*Chemical Symbol*	*Gas*	*Chemical Symbol*
Nitrogen	(N)	Krypton	(Kr)
Helium	(He)	Xenon	(Xe)
Argon	(Ar)	Radon	(Rn)

Trace constituent (less than 1 gram constituent per *ton* of seawater)

Constituent	*Chemical Symbol*	*Constituent*	*Chemical Symbol*
Lithium	(Li)	Indium	(In)
Beryllium	(Be)	Tin	(Sn)
Rubidium	(Rb)	Antimony	(Sb)
Cesium	(Cs)	Iodine	(I)
Barium	(Ba)	Tungsten	(W)
Radium	(Ra)	Gold	(Au)
Scandium	(Sc)	Mercury	(Hg)
Yttrium	(Y)	Thallium	T1
Titanium	(Ti)	Lead	(Pb)
Vanadium	(V)	Bismuth	(Bi)
Chromium	(Cr)	Lanthanum	(La)
Manganese	(Mn)	Cerium	(Ce)
Iron	(Fe)	Praseodymium	(Pr)
Cobalt	(Co)	Neodymium	(Nd)
Nickel	(Ni)	Samarium	(Sm)
Copper	(Cu)	Europium	(Eu)
Zinc	(Zn)	Gadolimium	(Gd)
Gallium	(Ga)	Dysprosium	(Dy)
Germanium	(Ge)	Holmium	(Ho)
Arsenic	(As)	Erbium	(Er)
Selenium	(Se)	Thulium	(Tm)
Aluminum	(Al)	Ytterbium	(Yb)
Phosphorus (as phosphate)	(PO_4)	Lutetium	(Lu)
		Thorium	(Th)
Niobium	(Nb)	Protactinium	(Pa)
Molybdenum	(Mo)	Uranium	(U)
Silver	(Ag)		
Cadmium	(Cd)		

Background Information: Movement of Materials

Sediments, the fragments of rocks and minerals eroded from the earth's surface, are carried about by a variety of agents: moving water, air, organisms, ice, or some combination of these. Looking at these four agents individually, moving water transports much more material, volume-wise, than any of the other three. Moving water can move sediments in several ways: it can carry them along in suspension (that is, the tiny rock and mineral fragments are held, suspended somewhere between the surface and the bottom of the water column and are moved along with the flow of the water); it can roll larger sediments, stones, rocks and even sometimes boulders along the bottoms of rivers and streams. In addition, water can dissolve many minerals and carry them along in solution. These materials that are carried along, dissolved in water, can come out of solution (or be precipitated) when the water changes temperature and becomes colder or when the water simply cannot hold any more and has become saturated. To observe this, try dissolving sugar in a glass of water. How much sugar can you add before the water in the glass fails to dissolve any more?

For now, we will consider only the movement of sediments in water by suspension or by rolling along the bottom. Substances that are dissolved in water are discussed in the background information on the chemical composition of seawater.

Generally speaking, sediments can be classified by size into several categories: clay-sized, silt-sized, sand-sized, gravel-sized, pebbles, cobbles, stones, rocks, boulders. Which sized sediment do you suppose would be the easiest to transport in suspension? Clay-sized sediments are so small that even a very slowly moving river can move these particles in suspension. The ability of a river or stream to move sediments in suspension, then, depends on two basic factors: the velocity of the flow of the river or stream, and the size of the particles. The faster the river or stream flows, the larger the particle it will be able to move.

As sediments are moved along in suspension in the water of a river or stream, they are also acted upon by gravity which causes them to be pulled down toward the bottom of the river or stream. How quickly they respond to this pull, and settle out of the water column onto the bottom also depends basically on the particle size, and on the velocity of the flow of the river or stream. Suppose the fast flowing river enters an estuary or bay which is flowing very slowly. The result is similar to a person jogging on flat ground suddenly coming upon a hill up which he must run. The person will be slowed down (unless he increases his effort) but not stopped. Thus, the river will also be slowed down upon meeting the estuary. What happens to the sediments carried by this river as it flows into the estuary? They will tend to settle out onto the bottom in a sequence dictated by their size. In other words, the larger particles will settle out faster than the smaller particles. This occurrence can be explained mathematically by *Stoke's Law*, which says that round particles of the same velocity, but of different sizes, which are falling through a fluid will fall at a velocity which is proportional to the square of the radius of the particle (i.e., the larger the particle, the faster it falls!). This law has some exceptions, but is generally true for all sizes of sediments.

So, what does all this mean to the Gulf of Maine? Several major rivers empty into the Gulf: the Merrimack, Androscoggin, Kennebec, Penobscot, and St. John. These rivers not only bring a great deal of fresh water (250 billion gallons per year) into the Gulf, but also carry sediments which are very gradually covering the Gulf's glacial topography. Sediments that do not settle out upon reaching the Gulf, or ones that are eroded off headlands by wave action are transported about within the Gulf by currents. As was discussed in the background information on currents, the surface circulation in the Gulf is in a counter-clockwise direction. Thus, materials eroded from headlands in eastern Maine are carried southward. At the southern edge of the circulating Gulf gyre, these sediments are deposited in the shallower inshore waters late in the summer when the currents weaken. This deposition of sediments, particularly sand particles, is responsible for the construction of the sandy beaches, barrier islands, capes and spits which are commonly found in the southern portions of the Gulf (Portland to Cape Cod). A sandy beach, such as Old Orchard Beach or Popham Beach might conceivably contain sediments eroded from East Quoddy Head, carried by the surface currents southward and subsequently deposited. By the same token, these sandy southern beaches are themselves eroded by winter storm waves, some of their sandy sediments carried off in the process and added to the circling Gulf gyre. Because of the erosion of wave action and the subsequent movement of the sediments by currents, sandy beaches, spits and islands are constantly in a state of flux; sand comes and goes and these areas are forever changing. Efforts to control this movement of sand within these unstable areas have largely been fruitless since these efforts seek to interfere with the natural balance established by the waves, and currents.

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Background information: Beach Dynamics

Thus far in Section I, we have discussed the physical processes of tides, waves and currents and the geologic process of sediment transport as these occur in the Gulf of Maine. All of these processes play a major role in the formation, erosion and rebuilding of the beaches of northern New England.

In later subsections we will discuss the various beach types (rocky, sandy, muddy, pebbly) that exist along the northern New England coastline and the relationships of each to marine life in the Gulf of Maine. For purposes of this subsection, we will consider only the sandy beaches. The reasons for this are two:

1. the sandy beaches of northern New England collectively represent one of the area's most valuable coastal resources because they are the most publically popular of all the beach types from a recreational standpoint and therefore are most involved in the problem of "coastal access" and,
2. sandy beaches are the most readily eroded of all the beach types and, in light of their great use by humans, must be managed properly. While sandy beaches are less important than other beach types in terms of marine life, they are more "dynamic" geologically, and so will be dealt with exclusively here.

Sandy beaches are formed by the deposition of sand sized sediments onto shorelines. As discussed in the subsection on movement of materials, rivers, currents, waves and tides move materials either towards or away from the coast (i.e., out to sea). Since larger materials are dropped first by moving water, riverborne rocks and boulders rarely reach the coastline. Generally speaking, only storm waves have enough energy to cast these large sediments onto beaches. Silt and clay sized particles, on the other hand, can be carried long distances by relatively slow moving water. Hence, they also rarely end up on beaches, either. Rather, most are deposited out in the intertidal zone beyond the beach face where they form mud flats or are carried out to sea to enter the offshore current systems. It is sand sized particles that are usually deposited by rivers and waves of normal energy onto shorelines to form beaches. The process of sediment transport by moving water (and wind, also) actually *favors* the formation of sandy beaches over rocky, pebbly or muddy ones. Why then, you might ask, aren't there more sandy beaches in northern New England, particularly Maine? To answer this, let us examine two factors necessary for the formation of sandy beaches.

First, in order for sandy beaches to form there must be a *continuous* supply of sand sized sediments. Basically there are four recognized sources of sediments for beaches:

1. riverborne sediments;
2. reworking of glacial deposits by waves (this can occur either through wave action on glacial deposits located on coastal land or on deposits located offshore);
3. erosion of local bedrock;
4. onshore transport of sands formed from the crushed skeletons or shells of animals.

Of these four, one can find examples of each type along the northern New England coast (see Table I) but, by and large, the most important source of sand for our beaches is number 2: reworking of glacial deposits by waves.

Second, these sediments are eroded and carried away by many of the same processes that brought them to the shoreline in the first place: waves, tides, winds, and currents. Since the reworking of glacial deposits is the most common source of sand sized sediments for northern New England beaches, most areas are *continuously* being eroded and there is little chance for the sand to accumulate into a beach. The accumulation of sand into beaches requires certain conditions, namely, decreased wave action to the point that sand will be deposited rather than eroded. This condition exists only in a relatively few places along the Maine coast. The coast of that state is primarily rocky because the wave and tidal action are continually wearing away the glacially deposited shoreline boulders and not allowing the resulting sandy sediments to accumulate to any degree where they are eroded. Instead, currents pick up these sediments and transport them to areas where conditions are right for accumulation.

Let us now examine how certain physical processes, notably waves, winds, tides, storms, and currents influence the dynamics of sandy beaches.

In our discussion of waves in a previous subsection, we learned that waves "break" when they move into water of a certain depth (a depth that is about one-half the value of the wave length). Waves travelling towards shore tend to move sediments in an on-shore direction until they break. At this spot, called the "break-point" they deposit much of their sediment load into a "break-point bar." After that point, what happens regarding the sediment depends upon the wave steepness.

There is a certain "critical steepness" value for waves that determines whether sediment will be removed *from* the beach by the wave *after* it breaks or whether sand will be moved *onto* the beach from the break-point bar. (This value depends upon the grain size of the beach. Most of northern New England's sandy beaches are fine to medium grained. This means that waves of 0.75 meter (about 2½ feet) in height will build up the beach, while steeper waves will erode it. This is based on a wave height to wavelength ratio (or "steepness" value) of 0.012 and a wave period of 6 seconds. Thus, steep, high energy waves tend to bring sand shoreward as far as the "break-point bar," deposit it as they break, and then to also erode sand from the beach face, also depositing that sediment at the break-point bar as the wave returns to sea. These bars seldom are built up above the surface of the water because low energy waves of steepness below the critical value will pick up sand from the break-point bar and transport it to the shore, rebuilding the beach.

In the subsection on waves, we also learned that waves *refract* or bend along the contours of the bottom as they approach the shore. As a result of this, beach faces tend to be oriented by the approaching wavefronts, roughly giving a "mirror image" of the shapes of the wavefronts which are, in turn, influenced by the bottom topography. Refraction of waves causes the wave energy to be concentrated on headlands and dissipated in bays. Also, offshore shallow areas can cause wave energy to be "focused" on certain portions of a beach, resulting in excessive erosion or deposition at that spot.

Winds are also an important force in beach dynamics. Not only do they influence the height of waves which strike the beaches, but also are the paramount agent in the formation of dunes and in the along-shore transport of sand.

Wind transport of sand occurs in three ways:

1. creep (a simple rolling of sand grains along dune or beach surfaces);
2. saltation (bouncing of individual sand grains); and
3. suspension (a carrying of sand grains a long distance through the air in "sheets").

All three of these can operate at the same time, but generally speaking, only one will dominate at a given wind speed. As might be expected, "creep" dominates at low wind velocities, "saltation" at intermediate, and "suspension" at high velocities.

The most important winds along the northern New England coast, in terms of dune dynamics, are the northeast and southwest (which prevail in winter and summer, respectively) and the northwest. The influences of these winds are summarized in Table II.

Several other processes which affect beach dynamics and which will be discussed here are tides, storms, and currents. The tidal range, which in northern New England is quite large, determines the vertical distance over which the swash of waves is active, and consequently causes a general increase in beach width and height. The large tidal range also distributes sediments over a broader zone of beach, creating a gentle slope, and multiple beach faces or berms.

Storms can be agents of construction *or* destruction for northern New England beaches depending upon where they occur. Storms in the immediate vicinity of the beach (e.g., the classical "Nor'easter") create short term high energy waves which erode sediments from the beach, while storms farther out to sea result in long, low energy swells which act to build up our beaches. Northeast storms which occur along the immediate coast are also responsible for flooding which severely erodes the frontal dune ridge, but can also add to back dune development if storm waters wash over the tops of dunes depositing sand on the back sides.

The types of currents which move sand in the vicinity of northern New England beaches are: tidal currents, river currents, estuarine currents, Gulf of Maine gyre, and longshore currents. Strong tidal currents can move sand both downstream (on the ebb) and upstream (on the flow). The result is the formation of deltas at the mouths of rivers with a complex series of bars and channels. The shorelines of beach faces and spits are extremely unstable due to the influence of the tides. The combination of river and estuarine currents and the Gulf of Maine gyre on moving sediments has already been discussed in the subsections on currents and movement of materials. In the spring and early summer, this combination is an especially important factor in the sand budgets for beaches, as strong downstream floods carry large quantities of sand into the Gulf of Maine where it is picked up by the circulating gyre currents. The fourth type, longshore currents are created by a variety of factors: wave angle approach; longshore differences in wave energy; wind; and tide. When waves approach a straight coastline at an oblique angle, a longshore current is created which flows parallel to the coastline landward of the breaker zone. This longshore current is responsible for the transport of sand parallel to the shore. Longshore differences in wave height are largely responsible for the creation of a "cell circulation" (an almost completely closed circle) of rip currents and longshore currents. This results in a "ridge and runnel" beachface configuration where sand is removed in the vicinity of the rip currents (See Figure 11). Winds that blow parallel to the shore create long shore currents that flow in the direction of the wind and which carry sediments along with them. Tide induced longshore currents are usually associated with baymouth delta channels, and can be responsible for the removal of sediments from nearby beaches or the building up of beaches depending upon other circumstances. In 1940, Popham Beach State Park experienced a net accumulation of sediments thanks to tidally induced longshore currents, while in 1952, the very same beach suffered a major recession because of these currents!

Finally, a word should be said about the progressive rise in sea level that is presently taking place globally. In the Gulf of Maine, this rise is occurring at a rate of about 23 centimeters per century (about 10 inches). The factors primarily responsible for this change are: 1) glacial-tectonic influences (upward movements of the earth's crust); 2) melting of the polar ice caps; and 3) excess water being moved onto the continental shelf due to the worldwide sea level rise. The long term advance of seawater onto the land has several significant impacts on northern New England's beaches:

1. Erosion of the beach and shoreline retreat is the rule rather than the exception.
2. The rates at which beaches respond to the processes of deposition and erosion will be important in determining whether or not beaches can maintain an equilibrium with the rise of sea level.
3. The beachface, frontal dune ridge and backdune area must migrate upland.
4. Unless new sand deposits are becoming involved in the sediment selection process of waves and currents, the sand supply to beaches from submerged offshore deposits of glacial outwash sediments are diminishing. Most of Maine's beaches are non-sediment-starved which implies either a diminishing supply or such relatively rapid retreat that the present supply rate is inadequate.

The dynamics of sandy beaches are important to all of us, not only those living in portions of our region that happen to contain such beach types. As mentioned, sandy beaches are enormously popular among tourists, visitors, and residents alike as recreational areas. In Section III, we will be discussing in detail the significance of recreation and tourism to the economy of northern New England, so suffice it for now to say that these industries rank *second* in the region in terms of income to the area and cannot, therefore, be looked upon as unimportant. Largely because of the dependence of the tourist and recreational enterprises upon sandy beach areas, and also because these areas represent unique natural habitats, we need to be concerned about the proper management of our sandy shorelines. As we have seen, sandy beaches are constantly in a natural state of flux, undergoing erosion and rebuilding in a cyclic basis. The efforts of humans to either enhance (through beach enrichment — pumping of sand onto beaches) or inhibit (through the construction of seawalls and jetties, dredging, etc.) the natural processes of deposition and erosion have largely proven unsuccessful. (These will also be discussed in greater detail in Section III.) Development projects along beachfaces and on dunes also have failed to take into account the dynamic, ever changing nature of the sandy beaches. Humans continue to build upon these fragile coastal structures, risking loss of property due to storm damage, flooding, erosion, etc. Our governmental agencies also continue to ignore the facts of beach dynamics by subsidizing human development of these areas through the federal flood insurance program. It has become quite clear over the years, that in order for a proper, effective program of shoreline management to be instituted, voters and policy makers alike need to be better informed about the dynamic nature of our sandy beaches.

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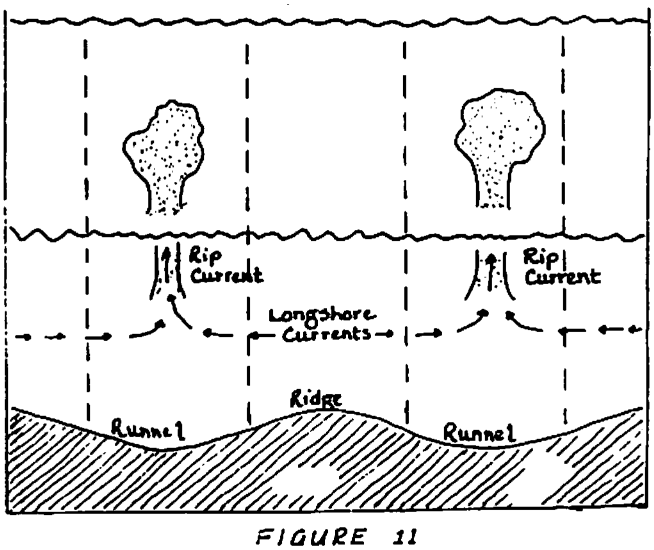

FIGURE 11

TABLE I

Source of sandy sediments and beach examples for each

Source of sandy sediment	*Beach Example*
Riverborne	1. Popham-Seawall Beach - made up of sand carried by the Kennebec River. 2. Old Orchard Beach and Hills Beach made up of sand carried by the Saco River.
Reworking of Glacial Deposits	1. Most Maine beaches, (e.g. Rogue Island Beach, Rogue Island; Goose Rocks Beach, Kennebunkport; Scarborough Beach, Scarborough; Sandy River Beach, Jonesport; etc.)
Erosion of Local Bedrock	1. Sand Beach on Mt. Desert Island
Onshore Transport of Sand Sediments formed from crushed shells and skeletons of marine animals	1. Sand Beach, Mt. Desert Island 2. Merchant Island Beach 3 Marshall Island Beach

TABLE II

Characteristics and Influences of the most important winds on the dunes of coastal northern New England

Wind Direction	*Characteristics and Influences*
Northwest	1. Dry, seaward blowing wind. 2. Usually high velocity. Most common in fall and winter. 3. Form parabolic or U-shaped dunes by scooping sand from unvegetated back dune areas (are commonly seen at Ogunquit, Seawall, Popham, and Reed State Park beaches). 4. Builds up the tops of dunes by transporting sand from upland areas. 5. Sand from the front part of the dunes tends to be moved in an easterly direction, aiding the construction and growth of the "aeolian ramp" (a wedge of sand which fills the "frontal dune scarp" or cliff cut into the front of the dune by winter storms). 6. Because these winds blow offshore, they flatten incoming waves and aid the onshore transport of sand.
South to Southwest	1. Occur throughout the year, but are most prevalent in summer. 2. Are most responsible for development of the "frontal dune ridge" (sand is blown inland from the beach face or berm and is caught by vegetation, resulting in the growth of the front part of the dune). 3. Aids in the recovery of the frontal dune ridge after storm erosion. 4. Are also important in general onshore transport of sand (these winds blow in off the water) from the beach face, maintenance of dunes, and redistribution of sand to east and northeast sections of the beach. 5. Cause the formation of low energy waves which transport sand onshore, creating the wide, summer berm or beach face. 6. Also important in the formation of the aeolian ramp. 7. Are also responsible for the "flagging" effect on white pines due to the blowing off salt spray onshore. ("Flagging" refers to the stunting of branches on the windward side of the tree.)
Northeast	1. High velocity, moist winds that blow mostly in winter. 2. Create steep waves which erode beaches and transport sand both offshore and along shore by wind induced long shore currents. 3. The heavy precipitation associated with these winds helps prevent movement of sand off the beaches and dunes.

Background Information: Bottom Topography of the Gulf of Maine

The Gulf of Maine extends approximately from Cape Ann, Massachusetts, northeast to Cape Sable Island off Nova Scotia, a distance of 225 nautical miles (416 km), and also from the coastline of northern New England out to the 50 fathom line (90 meter depth on the northern edge of Georges Bank) (see Figure 12).

The Gulf has been described by the United States Geological Survey as "one of the most striking topographic features of the east coast of the United States . . ." The reason for this description is that the Gulf is, in many ways, a partially enclosed sea. It's oceanward boundaries are formed by the shallow Georges Bank on the south, Browns Bank on the east, and on the southwest by Nantucket Shoals. Georges Bank averages less than 60 meters (about 180 feet) in depth, and in some areas is less than 4 meters (or about 13 feet) deep. The only deep water connection between the Ocean and the Gulf is through the Northeast Channel (232 meters or about 700 feet deep) which runs between Georges and Browns Bank. The Great South Channel and the channel between German Bank and Browns Bank off Nova Scotia are both relatively shallow. The Gulf of Maine, then, which itself averages 150 meters or 450 feet in depth, is more or less separated from the deep water of the nearby Atlantic Ocean. Most of the exchange between Gulf waters and Ocean waters takes place across the shallow banks.

Between these seaward boundaries and the shoreline of northern New England, the Gulf contains many interesting features. Some twenty-one deep basins dot the bottom of the Gulf, with the deepest being Georges Basin (377 meters, or about 1,100 feet). There are also numerous submarine ledges and ridges scattered throughout the Gulf such as Jeffreys Bank, Cashes Ledge, Three Dory Ridge and Grand Manan Banks, which are upward protrusions of the floor of the Gulf. Many of these protrusions are composed of the very ancient basement rock which forms the underlying foundation of the Gulf of Maine. This foundation is called the Avalon platform by geologists, and consists of rock between 250 million and 500 million years old. Other ledges and shoals, like Jeffreys Ledge are composed of much younger rocks (about 60 million years old) while smooth slopes have been formed (and are still being formed) on Georges Bank by sediments of the Recent period and are less than 20,000 years old. These have been deposited by glacial action and river run-off.

The bottom of the Gulf of Maine presents a picture of a moderately deep basin, bounded by Northern New England and maritime Canada to the north and west and by shallow banks and shoals to the south and east. Within these borders exist numerous deep basins and shoal ledges. Rocks of various ages mal:e up these features of the Gulf's bottom topography. This bottom topography has important influences on the physical, chemical and biological features of the Gulf. As mentioned the shallow bordering banks at least partially separate the Gulf of Maine from the Atlantic Ocean. Hence we find conditions that differ from those in the open ocean. First, the Gulf has its own circulation patterns (see Background Information: Currents) in which the surface currents flow in a more or less counter clockwise direction. This is opposite to the flow of the major current systems in the open oceans of the northern hemisphere which run clockwise. The Gulf circulation pattern has an important influence on the transport of sediments contributed by rivers and eroded from headlands. These materials are, by and large, carried southward along the entire northern New England coast rather than northward toward the Canadian maritimes which would be the case had the ciruclation pattern run clockwise. Thus, sediments and nutrients are, for the most part, kept within the Gulf of Maine.

Second, the bottom topography influences the temperature and salinity patterns within the Gulf. In the north eastern section of the Gulf, from the Bay of Fundy out to the Scotian Shelf, the least stable conditions exist due to frequent vertical mixing. This mixing is facilitated by the entrance of somewhat warmer, but much saltier bottom water from the ocean through the Northeast Channel. The mixing with the cold, less saline waters above give this area higher salinities than exist elsewhere in the Gulf. Mixing also helps prevent the formation of a stable thermocline (see Background Information: Chemical Composition of Seawater). Because of the lack of a stable thermocline in this area, surface temperatures tend to be lower than in more southerly portions of the Gulf where the thermocline is well established in summer. Here, in the section of the Gulf between Cape Ann, Jeffreys Ledge and Cape Elizabeth, the surface waters are the warmest and least salty of anywhere in the Gulf. Thanks to the stable thermocline which develops in this region, there are large differences between the temperatures and salinities of the surface waters and the bottom waters which effectively presents a barrier against mixing. It should also be noted that this area receives the least contact with ocean water because of the presence of Georges Bank and Nantucket Shoals.

Finally, this bottom configuration of the Gulf of Maine influences the biology of the area. The shallow banks and the area of vertical mixing near the Northeast Channel are the most productive areas in terms of fishlife of anywhere in the open Gulf. This is because mixing of bottom waters with surface water brings nutrients within reach of the plant plankton that form the first link of the marine food chain. If the Gulf of Maine were simply a deep, flat bottomed basin that gradually merged with the Atlantic Ocean, devoid of the banks, ledges and channels that do in fact exist, it would likely not be as rich an area in sealife as it is, in fact, today.

Thus, knowing something about the geographical and geological features of the Gulf of Maine gives us clues as to the physical, chemical and biological characteristics of the area.

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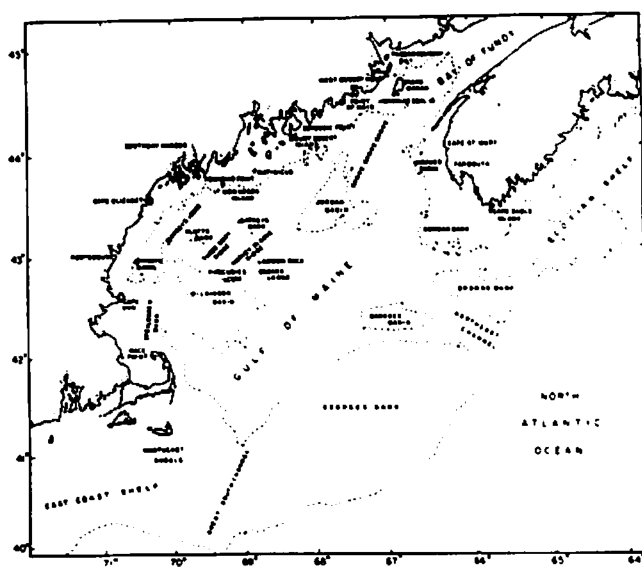


FIGURE 12

Background Information: Who Lives Here?

The offshore waters of the continents of the world are home to many more kinds of marine creatures than are the open waters of the ocean. The Gulf of Maine is particularly rich in marine life. Factors that have already been discussed such as tides, currents, salinities, sedimentation, freshwater input, temperatures, etc. all have an effect on the kinds and numbers of organisms that occur in the Gulf. Of particular importance is the process of upwelling or vertical mixing of bottom waters with surface waters. We have said that the Gulf of Maine is very rich in marine life. What kinds of marine organisms live there? Basically, the life within the Gulf of Maine and in other marine environments can be grouped into several categories called *phyla* (singular, *phylum* — pronounced fi la and fi lum). All known living things on earth have been classified in this manner.

If we begin with the Plant Kingdom, we have several groups or phyla represented in the Gulf. The smallest plant members found in marine environments are the plant plankton (called *phytoplankton*). There are numerous phyla of phytoplankton, but the most common are the diatoms and dinoflagellates. Diatoms are characterized by having a two part shell made of silica, in which one part fits over the other part, much like a box. Some common diatoms are shown in Figure 13.

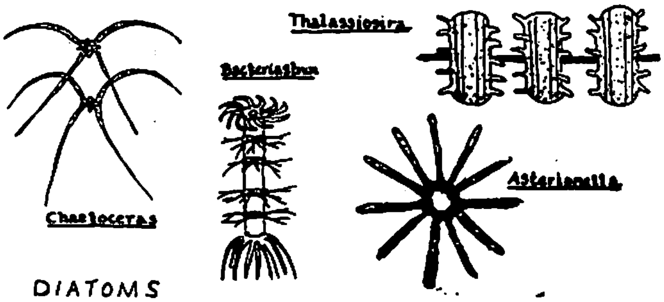


FIGURE 13

Dinoflagellates differ from the diatoms in that they do not possess a two-part shell, but do have two "tails" (called flagells) which enable them to move about. (Fig. 14) Another primarily microscopic group of marine plants are the blue-green algae. While the individuals of this group are very small, large masses of these algae can often be noticed. For example, the blue-green algae, *Calothrix* often appears as a black mat on rocks in the upper tidal area, and are known as the "Black Zone."

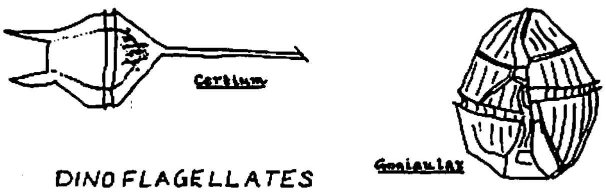


FIGURE 14

The most commonly known algae are those that are macroscopic (large enough to be seen as individuals, without the aid of a microscope). There are several macroscopic algae phyla that occur in the Gulf of Maine. The green algae group (Phylum Chlorophyta — chloro means green, phyta means plant) includes the common flat green sea lettuce, (Fig 15) and the stringy maiden hair seaweed. Phylum Phaeophyta, the brown algae, contains our most common seaweed — rockweed and kelp — as well as numerous other species. (Fig. 16) Finally the red algae (Phylum Rhodophyta) are represented by Irish moss (Fig. 17) and dulse among others.

Within the coastal zone are many important land plants. These plants belong to the Phylum Spermatophyta, the flowering plants, and while the flowers themselves are insignificant, the seed heads are usually easily seen and distinctive. In this group we find the common salt marsh grasses, thatch grass or salt marsh cord grass, fox grass or saltmarsh hay, spike grass, glasswort or marsh sampire, and black grass. Some are

SEA LETTUCE
FIGURE 15

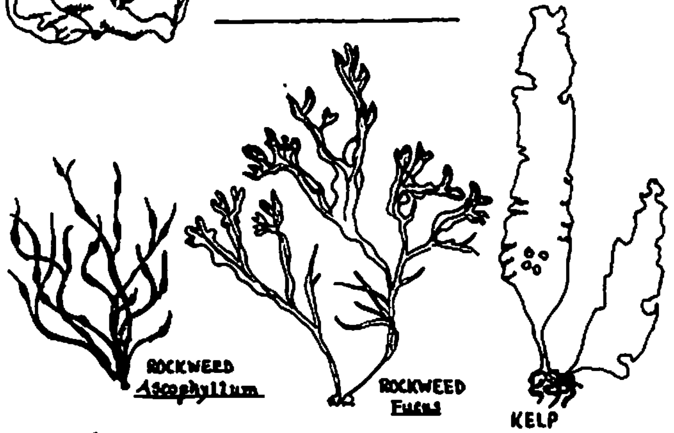


FIGURE 16

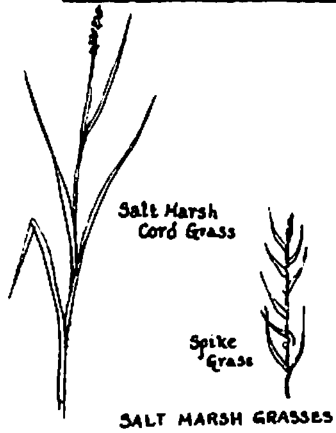


FIGURE 17

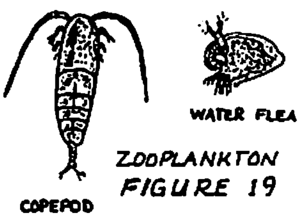
FIGURE 18

represented in Fig. 18. These land plants must endure the inundation by salt water that occurs on every high tide. Some, like saltmarsh cordgrass and the glasswort are found near the seaward edge of the saltmarsh and are soaked twice everyday by the high tide. Others like the saltmarsh hay, spike grass and black grass are located more landward but are subject to salt spray and occasional flooding by spring tides. Most land plants would die if exposed to salt water, yet these plants thrive in it. They have adapted ways of dealing with the salt in the water, enabling them to survive in this harsh environment. For example, saltmarsh cordgrass and saltmarsh hay both have the ability to secrete salt through special glands in their leaves. if you've ever walked through a saltmarsh on a summer's day, wearing shorts, your legs will be covered with a white dust when you emerge. If you taste this dust, you will quickly discover that it is salt. You have brushed the salt off the leaves of the saltmarsh plants as you passed by. Glasswort, on the other hand, does not noticeably dispose of the salt. Instead it absorbs a great deal of the seawater, swelling up like a balloon, taking what it needs in the way of freshwater and excreting the rest of the water and all of the salt. This plant is very tasty in salads and at one time was used to make pickles.

Moving on to the Animal Kingdom, we find a variety of representatives from every one of the major phyla. In fact, some of the phyla in the Animal Kingdom comprise *only* marine creatures. Others contain species which are primarily marine but that have a few freshwater relatives.

The smallest and simplest animals in the sea are the zooplankton (zoo — pronounced "zo," rhymes with toe — meaning animal; plankton, meaning drifting). The zooplankton contains the larvae of many familiar animals like crabs, clams and starfish, as well as adult animals that are at the mercy of the currents like jellyfish, and tiny insectlike creatures called copepods. Thus the zooplankton spans many animal phyla and plays a very important role in the marine environment. Some zooplankton are represented in Figure 19.

Other creatures to be found in the various environments of the Gulf of Maine include the sponges (Phylum Porifera), like the crumb of bread sponge (Fig. 20), the jellyfishes (Phylum Coelenterata) such as the common moon jelly, and the lion's mane jellyfish. (Fig. 21) Also in this group are the sea anemones. (Fig. 22) Comb jellies (Phylum Ctenophora) (Fig. 22) resemble jellyfish but do not sting. In addition, they glow in the dark (bioluminesce) when agitated. Phylum Platyhelminthes, the flatworms, is represented in the marine environment by the turbellarians. Other worm phyla include Phylum Nemertea, the ribbon worms, and Phylum Annelida, the true or segmented worms. This latter group contains the familiar earthworm (which is not marine) and its saltwater relatives, the clam worm, the blood worm or beak thrower, and the trumpet worm. (Fig. 24)



ZOOPLANKTON
FIGURE 19

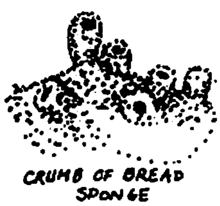


FIGURE 20

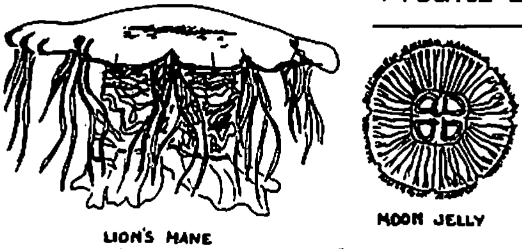


FIGURE 21

FIGURE 22

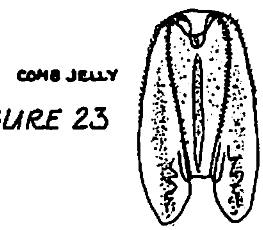


FIGURE 23

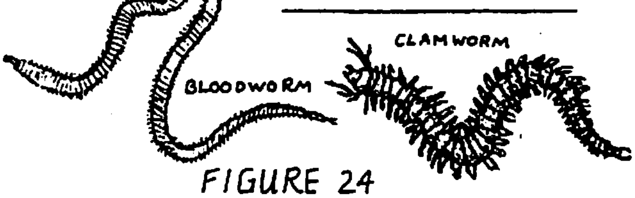


FIGURE 24

Continuing up the Animal Kingdom ladder, we find marine crustaceans (Phylum Arthropoda or joint-footed animals) like the familiar lobster, rock crab, hermit crab, shrimp, the beach fleas or sand hoppers, and water sowbugs or isopods. Also in this phyla we find marine relatives of the spider, the most notable being the horsehoe crab. (Fig. 25)

The next important group are the mollusks or shellfish (Phylum Mollusca) which are also represented by familiar creatures: the soft clam, the blue mussel, the surf clam or hen clam, the common periwinkle and the whelks or "wrinkles" (dogwelk, waved whelk, tenridged whelk.) (Fig. 26) The mollusk group also contains some surprising members like the octopus, squid and the sea slugs. These three actually have "shells" but they are either much reduced or internal.

The sea stars (or starfish — Family Asteroidea) are but one group found in the Phylum Enchinodermata (spiny skinned animals). Other members include the sea urchins, sand dollar, and the sea cucumbers. (Fig. 27)

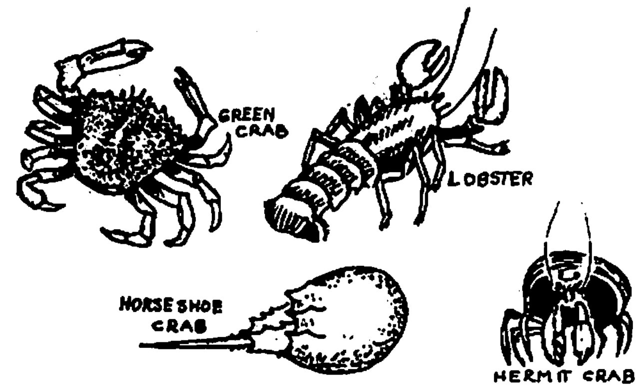


FIGURE 25

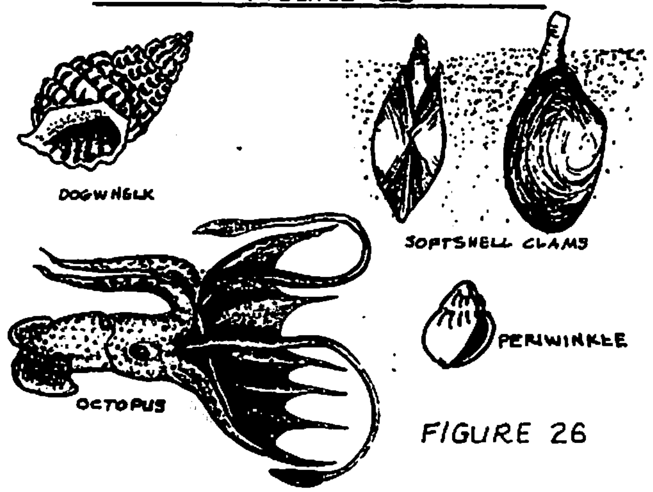


FIGURE 26

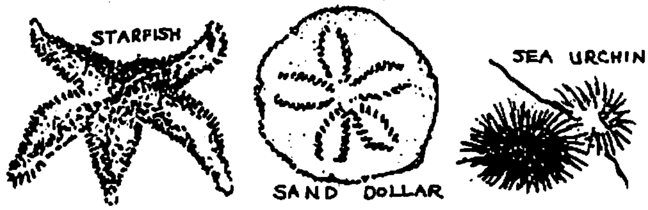


FIGURE 27

Before moving into Phylum Chordata, the vertebrates (of which we are members), there is one other group we should consider: Phylum Bryozoa, the "moss animals." Bryozoans are tiny colonial animals that grow on rocks, algae, shells, wharf pilings, etc. Some are stalked while others are encrusting. Two common bryozoans in our area are the tufted bryozoan, a stalked variety, and sea lace, an encrusting form.

Phylum Chordata, the vertebrates, or animals with backbones, are most familiar to us. This phylum contains the fishes (class Pisces), the frogs, toads, and salamanders (class Amphibia), the snakes, turtles, lizards (class Reptilia), the birds (class Aves) and the mammals (class Mammalia). Of these five classes, three have true marine members and one other can be included depending on one's definition of "marine". Most of us are aware of at least a few of the vast variety of marine fishes living in the Gulf of Maine: the codfish, the haddock, the flounders, the skate, the dogfish shark, etc. The reptiles have marine relatives like the diamondback terrapin, the loggerhead and leatherback turtles, and the marine iguana, but these do not generally occur in the Gulf of Maine. The mammals, however, have numerous species living in the Gulf, including the harbor porpoise, harbor seal, right whale, fin whale and others. Finally, one could argue that class Aves, the birds, also has marine representatives. While no bird lives exclusively or even mostly in the water, there are some bird species like the puffin, the shearwaters, the fulmar, the guillemots and the petrels that never come inland (except when blown there by storms) but spend their entire lives at sea, nesting on offshore islands, or on the coastal edge of continents.

We have just taken a very superficial look at the huge number of plants and animals that one can find living out their lives in the Gulf of Maine. The examples of the species within the various phyla that have been given here are but a small fraction of the total number of species that can be found within each of these phyla. It is important to understand this richness of life, this enormous variety of species that exists in marine environments before one can even begin to comprehend the interrelationships between these myriad of animals and plants. The sheer numbers alone are mindboggling, but the countless connections between species is truly amazing and something *not* to be taken lightly. A very simplified view of these relationships will be given in a later subsection, but it must be constantly remembered that the picture is infinitely more complicated than that presented.

Summary of the major plant and animal phyla found in the Gulf of Maine:

Plant Kingdom

Plylum Chrysophyta	Diatoms (plankton)
Phylum Pyrophyta	Dinoflagellates (plankton)
Phylum Cyanophyta	Blue-green algae
Phylum Chlorophyta	Green algae
Phylum Phaeophyta	Brown algae
Phylum Rhodophyta	Red algae
Phylum Spermatophyta	Flowering plants

Animal Kingdom

Phylum Porifea	Sponges
Phylum Coelenterata (Chidaria)	Jellyfish, Sea anemones
Phylum Ctenophora	Comb jellies
Phylum Platyhelminthes	Flatworms
Phylum Nemertea (Rhycocoela)	Ribbon worms
Phylum Annelida	Segmented worms
Phylum Arthropoda	Crustaceans (crabs, shrimp, lobster, etc.) Insects Spiders
Phylum Mollusca	Shellfish Bivalves (2 shells — clams, mussels) Univalves (1 shell — snails, etc.) Shell not in evidence (slugs, octopus, squid)
Phylum Echinodermata	Starfish or seastars, seacucumbers, sea urchins, sand dollars
Phylum Bryozoa	"Moss animals"
Phylum Chordata	Tunicates Fish Birds Mammals

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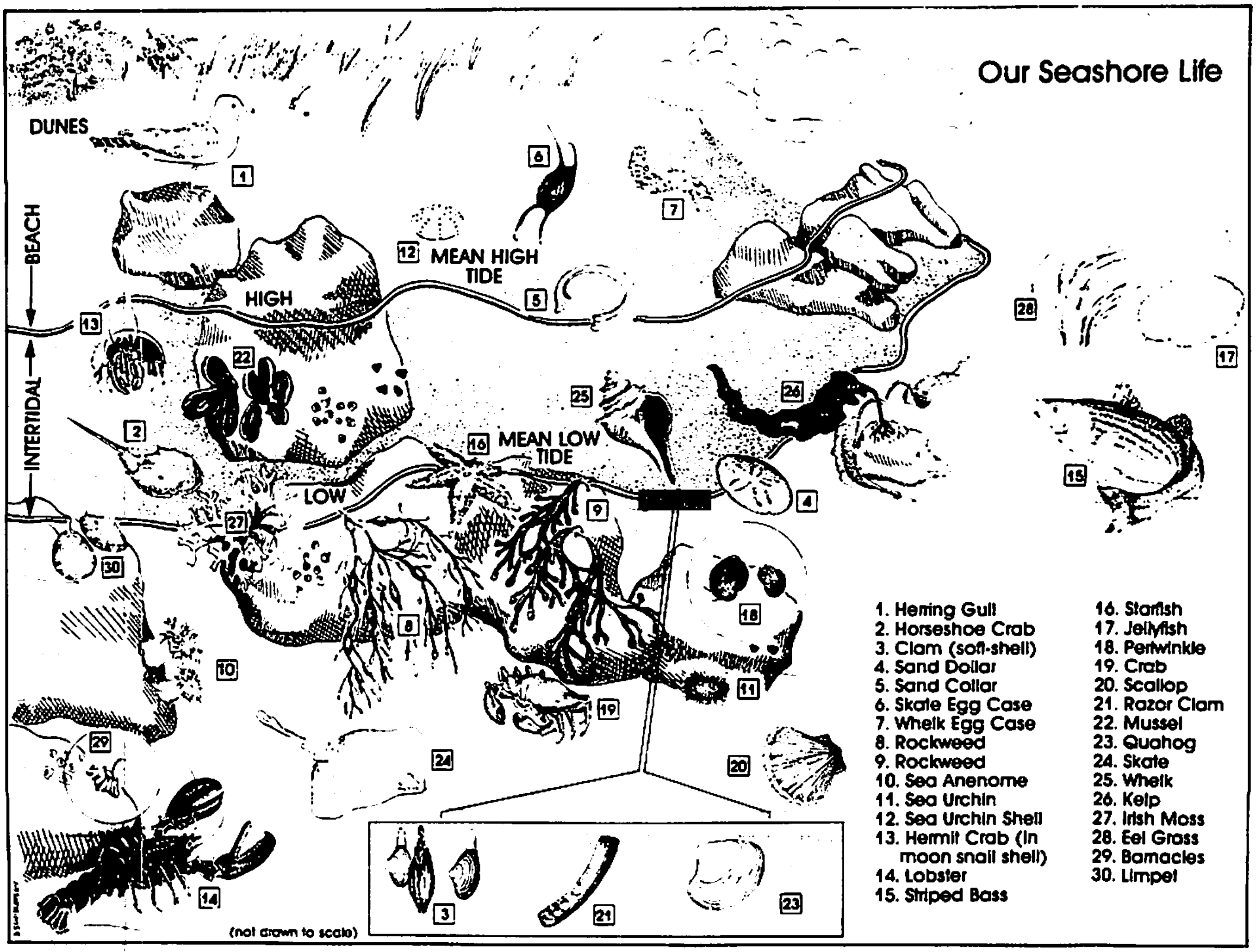

Background Information: Who Lives Where?

Now that you have some general idea of the many kinds of living things, both plants and animals, that can be found in the Gulf of Maine, it is important to realize that these organisms are not found living *just anywhere* within the Gulf. Each of these plants and animals have a particular place in which they spend most of their time. The home of a plant or animal is called its *habitat* and you will soon discover that each plant and animal has certain characteristics that enable it to live better in one kind of habitat than another.

The Gulf of Maine, and all other marine coastal areas as well, is made up of basically four different habitats: the shore, the surface of the water, the bottom, and the area between the surface and the bottom (the open water zone). Most of us have a greater opportunity to observe life that lives on the shore than the other areas, so we will concentrate on that habitat first.

The shore is the place where the sea meets the land. In the information on tides we learned that the size of the shore changes, extending farther out to sea on the low tide, shrinking back inland on the high tide. This area, from the point of the highest tide to the point of the lowest tide is called the *intertidal* zone and is a very important place to coastal creatures. We shall consider this zone in a moment. First let's take a look at the different types of shores that exist, because the material that a shore is made of has a great influence on who lives where.

Basically four different types of shores are represented along the coast of the Gulf of Maine. These are *rocky*, *shingle* (or *pebble)*, *sandy* and *muddy* shores. Often the distinction between these types is not really clear; in other words, one type may be found mixed with another type. It is quite common, for example, to find a rocky shore with large sandy or muddy areas. By and large, however, the Gulf of Maine contains mostly rocky shores, with some sandy beaches found in the southern areas.

The rocky shore is generally divided into subareas called regions, bands, or zones. Each of the zones have different environmental conditions which influence what kinds of plants and animals live there. There is no standardized set of names for these zones, but we will use the following commonly used terms:

The *supralittoral* zone is also called the upper shore, splash, or spray zone. it is rarely covered by water except during the very highest of tides, such as occur with storms. However, this area constantly receives salt spray and splashes.

The *littoral zone*, also called the black zone is often covered by water during normal high tides, but this coverage is usually not for a very long period of time.

The *midlittoral zone* or middle shore is covered by water during normal high tides and part of it may also be under water during normal low tides. It is the largest of the rocky shore zones and is itself subdivided into smaller regions known as the Barnacle zone, the Rockweed zone and the Irish Moss or Red zone.

Finally, the *sublittoral zone* or the lamanarian or scuba zone is the most seaward of the zones. It is usually underwater, although parts of it may be exposed during extremely low tides, such as often occur during hurricanes. For practical purposes, this zone extends out along the bottom of the Gulf to a depth of about 120 feet.

The intertidal zone, which we referred to before, includes at least part of all of the above zones. The supralittoral and sublittoral zones extend above and below the intertidal zone respectively. The littoral and midlittoral zones make up the largest part of the intertidal zone. The boundaries between these zones are not usually clearly distinct except along steep vertical cliffs. Nevertheless, you will notice a change in the animal and plant populations that corresponds roughly with the existence of these zones.

Who, do you suppose, would live in the supralittoral zone? This is the area that receives a saltwater covering only from extremely high tides and from spray and splashing. In this region, we find basically land dwelling plants and animals that are hardy enough to stand the exposure to the salt spray. Plants like lichens, mosses, beach peas, beach roses (rugosa rose), and salt marsh plants like glasswort can be found in the rock beach supralittoral zone. Most of the animals dwelling permanently in this area include arthropods (from the Phylum Arthropoda) like spiders, isopods (for example, pill bugs or sowbugs), mites, and, a mollusk and the land snail.

The littoral zone, or upper intertidal zone, is also called the "black zone." The black zone gets its name from the abundant blue-green algae, *Calothrix*, which, when wet, or in mats, appears black or dark green. Other species of the black zone include animals which are primarily marine but have the ability to breathe air, or, at least are able to spend time out of water without breathing very much. These animals must also be able to keep moisture around their bodies so as to prevent their drying out during times of exposure to the air. A common example of such a creature is the periwinkle, which has a hard covering on its foot, called a "trap door" or operculum. When exposed to the air, the periwinkle pulls its foot into its shell and tightly seals off the shell opening with the operculum. This enables the periwinkle to trap moisture inside its shell and to thereby survive long periods of time out of the water. This ability also allows the periwinkle to travel about, into and out of the water, and explains why this creature is found throughout the intertidal zone. Another animal of the littoral zone, somewhat less mobile than the periwinkle, is the limpet or "Chinaman's hat" shell. The limpet cannot withdraw its foot and close off its shell because it lacks an operculum. Instead, it uses its strong foot to attach its shell tightly to rocks trapping moisture within. The limpet is also sometimes found in the midlittoral zone.

The midlittoral zone contains the greatest variety of intertidal plants and animals. The upper section of this area, called the *barnacle zone* is so named because of the large concentration of this crustacean. The whitish upper band of barnacles fades to a brownish yellow color below as we move from one species of barnacle to another. Barnacles are small animals living within the white or yellow shell. When they are exposed to the air at low tide, they close their shells up very tightly to conserve moisture. When covered with water, however, they stick out their tiny legs and wave them about capturing food and oxygen from the water. Since they have jointed legs, they are actually related to the crabs and lobsters, even though they may appear to look more like a mollusk.

Another important animal of the midlittoral zone is the dogwhelk. This whelk somewhat resembles the periwinkles, but is more pointed. In addition, on its underside, it has a long groove in its shell extending from the region of the operculum. Through this groove, the dogwhelk can extend its "tongue" or proboscis. In this proboscis is located a hard, rough structure called the *radula*. Using the radula the dogwhelk can drill holes into the shells of other mollusks, insert the proboscis into the body of the other animal and digest the contents. The dogwhelk also releases a chemical enzyme which softens the shell of its prey and greatly aids the drilling. The dogwhelk will not only eat periwinkles, moonsnails, etc., but also will eat other dogwhelks!

Also found in the midlittoral zone of the rocky beach are blue mussels. Usually these bivalves (two-shelled mollusks) live attached to the rocks and, under certain conditions form a distinct band across the midlittoral zone. Limpets occasionally will occur here, also attached to the rocks, and the roving periwinkles often move in, sometimes in such abundance that they form a narrow horizontal strip.

The next lowest subzone of the midlittoral zone is the *rockweed zone*. As you might expect, the predominant form of life here are the brown algae, rockweed or bladder wrack, and knotted wrack. This seaweed attaches itself to the rocks by a rootlike structure called a holdfast. The thick layer of seaweed in this zone retains moisture and provides protective covering, so we find many kinds of small animals living here. If you looked carefully under the rockweed, you would likely be able to find green crabs, limpets, periwinkles and other snails, beach hoppers, blue mussels, dogwhelks, scaleworms, barnacles and occasionally sand worms or clam worms. Hydroids, which are related to the jellyfish and sea anemones (Phylum Coelenterata) may sometimes be found growing on seaweed, empty shells (or shells occupied by hermit crabs). These are tiny animals that resemble plants,with stalks and petal-like tentacles. The coiled tube worm, is an unusual creature also found here attached to rocks or rockweed. This minute worm lives in a coiled white shell made of calcium and, at first glance, resembles a tiny barnacle. When seen underwater, the tubeworm extends tentacles out to catch food as it passes by.

The lowest level of the midlittoral zone is called the *red algae* or *Irish moss zone*. True to its name, this zone contains the familiar algae, Irish moss. This seaweed, which varies in color from dark brownish purple to bleached-out white, usually occurs on shores that are exposed to the open sea and the plants offer a home for creatures like the coiled tube worm, moss animals, (Bryzoans), scale worms, round worms, amphipods, and even tiny blue mussels and periwinkles. Other red algae species living in this area include the encrusting coralline algae, *Porphyra*, another seaweed which resembles purple tissue paper and occurs in tidepools, and dulse.

Tidepools, which occur in this area, are depressions in the rocks that fill up with water when the tide is high but do not drain out when the tide recedes. They are usually small, shallow, quiet pools of water that heat up rather quickly in the sun or become almost fresh when it rains. Within these pools, you can find animals that can stand the extremes of temperature and salinity. The crumb-of-bread sponge, the green sea urchin, the chiton, amphipods and sometimes small fish can be found living in these pools. These animals, plus others like starfish, brittle stars and sea anemones also occur in the lowest sections of the midlittoral zone.

The last zone of the rocky shore that we shall consider is the *sublittoral zone*. As we noted above, this zone is rarely *uncovered*, its upper portions only occasionally experiencing exposure during extreme low tide. This zone is also called the laminarian zone to draw attention to its most common plant, kelp or *Laminaria*. The kelps have holdfasts that secure them to rocks. They are usually very long so that they may have their holdfasts attached on the bottom in fairly deep water while the tips of their fronds float near the surface. (The kelps of the west coast of the U.S. where coastal waters get deep very quickly are sometimes fifty feet long. Our eastern kelps are usually between five and ten feet long.) The animals of this area include the coiled tube worm which lives hiding in the holdfast. Basically, the animals of this area are the fishes and some bottom dwelling creatures like lobsters and other crabs which move in and out of the area. These animals will be considered in the paragraphs on open water areas away from shore.

Thus far we have confined ourselves to the habitats of the rocky shores. We should take a brief look at the three other types of shores, sandy, pebbly (or shingle) and muddy. *Sandy shores* are common in the southern portions of the Gulf of Maine coastline. They occur primarily between Cape Elizabeth, Maine (near Portland) south to Cape Cod, Massachusetts, and are the predominant beach type of the mid Atlantic and southern states. Howver, large sandy areas may be adjacent to the mostly rocky terraine of northern shores. The residents of sandy beaches are not immediately evident. They include mostly animals that bury themselves, like soft clams, and sandworms. Hermit crabs occur in quiet water areas of sandy shores and sand shrimp may be found among the eelgrass, which is the predominate marine vegetation of these areas. Land plants on sandy shores include pigweeds. Sandy beaches also display "strand lines," long rows of debris deposited by the high tide. In these lines, you can find all sorts of natural and man-made treasures from the sea as well as animals that have moved into the mess temporarily until the debris is removed by another tide or blown away by the wind. Such temporary tenants include sand hoppers, certain land insects like ants and beetles and even an occasional butterfly.

A second type of shore, and an important marine habitat in New England is the *mudflat*. Mudflats often comprise the intertidal area of a rocky shore, but usually only when the rocky beach is fairly protected and gently inclined, not steep and exposed to ocean waves. These mudflats are home to huge mats of the green algae, sea lettuce and to the flowering seaweed, eelgrass. Hiding in the weed and lettuce or burrowed in the mud can be found a large variety of small fish including mummichogs and stickle-backs, also mudsnails, hermit crabs, bloodworms, lugworms, and, of course, clamworms and soft clams which make the areas economically important to man. The landward edges display glasswort, saltmarsh grasses, sumac, beach pea and other salt tolerant land plants.

The last shore type that we will consider here is the *pebbly* or *shingle beach*. These are generally steep-faced beaches composed of pebbles and rounded stones which are rolled about by the wave action. Animal and plant life is rather limited on the shingle beach. (Why do you suppose this is true?) Mostly what you will find living here will be floating plants and animals like sea lettuce, and jellyfish, and animals that move in and out of the area at will, such as fish, swimming crabs and birds. The beach itself will be practically lifeless except for an occasional sand crab that has burrowed into the sand beneath the pebbles, or a sand hopper.

Think about the reasons why some types of beaches make better habitats, or living areas, for plants and animals than others. This will be discussed further later on. Moving away from the shore to the open waters of the Gulf of Maine and ultimately to the Atlantic Ocean, we find four more important habitats: the bottom, the water between the surface and the bottom, the surface film and the air above the water. It shouldn't be too difficult to guess some representative plants and/or animals of each of these different areas.

The bottom of a body of water, also called the *benthos*, is home to a great many animals but few plants. (Why do you suppose that this is so?) The most popular benthic animal in our area, for many reasons, is the lobster. This creature hides among cracks and crevices of rocks at depths ranging from fairly shallow (10-15 feet) to fairly deep (100+ feet). Other benthic animals include the rock crab, the sea scallop, the ocean quahog or mahogany clam, the surf clam or hen clam, the basket star and several species of brittle star. Generally speaking, these creatures live below the low tide mark (in the sublittoral zone and beyond) and some are found at surprising depths. For example the deep sea, or pink, shrimp is only found at the bottom of waters over 100 meters (300 feet) deep. Some commercially important fish species that live primarily on the bottom include the flatfishes (blackback flounder, yellowtail flounder, halibut) the skates, and the anglerfish (or goosefish or monkfish).

As we move upward from the bottom to the surface, we travel through a "middle area," generally known as the *pelagic* zone. It is here that we find the greatest variety of fishes, the cod, the hakes, haddock, pollock, swordfish, tuna, redfish, mackerel, smelt, menhaden (or pogy), herring, cusk, and wolf-fish. Some like the cod, haddock, mud hake, redfish, cusk and wolf-fish live very close to the bottom while others, pollock, swordfish, tuna, mackerel, smelt, herring and menhaden range alone or in schools at various depths in between. Most marine mammals (whales, seals, porpoises, etc.) are also found in the pelagic zone.

Finally we reach the surface which is the most important habitat for plant and animal plankton, and large drifters like jellyfish. Plant plankton (phytoplankton) by and large stay at the surface permanently, while some animal plankton (zooplankton) are known to migrate to some depth at night and return to the surface during the day where they feed on the phytoplankton.

The plants and animals discussed in the preceding paragraph live in the water at the surface. A thin surface film separates this habitat from that of the pelagic birds who sit on the water but live mostly in the air (except when they enter the water to feed). While it is not normally considered a marine environment, as such, the air above the water is an important habitat for animals that are rarely, if ever, seen on any land except to breed, and for that reason is included here in this discussion of marine habitats.

You may ask "Why is it important to know *where*, within the marine environment, these different plants and animals live?" One reason is purely practical: if we wished to study a particular plant or animal it would help us immensely if we knew where to find it within the marine environment. By the same token, if we wished to *harvest* a certain plant or animal, it would save us a great deal of time and money if we went looking for it in the right place. Say, for instance, we wanted to catch a codfish for dinner. We would be likely to go hungry if we sat out in our boat with a fish line that only extended some ten feet below the surface in water one hundred feet deep! Finally, by knowing something about the habitats of marine creatures, we can have a better idea of the kinds of organisms that will be affected by different actions by people. For example, what groups of organisms would likely be affected by an oil spill that spreads out over the surface of the sea but doesn't reach land? What animals would primarily be disturbed by a dredging operation?

Unless we, who do *not* live there, have some idea of what *does* live there, and equally importantly, of what lives *where*, in the marine environment, we cannot make wise judgments about what should or should not be done *to* that environment.

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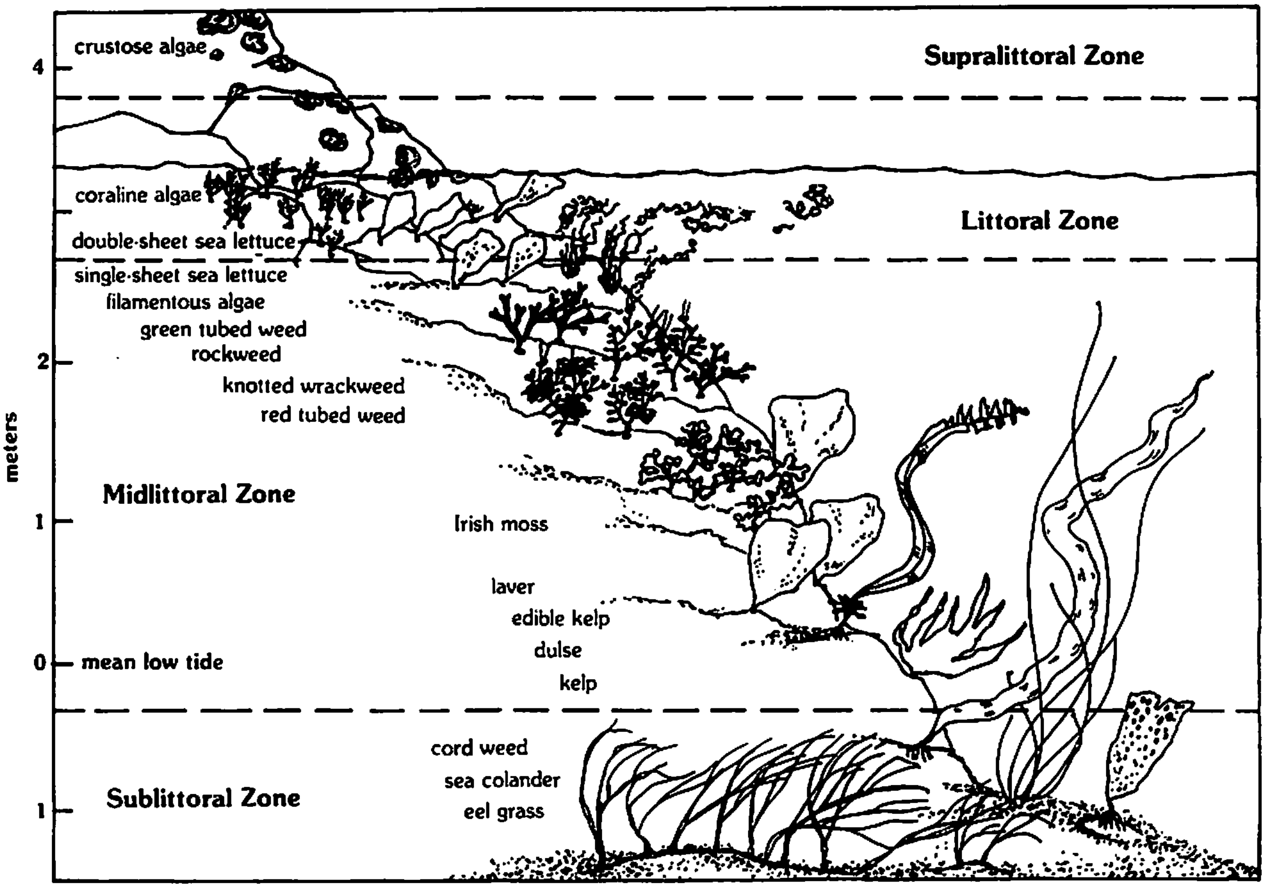
Algae Zones



Background Information: What Are the Relationships Between the Plants, Animals and Their Environment In the Gulf of Maine?

The information up to this point has been primarily concerned with *describing* the physical, chemical, geological and biological characteristics of the marine environment in general and of our own Gulf of Maine, in particular. You are probably wondering by now "How does all this fit together? How are the physics, geology, chemistry and biology of the marine environment all related? What does all this have to do with me, anyway?" Perfectly justifiable questions! In this subsection, we will attempt to illustrate some of the ways these various processes are related to each other. In later sections, we will attempt to show the relationships to us, the human citizens of the Gulf of Maine areas.

You learned in the subsection on sediment transport and salinity that a variety of substances are carried by rivers to the sea. While some of this material remains as solid particles and is carried in suspension or is bounced along the bottom, much of it is dissolved by the water and remains in solution, contributing to the salinity of the Gulf. These materials get into river systems by a process called *weathering*. Weathering is actually caused by a combination of physical and biological agents. Rain, freezing and thawing, and certain plants and animals help to *erode* or break down rocks into particles small enough to be washed into the rivers. (In a heavy rainstorm, actually, quite large rocks and stones can be moved into rivers from their banks!) So here we have a relationship between the physical and biological process of weathering and the geologic process of sediment transport and the chemical characteristic of salinity.

Two physical processes occurring in the marine environment itself, waves and tides, also contribute to the amount of sediment in the Gulf. Both waves and tides contain large amounts of energy that causes erosion of the shores and coastal bottom of the Gulf. This material, as well as sediments contributed by rivers, enters the current system of the Gulf. Here again we see a relationship between the geological process of sediment transport and the physical characteristics of the Gulf (the waves, tides and currents). What happens to these sediments? When the currents grow weak in late summer, most sediment material is deposited directly onto the mainland or onto offshore barrier islands. Later, during winter storms when wave action is the fiercest, some of this material is removed and deposited offshore or returned to the current system that strengthens again come spring. Thus, waves, tides and currents (physical processes) are most certainly related to the building up and the wearing down of beaches (coastal geological features). Why some beaches are entirely rocky, others entirely sandy, others muddy and yet still others, a combination, has a great deal to do with the physical forces of currents, waves and tides.

The chemistry of seawater is very closely related to both the geology and the physics of the coast. The salinity distribution in Gulf waters depends a great deal on the geology of the area, especially the bottom topography. As was noted in the subsection, "Chemical Composition of Seawater," the salinities tend to increase from south to north. This is due to the greater degrees of vertical mixing of waters in the northern part of the Gulf where it receives an injection of warmer, but saltier water from the south through the Northeast Channel. Thus, this geologic feature, the Northeast Channel, is an important factor in determining how dissolved substances are distributed throughout the Gulf. The physical processes of tides and upwelling tend to mix the surface waters with deeper waters in this portion of the Gulf, contributing to the higher surface salinities by bringing up nutrients and sediments from the bottom. By the same token, in more southerly sections of the Gulf, less vertical mixing takes place. The Great South Channel, which separates Georges Bank from the East Coast Shelf near Cape Cod, is relatively shallow compared with the Northeast Channel and it does not allow as much "outside" water to enter the Gulf. The tidal turbulence is less in the southern portions of the Gulf and these two factors combined with less winter cooling of the waters create the situation of a stable thermocline which inhibits vertical mixing of waters to a large extent. Thus, the waters of the more southern sections of the Gulf are less salty than those of the north because of physical and geologic factors.

All three, the physical, chemical, and geological, characteristics greatly influence the biology of the Gulf of Maine. We have learned that several types of beaches exist in Maine that can be identified according to the size of sediment particle that makes up each: rocky, pebbly, sandy, muddy. Very different kinds of plants and animals live at each type. For example, the rocky shore inhabitants are, by and large, organisms that have the ability to cling to, or hide among, rocks to protect themselves from the fury of the waves and tides. If they were unable to do so, they would be washed away by every high tide or every big wave. Animals like the periwinkles and other snails, and the limpets have a strong muscular foot with which they can grip the rocks. Likewise, starfish and sea urchins have hundreds of suction-cup like "tube feet" which enable them to do the same. Blue mussels attach themselves to rocks and to each other by means of tough threads (called the *byssus*). Even the plants, the rockweeds and kelps in particular, have root-like "holdfasts" that anchor them to the rocks. Rock crabs hide amongst the rocks for protection from the elements.

Pebbly, sandy and muddy beaches tend to be populated by animals who can tolerate being moved about or who can burrow for protection. Sand crabs, mole crabs, fiddler crabs, beach fleas, sand worms, and clams are examples of animals that can bury themselves. Hermit crabs and mud snails have some ability to grip the bottom, but also do not appear to mind being washed around by waves and tides. Mud flats offer more protection for burrowing creatures like soft clams, razor clams and worms than do either sandy or pebbly beaches because it requires more wave and/or tidal energy to erode and move away mud than sand or pebbles.

The topographic and geologic features of the bottom of the Gulf also influence who lives there. Cod, for example, tend to stay over rocky or pebbly bottoms or ledges, although in early spring they can be found over soft sand or mud. Haddock prefer gravel or gritty clay bottoms, while the white or mud hake, as its name implies, lives over muddy bottoms, as does the red hake. Cusk, another commercially important fish species is usually found on rocky bottoms and around boulders where it feeds on crabs and mollusks. The flatfish, like the flounders and the soles, generally prefer soft sandy bottoms as they often bury themselves for protection.

The physical forces of tides, waves and currents have a great deal to do with "who lives where." As we saw in the previous subsection, the rocky shore, in particular, is easily divided into several zones which are generally based on the furthest extents of the tides and of the splashing of waves. Clearly, only those animals that can tolerate being exposed to dry air and hot sun for six hours at a stretch will be able to survive in the intertidal zone. Animals like the periwinkle, that can pull its body and foot tightly inside of its shell and seal itself off from the outside environment are found here because they have adapted this mechanism for survival.

Currents are also very important to marine flora and fauna, particularly in offshore areas. Currents are largely responsible for the transportation of the minerals and nutrients that enter the Gulf via rivers, out to the open areas where they can be utilized by marine plants that live there. We have discovered that there are numerous substances that are necessary for plant growth in the ocean. These substances, for example, carbon, oxygen, nitrogen, phosphorus, manganese, iron, cobalt, copper, zinc, silicon and boron, vary in amounts from place to place and living organisms depend upon surface and deep water currents and upon the physical processes of upwelling, convection and tidal turbulence to make these essential materials available to them. The deep ocean currents, in particular are responsible for bringing oxygen from the surface, where these currents are formed, down to the depths of the ocean, where the currents spend the bulk of their existence.

Finally, the chemical makeup of the water is crucial to the biology of an area. We have already discussed the nutrient elements and their importance to marine life. One mineral important to plant and animal life, that has not yet been discussed is calcium carbonate (occurring as calcite or aragonite). This substance is used by corals, mollusks, echinoderms, brachiopods, forams, (zooplankton) and coccolithophores (phytoplankton) to make shells, and/or skeletons. The distritribution of this mineral in ocean waters will therefore influence the distribution of the plants and animals that utilize it. In addition, the distribution of calcium carbonate also influences the type of sediments one finds on ocean bottoms and on beaches. In tropical areas, for example, the crushed remains of coral skeletons and mollusk and echinoderm shells make up the bulk of the beach sands and shallow, offshore sediments. The White Cliffs of Dover in England are composed primarily of chalks formed from the shell remains of the plant plankton family *Coccolithophoridae*.

But the salinity of seawater is related to the biology in more ways than just supplying nutrients and minerals necessary for growth and shell formation. The mere presence of salts in seawater affects the density of the medium and, thus, the ability of the water to support floating and swimming organisms. If you've ever had the opportunity to swim in freshwater and then in salt water (especially *very* salty water such as occurs in Great Salt Lake, Utah or in the Dead Sea) you would have noticed how much easier it is to "float" in the saltier water. Salt water makes one more buoyant than fresh water. While swimming and floating animals do live in fresh water, the size of freshwater creatures is generally limited. However, in salt water, much larger animals (like whales!) can be supported. Also, although the salinities of the open ocean are restricted to a fairly narrow range (33 o/oo to 38 o/oo), the salinities of estuaries, tidepools and salt ponds can vary quite a bit. Organisms living in these areas must be able to tolerate rather extreme changes in salinity over rather short periods of time. Tidepools, especially, are harsh environments. Formed by seawater left behind in depressions, tidepools can become hot and saline on a warm, dry, sunny day or can become rapidly diluted by a sudden shower. Yet, tidepools still support many kinds of marine plants and animals like rockweed, sea anemones, isopods, periwinkles, sponges and several types of small fish. Many organisms cannot stand drastic changes in salinity and will die if taken from freshwater and placed in salt water or vice versa. The Common Oyster, for example is a brackish water species and is intolerant of prolonged exposure to fresh water or marine salinities (over 30 o/oo). An oyster population living in a brackish lagoon behind a barrier island could be wiped out by a storm-caused or man-made breach in the island that allowed salty seawater to enter their habitat. The killfish, on the other hand, can successfully adjust to fresh, brackish or salt water environments. (Recall from the "Chemical Compositon of Seawater", the terms *euryhaline* and *stenohaline*).

We have said very little, up to this point, about the effects of temperature in the marine environment. In fact, temperature is a very important characteristic which can have important influences on the current structure and on the living organisms of an area. Let us first look at the effect on currents.

We have mentioned how salinity, or salt content, can influence the density of seawater (saltier water is more dense, less saline water, less dense). Temperature can have the same effect: colder water is more dense, warmer water, less dense. Hence, water that is cooled to a very great extent, for example, surface water at either the North or South Pole during the winter, will sink beneath the surface, being replaced by the somewhat warmer water below it. This water is the coldest of any on earth, so it sinks right to the very bottom of the oceans. There, thanks to the rotation of the earth, these cold waters move northward (in the case of South Pole water) to the equator forming *permanent* bottom currents in all of the earth's oceans. By the same token, water that is not cooled to such a great extent, sink to middle depths and form permanent intermediate currents. These currents stay at these middle depths because they are *less dense* than the very cold, very dense currents beneath them.

Another effect of temperature differences in the marine environment is in the formation of the *thermocline*. Have you ever been swimming in a fairly deep lake and dropped your feet down beneath you only to find that the water below you (where your feet are!) was much colder than the water near the surface where your head and chest are? If so, then you have experienced crossing the thermocline! THe thermocline forms in deep water in the late spring and summer when the sun's rays warm the surface waters of a lake or ocean. Beyond the depth to which the sun's rays can penetrate, the water is not warmed much at all. What occurs is an area where the temperature drops *sharply* from a fairly warm value to a rather cold one. This area is called the *thermocline*. The water below the thermocline is cold and therefore more dense than the water above. What happens is that the thermocline acts as a sort of wall, preventing bottom water from being mixed with surface water. What this means is that nutrients cannot be brought up from the bottom to the surface during the months that the stable thermocline exists. (In the fall, surface waters are cooled enough to cause the thermocline to break down — not a great enough density difference between surface and deeper water — and mixing can occur.) Thus, areas in which a strong thermocline is established (for example, in the southern portions of the Gulf of Maine) tend to be less productive in terms of marine life than areas where surface waters do not warm up as quickly because of more intense winter cooling and vertical mixing of water prevents a stable thermocline from forming. (For example, the northeastern sections of the Gulf.)

The formation of a thermocline is significant in another way. Currently experiments are underway to determine the feasibility of constructing an "ocean thermal energy conversion" (OTEC) plant. Such a plant would utilize the hot surface waters of the ocean in tropical areas to convert a "process liquid" with a very low boiling point (for example, liquid ammonia to vapor and then condense to vapor back to liquid using the cold waters beneath the thermocline as a cooling agent). The process of vaporization-condensation produces energy to run a turbine which generates electricity. An experimental OTEC plant is already in existence near Hawaii.

Finally, temperature affects marine organisms in a variety of ways. Some organisms can tolerate a wide range of temperatures and not be harmed (are called "eurythermal" organisms) while others are killed or severely damaged by even small changes in temperature (are "stenothermal" organisms). The discharge of heated waters into the marine environment by nuclear power plants is a concern which will be dealt with in some detail in Section III.

Not only do the physical, geological and chemical conditions of the environment have connections to each other and to the biological communities of the sea, but also the organisms — plants and animals — of the oceans have significant interrelationships with each other. Probably the most basic, and perhaps the most important, relationship between plants, animals and their environment is that of the *food web* (or food chain) relationship. (Fig. 28) In simple terms, the food web starts with energy from the sun which enables green plants to take carbon dioxide and water from the environment to manufacture their own food in the form of glucose (a sugar or carbohydrate). In the process (called photosynthesis), the plants also produce oxygen which is released for use by animals. The sunlit surface waters of the ocean are chock full of microscopic plants (phytoplankton) which support themselves through photosynthesis. Of course, all plants also need nutrients for growth and these, as has been mentioned previously, are extracted from the seawater. These tiny plants are grazed upon by microscopic animals (zooplankton) who are in turn eaten by filter feeding organisms like clams, mussels, many types of fish and many species of whales. Indeed, the largest creature in the ocean, the blue whale, feeds daily upon many tons of zooplankton mostly, tiny shrimp-like animals called krill. However, most of the animals that eat zooplankton are themselves food for some other organisms. The clam becomes a meal for a crab, for a boring snail, for a starfish, for a starfish, for a herring gull or for a person. The small herring is dinner for a larger fish like a bluefish, for a gull, for a seal or a person. The larger fish is eaten by an osprey, a seal or a person. And so on. As you can see there are some organisms that form part of the chain for *many* other organisms. So the term *food web* is actually more appropriate.

There are members of the web known as top carnivores who are not themselves eaten by any other organism (like people!). That position in the web becomes very important when one considers the movement of contaminants through the web. For example, if a contaminant, such as the chemical insecticide DDT (now banned for use in this country, but still used in other countries) is sprayed on marshlands and is absorbed by the mud, it will enter the food web and become more and more concentrated as it moves up the line of carnivores to the top. In the mud, it is picked up in small amounts by phytoplankton living there. Zooplankton will eat *many* phytoplankton. Minnows will eat millions of zooplankton and the chemical becomes concentrated even further. Larger fish eat the minnows, and an osprey will eat the larger fish. The osprey, being at the end of a branch of the web is receiving many more times the concentration of DDT than what originally existed in the mud because at each step in the web, the chemical becomes more concentrated. Human beings, also at the end of a food web branch, should consider carefully what kinds of substances they put into their environment!

To summarize the main points of this reading: we have seen that the physical, chemical and geological processes in the marine environment are very much inter-related. Indeed, we have presented only a small fraction of the many inter-relationships that exist amongst these processes. In addition, we have discussed how the physical, geological and chemical processes influence the biology (the living plants and animals) of the marine environment. Finally, we looked at just one example of the interrelationships *between* the biological members (the plants and animals) of the marine environment: the food web.

In later sections we will examine how the physical, geological, chemical and biological processes within the Gulf of Maine have an effect upon the people who live in the region of northern New England and maritime Canada both along the coast and inland.

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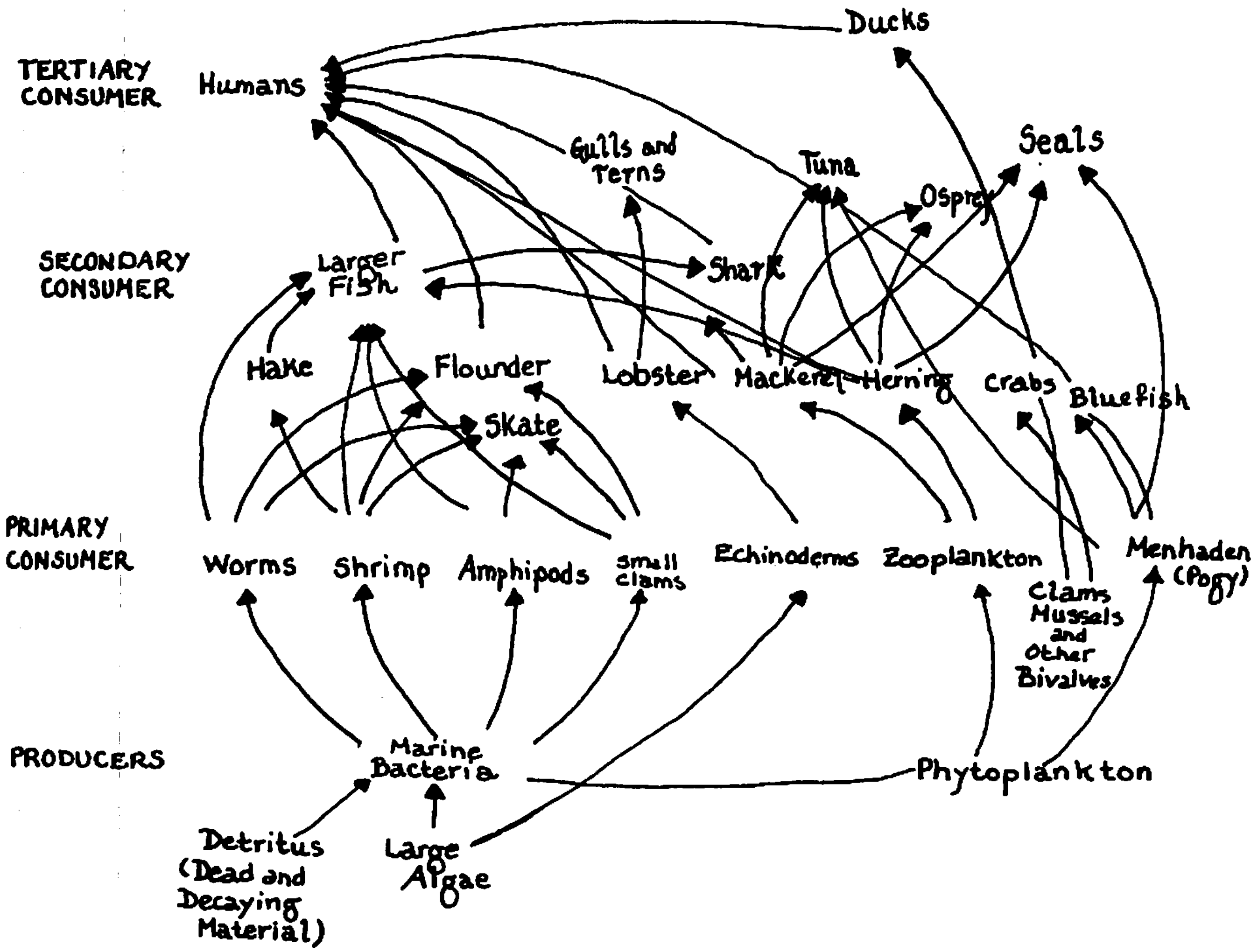

FIGURE 28

Section II: People and the Sea

Introduction

Most people are aware of relatively few of the many ways people use the sea to their benefit. It is important to realize just how crucial the "world of water" is to our daily lives before rational decisions can be made regarding our future use of this environment. The background information for this section will cover a number of "connections" between people and sea, which have been contained in two comprehensive readings:

1. Uses of the Sea (The Sea as a Provider)
   a. Food
      1. Fisheries
      2. Seaweed extracts
   b. Transportation
      1. Deep water ports
      2. Intracoastal waterways
   c. Fossil fuels, minerals
      1. Outer continental shelf (OCS) oil and gas development
      2. Ocean minerals mining
   d. National defense
   e. Water dependent industry/utility siting
      1. Nuclear power plants
      2. Oil refineries
      3. Alternative sources of energy
   f. Recreation
      1. Boating
      2. Swimming/Scuba Diving
      3. General Coastal Tourism
   g. Inspiration
      1. Sea literature
      2. Marine art
      3. Sea, inspired music, sea chanteys
2. Climate and weather (Because I Like It Here)

It is hoped that program participants, after studying this section, will take a look at the uses that are made of the coast in their own state and will come to a greater appreciation of our marine environment, as a result.

Background Information: The Sea as a Provider

How do we use the sea? What does the ocean *do* for us besides "sit there and look pretty"? How does it affect our daily lives?

A person living on the coast, when asked "why do you live near the sea?" might give one or both of the following reasons:

1. "Because I make my living from the sea."
2. "Because I *like* living near the sea."

Let us examine each one of these seemingly simple reasons in more detail, for they actually say alot more than they appear to at first glance.

How many people do you know who make their living from the sea? What do they do? Probably most of us in northern New England know someone who is a fisherman, a lobsterman, a clam digger, or a wormer. These are only a few of the ways people can earn their living from the ocean. Consider the following. Marine algae are used in the production of colloids or gelling compounds, known as carageenan, agar and alginate. These two compounds have hundreds of uses and most of us come in contact with products made with the help of a seaweed colloid every day. For example, carageenan and agar are used as a thickening agent in puddings, ice cream, syrups, cottage cheese, spaghetti sauce, and salad dressings. Just one use for alginate is in aiding the removal of rubber tires from their moulds during their production. A more complete listing of uses for marine colloids can be found in Table I. One of the most commonly used seaweeds in the marine colloid industry is Irish moss. Since our coastline is blessed with an abundance of Irish moss, northern New England is home to several marine colloid establishments. The owners and employees of these businesses, and the people who collect the algae for the colloid industry all derive income from the sea.

The mining of minerals from the sea is also a source of income for many people. Recall that the oceans receive hundreds of millions of tons of sediment each year from rivers. Most of this material is deposited in near-shore areas and onto beaches. Around the world, marine beaches and the coastal sea bottom are mined for diamonds, magnetite, columbite, ilmenite, sircon, schulite, monazite, platinum and silica. The most important mineral commodities mined in the world today are sand and gravel. Used extensively in the construction industry, sand and gravel traditionally were taken from land based pits near the market. However, opening up new pits close to population centers is becoming increasingly difficult and mining concerns are turning more and more to offshore sand and gravel deposits. Since much of the world's population is concentrated in the coastal zone, the mining of offshore deposits is still close to the largest markets.

Another promising sea-mineral venture is that of mining manganese nodules. It is thought that these nodules form when manganese, nickel, copper, cobalt and other minerals are taken out of seawater by certain marine creatures and are released when the animals die. The accumulating minerals form "lumps" of various sizes which lie on the sea floor in varying concentrations. In the Pacific, it is estimated that these nodules are forming at the rate of 10 million tons per year and on some areas of the sea floor they are as concentrated as 100,000 tons per square mile. Several nations (excluding the United States) have already begun to take steps towards mining manganese nodules and it is expected that by 1987, mining operations will be in progress. The nodules are particularly important for their nickel content. It is projected that by 1987, one-fifth of the United States nickel demand could be met by mining nodules.

Finally, deposits formed by the accumulation of animal and plant shells and skeletons are important sources for calcium carbonate (lime) which is used in the manufacture of commercial chalk, medicines, dentrifices, cement, garden lime and other products. Another important mineral deposit formed by the accretion of animal skeletons on the sea floor is calcium phosphate (phosphorite). This mineral has many important uses including the following: as a component of baking powder, as a plant food, as a plastics stabilizer, in glass, ceramics, and rubber. it is an important source of phosphorus which is used in safety matches, pyrotechnics, fertilizers, and steel. Another compound, formed from parts of organisms long dead, to be gotten from the sea floor is coal. Large reserves of oceanic coal are known to exist off Alaska and on the continental shelf of eastern Canada. In fact, coal is quite abundant off the shores of most coastal nations in the world. At present, power producing industries are looking to coal as oil reserves grow slim. Although land reserves of coal are very large, the convenient location of oceanic coal to the major centers of population could make it an important resource. Table III lists some important marine minerals, metals, and organic compounds and their uses.

In addition to mining minerals from on-shore and submerged, off-shore beach deposits, many substances that exist in solution in seawater can be removed by precipitation. Recall that the two most abundant elements in seawater are chlorine and sodium. These most commonly exist as the compound sodium chloride (often called "table salt"). Chlorine can be removed from seawater by electrolysis of sodium chloride and is used extensively as a water purifier, a disinfectant, a bleaching agent and in the manufacture of compounds such as chloroform and carbon tetrachloride. Other elements that are contained in solution in seawater that are important to humans are listed in Table II.

Minerals, metals and other solids are not the only commodities to be "mined" from the sea floor. Possibly the most controversial use of the sea is that of extracting petroleum and natural gas from the ocean floor. Already reserves of oil and gas located on the Outer Continental Shelf (OCS) have been tapped and thousands of possible drilling sites have been explored. Oil company estimates claim that some 186 billion barrels of oil and 844 trillion cubic feet of natural gas can be recovered from the Outer Continental Shelf of the United States. Off the East Coast, they estimate that reserves hold as much as 58 billion barrels of oil and 222 trillion cubic feet of gas.

At the present time oil is already being extracted from the

Outer Continental Shelf in the Gulf of Mexico and off California. Oil industries are anxious to exploit reserves elsewhere offshore including in two areas rich in fish: Georges Bank and the Gulf of Alaska. In northern New England, the conflict between the oil concern and the fishing industry over drilling on the Georges Bank is one of the most important issues facing that area; it will be dealt with in detail in a later section.

The petroleum industry has an important impact on the coastal zone as well as on the offshore ocean areas. Because the bulk of petroleum products are shipped by tanker, most refining facilities are located on the shore. The siting of this and other so-called "heavy industries" along the coast (includes power generation stations needing water for cooling and other purposes) is another serious issue for nothern New England. It, too, will be discussed in a later section.

We obtain energy from the sea in other ways besides drilling for oil. The ocean appears to be the most appropriate environment from which to extract solar energy. At the present time, demonstration facilities exist that make use of solar energy contained in seawater to generate power. The principal behind "ocean thermal" power generation lies in the difference in temperature between the warm surface layers of the seas and the cold ocean depths. Recall that in deep bodies of water, sunlight only penetrates to a certain depth and warms the water down to that depth. Below that point, the temperature of the water drops steadily (the thermocline) until a constant cold temperature is reached which persists almost to the ocean bottom. In the tropics, the difference between the surface temperature and the temperature below the thermocline can be greater than 20°C. Ocean thermal energy conversion (abbreviated OTEC) works essentially the same way as a steam powered plant. In the steam power plant, the heat from the boiler converts a "process fluid," usually water, to steam. As the fluid vaporizes it expands and it is this expansion that creates energy to turn a turbine and generate electricity. The steam is then condensed back to a fluid by contact with cold water. In the ocean thermal power plant, a liquid with a very low boiling point, like ammonia, or butane, is vaporized by the heat of the surface waters. The vaporizing fluid expands, rotates the turbine and generates electricity. The vapor is then condensed by contact with the cold ocean depths, is pumped back to the surface and the cycle begins again. With our present technology, OTEC generated electricity is rather expensive, however, the Department of Energy estimates that by 1990, OTEC electricity will be competitive with traditionally generated power and that by the year 2,000 OTEC could replace 400,000 barrels of oil a day. A "mini-OTEC" project has been installed near Hawaii and is currently producing small amounts of electricity.

Another potential use of the oceans so far as electricity is concerned is a site for windmills. Recall that winds are generated by air rising from, and falling towards the earth's surface (due to the heating of the surface by the sun) and by rotation of the earth. The oceans offer an ideal situation for windmills because there are no disrupting features like mountains, valleys, and forests to interfere with the wind flow.

In certain of the wind belts, most notably the Trades, the winds blow almost unceasingly at nearly constant speeds. These regions would be ideal for wind generated electric power plants. Again, however, at the current state of the art of wind generated electricity, the technology has not been developed to produce power economically. Many are hopeful for windmill use on the oceans in the future.

Other forms of ocean energy available for tapping include wave and tidal energy. Of these two, tidal energy has been successfully harnessed by plants in France and several projects are proposed for the Bay of Fundy where the tides are the largest in the world. Also, the meeting of fresh and salt water, such as occurs in an estuary, produces an enormous amount of energy. Experiments are underway to determine the feasibility of capturing this so-called "fresh water-salt water interface" energy for human use.

Finally, the ocean already plays a part in the generation of power by nuclear fission and most likely *will* play a role in the production of electricity by nuclear fusion. The first case, cold water is necessary for cooling. This explains why nuclear (and also fossil fuel) power plants are often located in the coastal zone where the supply of cooling water is abundant. The water extracted from the sea for cooling of the plant is returned at a higher temperature. This has been one of the points of controversy in the debate over power plant siting, and will be discussed more fully in a later reading.

Power generation by nuclear fusion involves the *joining* of the nuclei of two light atoms, usually two forms of hydrogen, deuterium and tritium. (Nuclear *fission*, in use today, *splits* a heavy atom of uranium.) The fuel for nuclear fusion will be "heavy" water (water whose hydrogen atom contains extra neutrons) which is available in the oceans. Thus when nuclear fusion is developed as an energy producer, ocean water will become the fuel, not just the coolant.

The sea, therefore, already plays some role in the production of energy for much of earth's society and it promises to assume an even more important position in the future.

In what other sea-related endeavors do Americans earn their living? We have barely scratched the surface of uses of the sea with those we have mentioned so far.

Historically the oceans were not only a source of food, but also were the primary "highways" for transportation. Indeed, our ancestors, and the great explorers before them landed upon the shores of America after crossing the great ocean in ships. Ocean trade dominated the cargo transport scene for the first two centuries of American existence. While overland and air transport have in this century captured a great deal of the business of moving goods and people, in some enterprises, ships have always played a major role, for example, in the oil industry and in the transport of mineral ores on the Great Lakes. Ships also continue to be important in carrying "containers" of goods to foreign ports. In 1977, the United States had some 550 ships in its merchant marine with a carrying capacity of more than 14 million tons. Over $400 million in subsidies are being paid to American operators of merchant ships to help keep them competitive in foreign trade with certain lines and cargoes. In excess of $20 million goes into research and development of the merchant marine and several million dollars more is allocated to the merchant marine academies around the country. Finally, the merchant ship construction industry, which employs over 100,000 people has also been subsidized by Congress. If we add several hundred thousand more people who work as ships' crews, repairmen, longshoremen, harbor pilots, marine insurers, marine lawyers, etc., we are talking about a very sizable number of Americans whose livelihoods are very much connected to the sea.

If we also consider the fuel costs involved in shipping a ton of goods by various means, (air truck, rail, barge), the implications for the future of water cargo transport, in these days of dwindling fuel supplies, becomes apparent. One gallon of fuel enables an airplane to carry a ton of goods only five miles; a truck, 50 miles; a freight train, 180 miles; and a barge on the inland waterways, 330 miles. The inland waterway system of the United States covers some 25,000 miles and could enable a vessel of the right size to navigate completely around the eastern half of the country: up the Mississippi waterway to Chicago and the Great Lakes, through the canal at Sault St. Marie and the St. Lawrence Seaway out to the Atlantic, down the east coast on the Atlantic intracoastal waterway, across the Gulf intracoastal waterways back to the Mississippi again. Because of the inland waterway systems, 40 of the 50 United States have "seaports". Figure 29 shows the waterways of the United States.

While we are on the subject of transportation, we should make special mention of the U.S. Coast Guard which falls under the jurisdiction of the Department of Transportation. This agency has responsibility over the "highways of the sea." The Coast Guard operates and maintains lighthouses, channel and other markers, enforces regulations concerned with coastal travel, aids seafarers in peril, broadcasts weather and tide information, sponsors safe boating programs and generally tries to make sea

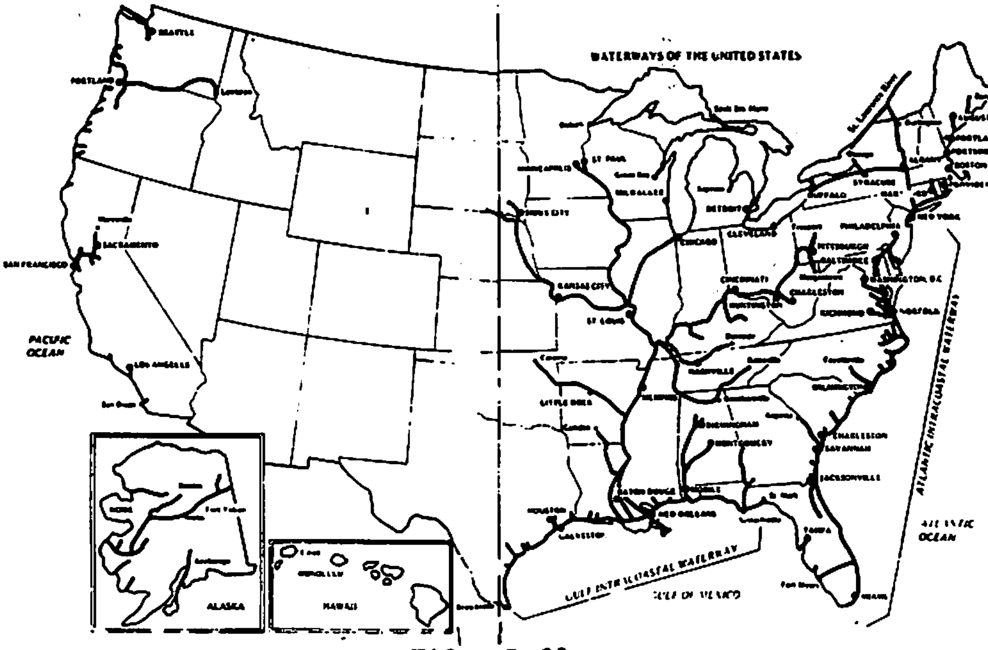

FIGURE 29

travel as safe and pleasant as possible for all concerned. The many thousands of Americans who work within the Coast Guard must also be added to the already large number of citizens whose jobs are ocean-related.

Most of us who have studied American history know of the important role the sea has played, and continues to play, in national defense. The United States, virtually separated from the rest of the world by the vast areas of ocean, has felt a need for a strong navy. In recent years, the Navy has concentrated upon the construction of nuclear powered submarines and other combat ships and upon ballistic missiles capable of travelling between 2,500 miles (POLARIS/POSEIDON missiles) and 4,000 miles (TRIDENT missiles). In 1977, President Carter asked that $41 billion of the total Defense budget of $110 billion be allocated to the Navy and that $8 billion be authorized for new ship construction alone. This was the largest peacetime commitment ever made to the Navy. The Reagan administration appears to be heading in the direction of increasing the Naval allotment even more.

Two establishments in Maine are very much affected by the U.S. naval budget. The Bath Iron Works and the Kittery Naval Shipyard are both involved in the construction, repair and storage of naval vessels and together employ a large number of people in the state.

While the uses of the ocean and inland waters discussed thus far employ literally millions of Americans, probably the average citizen is most aware of the value of the ocean and the sea-linked Great Lakes through his/her recreational habits. With the increases in leisure time and in expendable income, the tourist industry has grown to such proportions that estimates claim the recreation business stands in second place in coastal economic impacts (with offshore petroleum and gas in first place, fisheries, third). Indeed, water recreation has become so popular that most swimming areas of the coast can be characterized as places "where the surf is one-third water and two-thirds people." (John Steinbeck) According to some authorities, nearly 150 million Americans engage in aquatic recreation each year, be it sport fishing, boating, swimming, diving, sunbathing, or beachcombing. Maine, with its beautiful, rugged coastline, attracts millions of tourists every summer who camp, sail, hike, or otherwise, relax by the sea. Just one important feature of Maine's coastal tourism industry is the Windjammer fleets of the Camden-Rockland-Rockport area. Now numbering nearly twenty vessels, the fleet averages a gross income of well over $2 million annually.

Before leaving the subject of sea-related employment in America, let us return briefly to the fisheries. In Maine the fishing industry is in third or fourth place (depending upon when and by whom the estimate is made) in terms of economic impact, and its development is one of the most important coastal issues facing the state today. This and other crucial concerns will be dealt with in detail in a later reading.

On the national and world scene, the potential for development of the fisheries is virtually limitless. At present it is estimated that the United States consumption of edible fish products is 11 to 12 pounds per person per year. This is far less than the amount of beef, pork, poultry and lamb eaten by the average American and is probably one of the lowest consumption rates of any coastal nation in the world. Yet, medical authorities have recently warned that Americans are consuming too much of the animal protein that is also high in fat, cholesterol and calories (i.e., beef and pork especially). Seafoods are becoming increasingly preferred by nutrition-conscious Americans who realize the high protein, low-fat makeup of most fish.

Seafoods contain generous amounts of the so-called "building blocks" of proteins: the amino acids. Eight amino acids (tryptophan, phenylalanine, lysine, threonine, valine, methionine, leucine and isoleucine) are considered essential to human health and are found in goodly proportions in seafoods. In protein foods that are high in muscle fibers (e.g., beef, pork, lamb) these amino acids become "tied up" with muscle connective tissue and are thereby less available for digestion by the consumer. In general marine organisms have less connective tissue than "land" food animals and therefore the protein of seafoods is more easily digested. In addition, fish oil contains more of the polyunsaturates than even most liquid vegetable oils. Polyunsaturated oils have been shown to be important in the prevention of arteriosclerosis and heart disease. Fish and shellfish are also excellent sources of certain essential minerals: sodium, potassium, calcium, phosphorus, zinc, sulfur, chlorine, iron, manganese, magnesium, iodine, copper, molybdenum, cobalt, selenium, and fluorine. Iodine, fluorine and selenium are particularly important to human health (iodine, in the proper functioning of the thryoid gland, flourine in preventing tooth decay, and selenium is thought to be helpful in the prevention of cancer).

While fresh fish is being sought after by many Americans, by far the greatest demand is for the convenience of frozen breaded fish sticks, fish steaks and shrimp. Thus, in recent years, both the health-promoting values and the ease of preparation of different seafood products have helped increase the demand for this food from the sea.

Americans are also eating more fish indirectly whether they realize it or not. More than 55% of the fish caught off American coasts is made into fishmeal and fed to other animals, particularly poultry and pigs.

Finally, a change in the methods of processing fish, and new government regulations have made a difference to the industry. Between 1955 and 1975 the American fishing industry fell behind that of other nations and the U.S. began to rely more heavily upon foreign imported seafoods. In 1975, the United States ranked fifth in its total capture of fish and fourth in terms of economic value, yet the value of fish imports from abroad, worth about $1.7 billion, far exceeded the value of commercial landings by Americans. Foreign fleets had become highly technologized and were appearing in American waters in the 1960's with modern trawlers and large factory ships fully equipped for sorting, cutting and freezing the catch. Unable to compete with the highly successful foreign methods, the catches of many traditional fishing towns, like Gloucester, Massachusetts declined dramatically during these years. Yet Gloucester and other fishing ports were able to make the switch from the catching to the processing of fish, thanks, in large part to the use of the fish block, a method of freezing large numbers of fish into a solid block for preservation and then using saws to cut off separate filets into a convenience food for American restaurants, hospitals, schools and homes.

Still, most fishermen wished to remain *fishermen*, not processors, and in 1977, the Fisheries Management and Conservation Act was passed to protect American fishing interests in the adjacent seas up to a distance of two hundred miles offshore. The provisions of the Act allow for fishing by foreign fleets within the two hundred mile limit by permit only. These permits are supposed to be granted only after American fleets have caught all they are capable of catching. In addition, the Act requires that management plans be devised for each commercially important fish species and that the provisions of these plans be adhered to by American fishermen so as to protect the resource for future generations of fish harvesters. In the northern New England area, the New England Regional Fisheries Management Council is responsible for the management of the fisheries of the region. The progress made so far by this council in regards to the management of the fisheries of our area will be discussed more fully in a later reading.

We should not leave this short introduction to fishing as a means of making a living without mentioning the many related industries. We have discussed briefly, the processing of fish products. Several processing plants are located along the coast of northern New England, which include the sardine packing facilities of Prospect Harbor, Eastport, Lubec and several other coastal communities, and fish freezing plants like National Sea Products of Rockland, and others. In addition, many thousands of people are employed nationwide in the transportation of fish products to market, in the building and maintenance of fishing vessels, in the construction and repair of fishing gear, and in the handling of the catch at the wharves.

Finally, we should not fail to mention the thousands of marine scientists, historians, archaeologists and marine educators, who use the sea in their work. Curiosity about the world of water has no doubt existed ever since humankind evolved as a land animal. We have evidence from prehistoric times that early humans built and used boats for travel and for catching food. Indeed, the oldest relic of a vessel ever discovered is one found in the pyramid of the pharaoh Cheops at Giza in Egypt. This ship is about 130 feet long, built of wood that must have been imported from elsewhere, and dates back to 2600 BC (about 4500 years ago!) We have every reason to believe that ships were used even before that time, though the only evidence we have are ancient carvings and sculpture. We know also that ancient Greeks, notably Socrates and Aristotle held long discourses with their students on the wonders of the sea. From more modern times, we have the records of oceanic expeditions such as the *Challenger* exploration of the 1870's and the submarine travels of the early twentieth century. Indeed, the history of human interest in, and use of, the sea is rich and exciting, and it is certainly unfortunate that we have not even scratched the surface here.

There is yet another use of the oceans that deserves mentioning, for it is one that many people do not realize or take for granted: that is, the inspirational quality of the sea. As Hal Goodwin puts it in his book *Americans and the World of Water*, "'The World of Water' breeds legends, conjures images, inspires art and poetry and acheives mystical significance in religion." Certainly we've all heard at least one sea chantey, read at least one sea adventure story, and seen at least one painting that was inspired by the sea. There are *many!*

Sea chanteys were work songs sung aboard ship with a rhythm aimed at helping get the sails unfurled, or the anchor up, or some other shipboard chore accomplished. Today, in northern New England and maritime Canada we can listen to performers singing songs of the sea, some traditional sea chanteys, others composed by these contemporary performers themselves. In addition, many impressionistic, and romantic composers of the nineteenth century were inspired by the oceans: "La Mer (French of "The Sea") by Claude Debussey is only one example.

Painters and photographers have also expressed the moods of the sea, and its relationship to people, in their work. Paintings of sea battles during the American wars are very popular, as also are pictures of the great clipper ships. The famous lithographers, Currier and Ives, were literally launched into success by their depiction of the burning of the steamboat *Lexington* in 1840 on Long Island Sound. Indeed, many of their later prints depicted sea scenes. And the well known American artist, Winslow Homer, is best remembered for his paintings of events upon the waters: "Breezing Up," the whimsical scene of young sailors, and "The Life Line" depicting the rescue, via cable line, of a woman from a shipwreck. Photography has also become a popular art form, and the coast of northern New England has oftentimes been the photographer's model.

Perhaps most of us are aware of literary works that deal with the sea. Several of the classics like Melville's *Moby Dick* and *Billy Budd*, Richard Henry Dana's *Two Years Before the Mast;* Jack London's *The Sea Wolf;* Nordoff and Hall's "Bounty Trilogy" (*Mutiny on the Bounty, Men Against the Sea*, and *Pitcairn's Island*) are well known to American readers. Writers from northern New England have also made valuable contributions to the field of marine literature. Joel Hedgpeth in the book *Americans and the World of Water*, writes that "the book of our generation has been Rachel Carson's *The Sea Around Us* (1951)." Carson, a late resident of Maine, is probably best remembered nationally for her book *Silent Spring* which warns us of the dangers of pesticide use, yet most of her writings were about the sea: in addition to *The Sea Around Us*, she also wrote *The Edge of the Sea, Under the Sea Wind*, and *A Sense of Wonder. A Sense of Wonder* beautifully portrays a child's curiosity about the natural world of the Maine coast.

Finally, amongst the writings of two well-known twentieth century American writiers, John Steinbeck and Ernest Hemingway, can be found fables of the sea. In Steinbeck's *The Pearl*, the humble fisherman Kino seeks and finds a valuable pearl to provide money to save his son, but is cursed by the possession of the pearl and eventually returns it to the sea. Hemingway's classic, *The Old Man and the Sea* is the story of the aging fisherman, Santiago, who goes out on a voyage to conquer the "great fish." He catches an enormous marlin that pulls him for many days far out to sea. The old man wins the battle against the fish, but, in a sense, loses one to the sea, for in bringing the great catch back to shore, it is devoured by sharks. The message here, for many, is that "to the sea belongs her own" . . . it is not a place to be dominated by humans. As Rachel Carson writes:

> Eventually man, too found his way back to the sea. Standing on its shores, he must have looked out upon it with wonder and curiosity, compounded with an unconscious recognition of his lineage. He could not physically re-enter the ocean as the seals and whales had done. But over the centuries, with all the skills and ingenuity and reasoning powers of his mind, he has sought to explore and investigate even its most remote parts, so that he might re-enter it mentally and imaginatively.
>
> He built boats to venture out on its surface. Later he

found ways to descend to the shallow parts of its floor, carrying with him the air that, as a land mammal long unaccustomed to aquatic life, he needed to breathe. Moving in fascination over the deep sea he could not enter, he found ways to probe its depths, he let down nets to capture its life, he invented mechanical eyes and ears that could re-create for his senses a world long lost, but a world that, in the deepest part of his subconscious mind, he had never wholly forgotten.

And yet he has returned to his mother sea only on her own terms. He cannot control or change the ocean as in his brief tenancy of earth, he has subdued and plundered the continents. In the artificial world of his cities and towns, he often forgets the true nature of his planet and the long vistas of its history, in which the existence of the race of men as occupied a mere moment of time. The sense of all these things comes to him most clearly in the course of a long ocean voyage, when he watches day after day the receding rim of the horizon, ridged and furrowed by waves; when at night he becomes aware of the earth's rotation as the stars pass overhead; or when, alone in this world of water and sky, he feels the lonliness of his earth is space. And then, as never on land, he knows the truth that his world is a water world, a planet dominated by its covering mantle of ocean, in which the continents are but transient intrusions of land above the surface of all-encircling sea.

Rachel Carson
The Sea Around Us (1951)

Thus, we see that there are a myriad of ways one can make a living from the sea. There are Americans who fish; who mine minerals, metals and other important substances from the sea; who drill for oil and gas in seabed sediments; who transport goods and people over the waters; who defend our nation at sea; who work in land based, water-dependent industries; who provide entertainment and recreational opportunities in aquatic environments; who, by virtue of their curiosity and desire to learn about the sea and its relationship to humankind, study the oceans for a living; and, who inspired by the sea, write, paint, photograph and compose music. The numbers of Americans so engaged in "water-related" work, then, is really inestimable, certainly in the millions and certainly includes many hundreds of thousands of Americans who do *not* live along the coast. The ocean and its connected freshwater environments, then, provide employment opportunities for countless citizens, both coastal dwellers and inlanders, in nearly a countless number of ways.

References

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TABLE I
Uses of Marine Colloids Derived From Seaweeds

Dairy	**Agar**	**Carrageenan**	**Alginates**
Ice cream stablizer	x	x	x
Ice milk	x	x	x
Milk shake	x	x	x
Sherbets	x	x	x
Ice pops and water ices	x	x	x
Chocolate milk drink		x	x
Instant puddings		x	x
Flavored milk drinks		x	x
Cooked puddings	x	x	x
Eggnog mix		x	
Variegating syrups		x	
Cottage cheese		x	x
Neufchatel-type cheese	x	x	x
Cream cheese	x	x	x
Cheese spread		x	x
Whipped cream		x	x
Yogurt	x	x	
Packageable milk/cream	x		
Beverages			
Soft drinks		x	x
Fruit juices		x	x
Beer foam stabilizer		x	x
Beer clarification		x	x
Fining wines, etc.	x	x	x
Ageing of spirits		x	
Bakery			
Bread doughs	x	x	
Cake battters	x	x	
Fruit cakes		x	
Doughnuts		x	
Pie fillings	x	x	x
Fruit fillings		x	x
Bakery jellies	x	x	x
Boiled cream fillings		x	x
Doughnut glaze	x	x	x
Flat icings	x	x	x
Meringues	x	x	x
Cookies	x		
Batter and breading mixes		x	
Citrus oil emulsions		x	x
Cake fillings & toppings	x	x	x
Frozen pie fillings		x	

Confectionery			
Candy gels	x		x
Caramels, nougats		x	
Marshmallows	x		
Dressing, sauces			
French dressing		x	x
Salad dressing		x	x
Syrups, toppings		x	x
Relish		x	x
White sauces		x	x
Mustard, cocktail sauces		x	x
Catsup		x	x
Dietetic foods			
Starch free desserts	x	x	
Salad/French dressing		x	x
Jellies, jams		x	x
Syrups		x	x
Puddings		x	x
Sauces		x	x
Icings			x
Candies			x
Vegetable & health foods	x		
900 calorie foods		x	
Meat, Fish			
Sausage casing	x		x
Fish preservation			x
Canned fish, meat, etc.	x	x	x
Coated jellied meat		x	x
Antibiotic ice		x	
Sausage ingredient		x	
Preservative meat coat	x	x	x
Synthetic meat fibres		x	x
Miscellaneous			
Dessert water gels	x	x	x
Jams, preserves	x	x	x
Prepared cereals	x		
Processed baby food		x	
Soups	x	x	x
Coating fruits, vegs.		x	
Frozen foods		x	
Synthetic potato chips			x
Fountain toppings		x	x
Artificial cherries			x

TABLE II

Important Elements Removed From Seawater

Element	Use
Magnesium	Structural alloys, pyrotechnics, flash photography, bombs, steel manufacture.
Bromine	Used in the manufacture of gasoline antiknock compounds, fumigants, dyes and photographic chemicals.
Sodium chloride	Use as table salt.
Chlorine	Water purifier, disinfectant, bleaching agent, manufacture of chlorofoam, carbon tetrachloride.
Iodine	Medicines, antiseptics.

TABLE III

Minerals, Metals, and Compounds Mined From Ocean Sediments

Mineral, Metal or Compound	Use
Diamond	Jewelry, cutting instruments, phonograph needles, etc.
Magnetite	An important source of iron ore.
Columbite	A source of miobium, used in steel alloys, arc welding, superconductivity research. Also a source of tantalum, used in electric light bulb filaments, electrolytic capacitors, lightning rods, nuclear reactor parts, surgical instruments.
Ilmenite	A source of titanium, used in alloys for aircraft metals. Is lightweight, strong, resistant to high temperatures.
Zircon	Source of zirconium used in ceramics, refractory compounds, as an alloying agent, in nuclear reactors, in medical prostheses.
Scheelite	A source of tungsten (which has the highest melting point and the lowest vapor pressure of any metal). These properties make it useful in high temperature structural materials, electrical elements (lamp filaments).
Monazite	A source of cerium which is used to make lighter flints. Also a source of lanthanum which is used in glass manufacture and in carbon lights for motion picture and television studio lighting.
Silica	A compound occurring as quartz, sand, flint and agate. Is used to manufacture a wide variety of materials most notably glass and concrete.
Platinum	Used in electrical components, jewelry, dentistry, electroplating.
Tin	Used to coat other metals to prevent corrosion, used in alloys (soft solder, pewter, bronze)
Glauconite	A source of potassium oxide, used in agricultural fertilizers and as a water softener.
Manganese nodules	Contains *manganese* (used in the manufacturing of steel), *nickel* (used in making stainless steel alloys and in electrical plating), *copper* (used in the manufacture of electrical equipment, communication cables and wires, tubing and sheeting for the construction and chemical industries, alloys, etc.), *cobalt* (used in heat resisting alloys for gas turbines, and as a catalyst in exhaust gas after-burners).
Calcium carbonate	Used in the manufacture of chalk, medicines, dentifrices, cement, etc.
Calcium phosphate	Used in baking soda, plant food, plastics, glass, rubber, & ceramics manufacture, safety matches, manufacture of steel.
Coal	Fuel, petrochemicals.

Background Information: Because I Like It Here

Certainly, not everyone who lives in the coastal zone earns a living from the sea. There are countless persons who live there "because they like it." Why do they like it? Probably a nearly universal response would be the beauty of the nearby water environment, the closeness to nature, and the mystery of the sea . . . the same inspirational qualities that prompt musicians to compose, writers to write, artists to paint, sculpt and photograph along sea related themes. Another reason would undoubtedly be that the coastal dweller likes the climate of the area. Most of us are probably personally aware of the mildness of coastal winters compared with areas only twenty miles inland, and the coolness of seashore summers. Just why does this moderating effect of the oceans upon nearby land areas occur? Recall, the properties of water: its molecular structure of atoms of hydrogen and oxygen, its temperature/density pattern of expanding and becoming less dense as it freezes, its high surface tension, and its ability to absorb and store substantial amounts of heat. It is the last characteristic, the high *heat capacity* of water that affects the climate of the entire planet. The heat capacity of a substance refers to the amount of heat that is necessary to raise the temperature of that substance from one degree value to another. Water's heat capacity is high compared with other substances, which means that it takes a great deal more heat to raise the temperature of one gram of water one degree Celsius than it does to raise the temperature of one gram of, say, iron, by one degree Celsius. Thus, an enormous amount of heat energy from the sun can be poured down upon the oceans of the earth without raising its temperature by more than a few degrees. At the same time, the land areas which have a *lower* heat capacity or ability to store heat, are raised in temperature quite markedly in summer by the increased intensity of the sun's energy. By the same token, water loses its heat much more slowly than land because of this greater ability to store the sun's heat energy, and in winter, the oceans can be, and often are, warmer than the land. Thus, over the course of the changing seasons in northern New England, the temperature of the oceans changes very little when compared with the extremes of temperatures reached by the land areas from winter to summer.

Land areas immediately adjacent to the oceans receive the largest benefits of this heat capacity of water. On a hot sunny day in summer the land will heat up quite rapidly, while the nearby ocean will heat up, in terms of temperature rises, only very slightly, "storing away" most of the heat received. Since air will be rising over the land due to the great amount of heat being radiated, a low pressure area is created. The air over the water will not be heated nearly as much and the air pressure there will consequently be higher than over the land. Since air moves from areas of high pressure to areas of low pressure (or from areas of cooler temperatures to areas of warmer temperatures), the cooler sea air will move onto the land providing the relief of a pleasant "sea breeze." Often at night in the summer or during the winter, the land will be cooler than the water and the cooled air will move off the land towards the ocean, creating what is called a "land breeze." These air patterns, caused by the differences in heat capacity of land and water, help keep coastal areas cooler in summer and warmer in winter than inland areas where the influence of the ocean is diminished.

Just as the nearness to water makes living more comfortable, climate-wise, the presence of water on the earth's surface and in its atmosphere makes the earth itself habitable. As we have seen, water, with its high heat capacity is a veritable warehouse of solar energy, a characteristic that enables the water vapor in the atmosphere to "capture" and store solar heat, thereby protecting the earth from extreme heat during the day and extreme cold at night; a condition that is believed to exist on Venus and Mars, our planetary neighbors. Another capability of water, related to its heat capacity enables it to exist in two states simultaneously without a change of temperature. Amazing as this may seem, water does exist as both a liquid and a solid at 0°C (32°F) and as both a liquid and a gas (water vapor) at 100°C (212°F). The property that enables water to do this is called "latent heat" and it means that water in any state is a heat/energy source. When ice (at 0°C) melts to produce water at the same temperature, it absorbs heat (called the "latent heat of fusion"). When that water (at 0°C) freezes solid to produce ice at that temperature, the latent heat of fusion is released. This same process also occurs when water vaporizes to steam and when steam condenses back to water — heat is either released or absorbed.

Thus, the movement of water about the earth — on its surface, below the surface and in its atmosphere — profoundly effects the global climate and causes changes in the local "weather." The great worldwide circle that water travels in is called the water, or hydrologic cycle (see Figure 30). Water, evaporated from oceans, lakes, ponds, streams and rivers, from the land, and from plants (through a process called transpiration) travels as invisible vapor high into the atmosphere where it is cooled sufficiently to condense onto particles of dust. These dust-water droplets congregate into clouds, eventually falling to the ground as rain, hail, sleet or snow when the clouds become too overburdened. This liquid or solid water falling onto the earth ultimately ends up in ground water tables, rivers, streams, lakes and oceans. From surface waters, evaporation again takes water away in the form of vapor and the cycle begins again. While the amount of water that leaves the earth's surface due to evaporation and transpiration is balanced *globally* with the amount that returns via precipitation, as we all know, the cycle is not in balance *locally*, with some areas of the earth receiving far more precipitation than others, and yet other areas contributing more vapor due to high evaporations. The differences in precipitation and evaporation rates in different parts of the world are a result of more direct solar heating (near the equator, for example), wind patterns and the presence of large land areas. Thus, the *climate* of the earth and the *weather* of different localities depend upon the water cycle, solar heating and wind patterns caused by the rotation of the earth.

In this section, we have discussed just a few of the myriad of ways the oceans benefit our lives. On a worldwide scale, as well as here at home in northern New England, the sea provides many sources of employment; it is a popular spot for recreation; it plays an important role in our cultural heritage; it is responsible for the global climate characteristics and influences local weather patterns. We can begin to see, though we have barely scratched the surface, just how crucial our marine environment is to us. In the following sections we will discuss some of the important issues surrounding the use of our coastal lands and waters — issues about which we, as citizens of northern New England, must be prepared to make decisions in the very near future.

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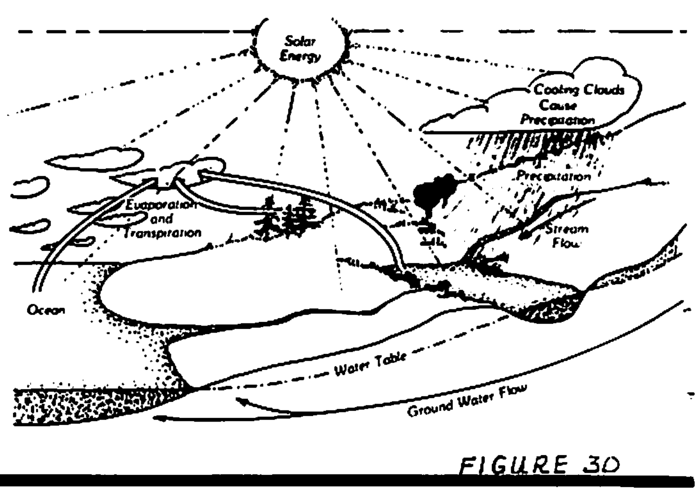

FIGURE 30

Section III: Coastal Issues of Northern New England

Introduction

In a brainstorming session with citizens of northern New England, one could easily compile a list of a hundred or more important issues facing the coast of that region today. It is beyond the scope of this program to consider *every single* coastal problem of the Gulf of Maine area. Rather, we will look at issues that have been deemed "most crucial" by several recent studies conducted by groups concerned about the northern New England coast. These issues are:

1. Fisheries Management
   a. Scientific Management.
   b. Social and Economic Relationships.
   c. Government Regulations
   d. Conflicts between Fisheries.
   e. Conflicts between Fisheries and other users of the coast.
2. Fisheries Development
   a. Harvesting technology.
   b. Port facilities.
   c. Marketing and Processing.
   d. Aquaculture
3. Industrial, Commercial and Residential Development
   a. Cargo Port Development and Operation.
   b. Energy Development and Transportation.
   c. Other types of industrial and commercial development affecting the northern New England coast.
   d. Tourism and Recreation.
   e. Cumulative Impact of Development.
4. Multiple Use Planning, Conflict Resolution, and Protection and Enhancement of Marine Resources
   a. Coastal Access.
   b. Conflicts among regulatory agencies.
   c. Conflicts between regulatory agencies and users of the coast.
   d. Conflicts among users of the coast.
   e. Shoreline Management.
   f. Waste Disposal in the Marine Environment.
   g. Dredging.

Each of these issues will be presented with background information and with questions for discussion and further research. We hope that all program participants will reach a greater understanding of the magnitude of the problems facing our coast today. Specifically, we hope that coast dwelling participants will examine these issues with regard to their own communities and that inland participants will better comprehend the relationship between their hometowns and the coast.

Background Information: Fisheries Management

There are many, many species of fish living in the Gulf of Maine. Of these, only a small proportion are considered to be "commercially valuable" and another small proportion are harvested, but are labelled "underutilized species." This latter group include fin and shell fish species which are edible and, indeed, are eaten by many people, but which do not have a broad market appeal.

Actually, the most economically valuable species, to the state as a whole, is not a finfish or a shellfish, but a *crustacean*: the lobster*. In 1980, in Maine, some 22 million pounds of lobster were landed that were worth a total of $42 million. Compare this to herring, which in 1980, had Maine landings of 108 million pounds, the highest, in terms of *quantity*, but with an economic value of $6 million (a ranking of fourth). These figures may explain why there are approximately 8,500 lobster fishermen in the state of Maine, which represents about 43% of the *total* number of commercial fishermen of all types. Table I lists the commercially important and also "underutilized" finfish species, 1980 landing values in quantity and economic value, habitat and habits of each species, commercial fishing methods used for each, and other interesting information. Table II gives the same information for the important shellfish, crustacean and worm species. Table III summarizes the rankings of these various species in terms of economic value to the total fishing industry, number of pounds landed and price per pound paid to the individual fisherman (1980 figures). Table IV gives a more detailed description of the most commonly used commercial fishing methods.

What are some of the issues that concern the fisheries of northern New England today? According to two recent studies**, fisheries issues can be grouped into two broad categories: fisheries management and fisheries development. These concerns are important not only to the fishermen of our region, but to all of us who eat seafood and to the economy of northern New England as a whole.

Let us first take a look at the issues in the category of fisheries management. In 1976, the Congress of the United States passed Public Law 94-265, the "Fishery Conservation and Management Act of 1976," better known as the "200-mile limit law." This law established a fishery conservation zone which extends outward exactly 200 nautical miles from the boundary of the territorial sea (an area of ocean whose boundary is 3 miles from the coasts of the United States). The law gives the United States exclusive fishery management authority over all fish within the fishery management zone, including anadromous species while they are within the zone (fish who live in the ocean as adults but who migrate to fresh-water to spawn, e.g. salmon, alewives, smelt), and also non-fish resources that occur on the continental shelf and sometimes extend beyond the 200-mile limit (e.g. this group includes corals, lobsters and crabs, mollusks such as surf or hen clam and ocean quahog, and sponges). The passage of this act was strongly urged by American fishermen because they felt that the law would prohibit foreign fleets from harvesting fish and other marine resources within 203 miles of our coastlines. However, once the act did indeed become law, supporters discovered that the story was not that simple. The act does not provide for blanket prohibition of foreign fishing within the 200-mile limit, but rather contains a complex set of exceptions which allow foreign fishing under certain circumstances. In addition, Canada has also claimed jurisdiction over the 200 miles that extend seaward from her coastlines. Just

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**In terms of value to the individual fisherman, bloodworms rank highest in economic worth, with a dollars per pound figure of $11.90 per pound compared with $1.90 per pound for lobster, which ranks 5th in this category. However, overall, bloodworm harvesting accounts for only 2% of the total economic value of all fisheries, bringing to the state of Maine about $1½ million.*

***The two studies are: University of New Hampshire — University of Maine Sea Grant College Program* Long Range Plan: A Framework for Research, Education, and Advisory Service Activities. *Draft for Comment. July 16, 1981. And, the Governors Advisory Committee on Coastal Development and Conservation.* The Maine Coast: Issues Considered *published by the Maine Coastal Program, Maine State Planning Office, October 1978.*

where the boundary between Canada's 200 miles and our 200 miles exists is an important issue in the Gulf of Maine area as both sides would like to claim the rich Georges Bank. More importantly, however, the law required that the fish and other marine species within the 200-mile zone be *managed* according to national standards, which are spelled out in section 301 of the law. To meet this end, the law called for the establishment of Regional Fishery Management Councils that have responsibility for formulating management plans for each important species within their regions. This requirement of the law has changed the character of fisheries in the United States and has caused former "200-mile limit" supporters to view the passage of the act as a very mixed blessing. Many of the problems that the New England Regional Management Council has had to face since its inception in 1977 have sprung from resistance to governmental regulation of a previously highly independent and rapidly expanding fishery and from frustration over the inadequacy of management tools available for meeting the new demands for management required by law.

The most commonly used tools for management of a fishery are catch quotas, gear restrictions, limiting access into the fishery, the closing of fishing grounds during spawning season and size restrictions. The one that has probably been fraught with the most conflict is the placing of quotas on how many fish can be caught. A quota is supposed to be based on the "maximum sustainable yield" of the fish species in question. This means that there is some specific number of fish that must be left in the sea to ensure propagation of succeeding generations that will yield similarly sized or greater catches each year. While this sounds, in theory, like a good idea, the problem arises when one tries to determine *how many* fish there are of a particular species in the sea (or at least in our case, on the fishing grounds of northern New England) and what proportion of this number can safely be caught so that a sufficient sized population will be left behind to reproduce. Fishery biologists and fishermen have long been at odds over this method, with fishermen (and even some biologists!) claiming that "you can't count fish," and therefore any quotas set are always too low. Most biologists, one the other hand, feel that, without some regulation, fishermen will be inclined to catch as much as they possibly can and will eventually overfish the resource. This is not a modern day problem. According to Spencer Apollonio, present commissioner of the Maine State Department of Marine Resources, in 1800 there was a great shift in the fishing industry of northern New England. Previously, fishermen had been staying relatively close to home, mostly remaining within the confines of the Gulf of Maine. Rather suddenly they began ranging farther afield out to the Grand Banks and the Strait of Belle Isle. What happened, says Apollonio, is that they had overfished close to home.

Yet, the New England Regional Council, ordered by the law to manage the fisheries of New England, species by species, and empowered by that same law to set quotas, did just that in 1978 for groundfish. Fishermen were immediately up in arms over this regulation. In an attempt to compromise, the New England Council discussed some of the other tools for managing the fishery, notably regulation of gear and boat size, and limiting entry of new fishermen into a particular fishery. In the finfish industry, provisions were formulated that regulated the size of mesh that could be used in a particular fishery. For example, in 1978, cod fishermen could take 2,500 pounds of cod per week but had to use a larger mesh so that small cod could escape. Later on in the regulations it stated that if a man were fishing for flounder (which requires a smaller mesh than for cod) he could keep 5,000 pounds of cod that he caught "incidentally" or "by accident." Needless to say, confided one fishermen, all the cod fishermen suddenly claimed they were fishing for flounder!

On the other side of the fence, however, it appears that restrictions on gear have kept two fisheries — lobsters and clams — alive and thriving. Lobsters can be harvested only by use of relatively inefficient traps, and clams, only by digging. No elaborate nets, dragging or dredging is allowed. As a result, many biologists agree that the lobster and clam industries are in a state of relative health because "overfishing" is a more difficult thing to do with the present methods. Nevertheless, some feel that the entry of more and more people into these industries, especially lobster, threatens the delicate balance between overfishing and harvesting "just the right amount."

This latter management tool, that of limiting the number of fishermen within a particular fishery, has met with opposition also, especially in "Downeast" Maine. Here, many fishermen are "jacks of all trades," digging clams or worms, setting lobster traps, tending herring weirs, and often getting away from the sea altogether to cut pulp and firewood during the winter. If he stopped lobstering for a time, say, and let his license expire, he might not be able to get back into the fishery when he felt ready to, because of the "limited entry" provision. Thus, the traditional independence of the "Yankee" to move from one occupation to another as he pleased would be hampered by government regulation.

Since 1978, the New England Council has taken new looks at the scientific information available regarding fish stocks and also at the nature of the New England fishery. It recently concluded two things: 1. the scientific advice available is inadequate to ensure a fair setting of quotas on fish species to the industry, and 2. there is not a just, equitable and politically feasible way to allocate fish to an industry as varied and traditionally independent as that in New England. As a result of these conclusions, the New England Council has adopted an "interim groundfish management plan" which attempts to conserve fish stocks, not through quota setting, but through the closing of spawning areas to fishing and by regulating net mesh sizes, to enable immature members of the species to escape.

Thus, we can see that the picture of managing the fisheries in northern New England is a complicated one. Not only do we have the problem of inadequate management tools, but also we are faced with several other factors: the social and economic characteristics of the fisheries; the governmental and jurisdictional relationships; and conflicts among the individual fisheries and between fishermen and other users of the coastal waters.

Dearborn, in the *"UMe/UNH Sea Grant College Program: **Long Range Plan, A Framework for Research, Education and Advisory Activities**"* writes, "The fishery in the Gulf of Maine is complicated not only in the number of species, their migratory patterns, and their interspecies interactions, but also by the nature, both human and structural, of the fishery itself. If one were to travel the shore perimeter of the Gulf of Maine, she/he would find fishing people, fishing vessels, and commercial and sport fishing patterns of amazing variety." This great variety and the basic independent nature of "Yankee fishermen" need to be taken into consideration when making decisions regarding the management of the fishing industry.

Another problem which must be faced is the relationship between the various levels of regulatory agencies. Long before the "200-mile limit law" and the New England Regional Fishery Management Council came into effect, there existed a number of local, state, multistate, federal and even international regulations concerning the fisheries of northern New England. The new law now leaves many of these former regulations under question: should these previous regulations be changed, be incorporated into the new law, or what? Clearly, the various jurisdictional agencies need to work together with representatives from the fishing industry in order to come up with an equitable, reasonable and consistent set of guidelines for managing the fisheries.

Finally, the problem of conflicts among fishermen and between fisheries and other users of coastal waters needs to be addressed. This is not a new situation brought on by the passage of the "200-mile limit law" but rather one that has existed for some time and has become aggravated by the law. Conflicts among fishermen include competition for the resource with such occurrences as lobster pot "raids" or destruction becoming more commonplace as more and more people enter that valuable fishery. Lobstermen and gillnetters are at odds with dragger fishermen, who, claim the lobstermen and gillnetters, destroy their gear with their heavy net or chain drags as they are pulled along the bottom. Competition for space is evident in conflicts among lobstermen, between lobstermen and aquaculturists, and between clam diggers and worm diggers. In southern and middle New England there is conflict between sport fishermen and commercial fishermen; this conflict is beginning to creep northward into our area.

Fishermen are also concerned about the use of coastal waters by other endeavors. At present, the most heated controversy is over the tapping of the energy resources of the sea. Ocean bottom drilling with its subsequent oil spills, disposal of drilling muds, movement of large carriers, and discarding of used equipment on the sea bottom are all issues which must be dealt with in the management of the many marine bounties.

Thus, we see that the management of the fishing industry is fraught with many complex and important issues and controversies. To date, some work has been done to help resolve some of these conflicts. Several surveys and studies have been undertaken of fishing ports and of fishermen themselves in order to try to put together an accurate picture of the fisheries. In an attempt to wrestle with the various governmental and jurisdictional relationships in the management process, representatives from local, state, federal and regional authorities have been meeting together to discuss specific instances where conflicts have arisen. For example, in Maine, the State Department of Marine Resources has jurisdiction over the inshore juvenile herring industry, while the New England Regional Fishery Management Council is reponsible for managing the adult herring which are found primarily offshore. However, there is some mixing of juvenile and adult herring. This fact, coupled with a legal requirement for consistency between different management plans for the same species make communications between the two agencies absolutely necessary. Additionally, the Marine Law Institute of the University of Southern Maine has been studying this issue of jurisdictional conflicts in an effort to present a balanced view of the problem.

And in the area of conflicts among fishermen and between fishermen and other users, the arenas for possible solutions to these conflicts have been the public hearings and the regulatory agencies or legislature. Public hearings have been held over the issue of oil drilling on Georges Bank, and pressure has been put upon state regulatory agencies and legislature regarding various regulations and restrictions (for example the recent uproar over the Department of Environmental Protection's order to sardine processing plants to cease dumping sardine oil into the marine environment). Neither of these arenas is fully adequate for dealing with these conflicts.

So the battle rages on and the management of the fisheries in northern New England continues to be one of the most important issues facing the region today and in the future.

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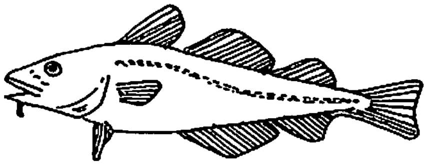
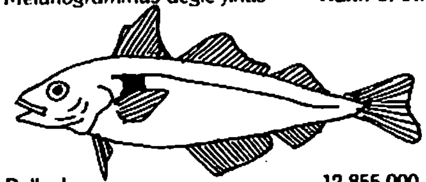
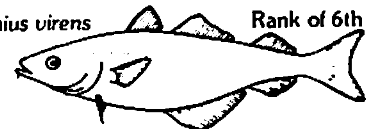
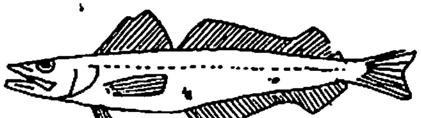
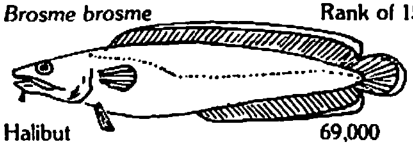
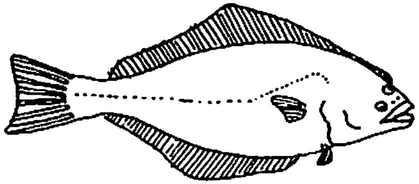
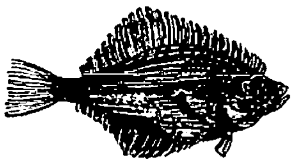
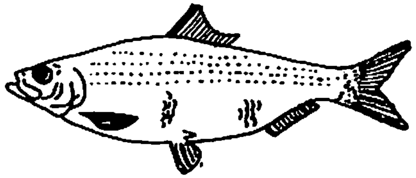
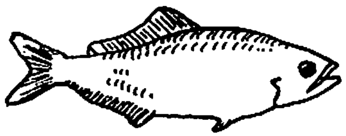
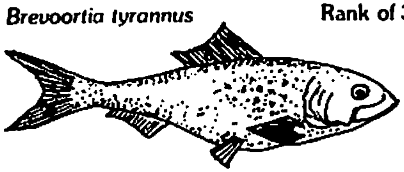
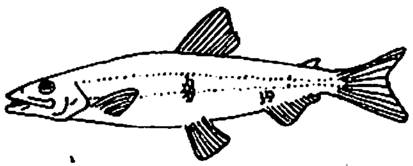
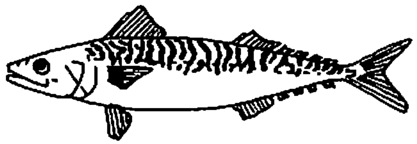
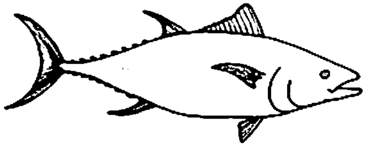
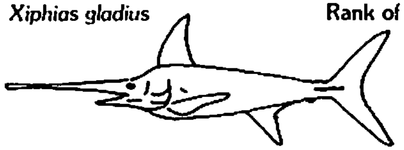
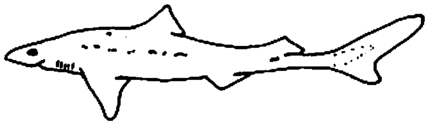
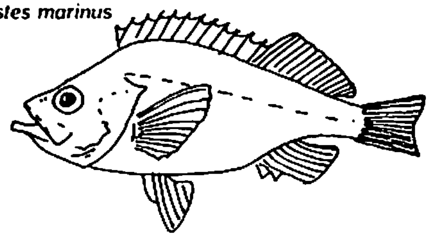
Table I
Commercially Important and Underutilized Finfish Species

Species	1980 Landings In Pounds and Rank (in terms of poundage) in total Maine fishery	1980 Economic Value (in dollars) and Rank (in terms of economic value) in total Maine fishery	Habitat/Habits	Commercial Fishing Methods Used	Other Information
Atlantic Cod *Gadus morhua* 	11,359,00 Rank of 7th	$2,623,000 Rank of 8th Price per lb: 23¢ Rank in terms of of price per lb: 18th	Move in groups Live within 1 or 2 fathoms of the bottom Range at depths from 18 to 1500 ft. Feed primarily on shellfish and squid Most of the year, prefer rocky, pebbly or shell bottoms. In March and April, can be found over soft, muddy bottoms. Prefer temperatures of 36-50 F.	Otter trawling Scottish seining Gillnetting Longlining Jigging	Spawn in winter, late Nov.-April Mature female (5-6 yrs.) produces 3,000,000 floating eggs Spawn in shallow water (less than 50 fathoms) Average size of adult is 5 to 25 lbs. and 18-28" in length. Large cod can be up to 100 lbs. and 5 ft. in length.
Haddock *Melanogrammus aegle finus* 	7,107,000 Rank of 8th	$2,902,000 Rank of 7th Price per lb: 41¢ Rank in terms of price per lb: 13th	Live at relatively shallow depths (150 to 450 feet) Prefer staying close to bottoms composed of broken gravel or gritty clay Feed on shellfish, crustaceans, worms, squid, small fish. Prefer temperatures of 36-50 F.	Otter trawling Longlining Gillnetting	Spawn from late Jan.-early April Mature female (3-4 yrs.) produces 170,000 eggs which float Fry often seek refuge around or under jellyfish Average size of adult is 2 to 3 lbs.
Pollock *Pollachius virens* 	12,855,000 Rank of 6th	$2,094,000 Rank of 9th Price per lb: 16¢ Rank: 22nd	Are pelagic fish Feed on sardine, herring, small crustaceans, fry of cod, haddock, hake Often "school" in pursuit of food Prefer temperatures of 38-50 F.	Longlining Gillnetting Otter trawling	Spawn late Oct.-early Jan. Average female produces 225,000 floating eggs Average size of adult is 4-5 lbs. and 24" in length
White hake or Mud hake *Urophycis tenuis*	5,997,000 Rank of 9th	$844,000 Rank of 14th Price per lb: 14¢ Rank: 25th	Prefer living over muddy bottoms Prefer temperatures around 45 F. Feed on bottom shrimp, squid, small fish Have "fin feelers" (ventral rays) protruding from sides with which they feel for food on the bottom. Live in water depths of 120-1200 feet	Longlining Gillnetting Otter trawling	Spawn late March-late Aug. Young fry hide in shells on bottom, particularly live scallop shells Average size of adult is 8 lbs. (Range from 1-20 lbs.) and 26-28" in length
Squirrel hake or Red hake *Urophycis chuss*	No statistics available	No statistics available	See white hake (above)	Longlining Gillnetting Otter trawling	See white hake (above) Differ from white hake in that they are more reddish in color, have longer ventral fin/feelers Average size of adult is 2-3 lbs. and 14" in length
Silver hake or Whiting *Merluccius bilinearis* 	535,000 Rank of 24th	$60,000 Rank of 31st Price per lb: 11¢ Rank: 26th	Are strong, fast swimmers Often pursue herring and other small pelagic fish for food Also eat small bottom fish Prefer temperatures between 40-50 F.	Midwater trawling Otter trawling Seining Traps	Spawn July-August Average size of adult is 2-3 lbs. and 14" in length

Species	Landings in Pounds	Economic Value	Habitat/Habits	Commercial Fishing Method	Other Information
Cusk *Brosme brosme* 	1,594,000 Rank of 15th	$290,000 Rank of 19th Price per lb: 18¢ Rank: 21st	Prefers living near rocky bottoms Feeds on small crabs and mollusks Are primarily solitary Prefer water depths of 60-600 feet Prefers temperatures of 34-48 F	Otter trawling Longlining	Spawn from April-July Average female produces 2 million bouyant eggs Average adult weighs 5-10 lbs. and 1½-2½ feet in length
Halibut *Hipoglossus* 	69,000 Rank of 30th	$109,000 Rank of 24th Price per lb: $1.58 Rank of 7th	Prefer living near bottoms composed of sand, stones, hard mud, hard clay. Prefer water depths of 180-600 fathoms Prefer temperatures of 36-46 F. Feeds on small bottom fish like sculpin, flounder, scrod, cod, haddock, hake. Also, occasionally crustaceans and mollusks.	Longlining Otter trawling	A *right handed* flatfish spawn March-April Mature female (9-10 yrs. old) produces 1-2 million eggs Eggs do not float but rather drift at depths of 30-50 fathoms Average adult weighs 100 lbs. (The largest on record was 600 lbs.) and 3-6 ft. in length.
Winter Flounder or Lemon Sole or Blackback *Pseudopleuronectes americanus* 	1,251,000 Rank of 16th	$387,000 Rank of 18th Price per lb: 31¢ Rank: 16th	Are called "winter flounder" because they appear inshore during the winter and move offshore in summer. Range from a few feet below surface to depths of 300 ft. Prefer living on soft sandy bottoms and often bury themselves Have a wide temperature tolerance: 32-60 F. Feed on small crustaceans, worms, small mollusks	Otter trawling Scottish seining	A *right handed* flatfish Spawns March-early May Average female produces 500,000 eggs annually. Eggs *not* bouyant, rather, sink to the bottom and stick together in clusters. Average size of adult is 1½-2 lbs. and 12-15" in length.
Witch Flounder or Gray Sole *Glyptocephalus cynoglossus*	3,601,000 Rank of 11th	$1,900,000 Rank of 10th Price per lb: 53¢ Rank: 12th	Prefers living on muddy sand, clay or mud bottoms in deep water (360-900 feet) Prefer temperatures between 35-48 F. Feed on small crustaceans, starfish, small mollusks, worms.	Otter trawling	A *right handed* flatfish Spawns late May-August Eggs are bouyant Average size of adult is 12-20" in length
Summer Flounder or Fluke *Paralichthys dentatus*	No statistics available	No statistics available	Not very abundant north of Cape Cod Live in shallow, near shore areas in summer Prefer sandy or muddy bottoms and water depths of 48-480 ft. with larger fish living deeper Feed on small fish, crabs, squid, mollusks	Otter trawling Scottish seining	A *left handed* flatfish Spawns late fall-early winter Eggs float and drift Average adult size is 16-22" in length 2-4 lbs.
American Dab or Canadian Plaice or Dab *Hippoglossoides platessoides* 	14,553,000 Rank of 4th	$4,914,000 Rank of 5th Price per lb: 34¢ Rank: 14th	Prefer living on bottoms composed of sticky, sandy mud in depths of 120-600 feet Prefer 35-45 F. temperatures Feed on sea urchins, sand dollars, brittle stars, small crustaceans, mollusks and worms	Otter trawling Scottish seining	A *right handed* flatfish Spawns late March-June Mature female (3 yrs.) produces 30-60 thousand floating eggs Average adult is 12-24" long and weighs about 3 lbs. (Range 1/2-6 lbs.)

Species	Landings in Pounds	Economic Value	Habitat/Habits	Commercial Fishing Method	Other Information
Yellowtail Flounder *Limanda ferruginea* 	643,000 Rank of 21st	$220,000 Rank of 20th Price per lb: 34¢ Rank: 15th	Prefers sandy or mud and sand bottom in water depths of 120-240 feet Prefer temperatures of 33-54 F. Feeds on small crustaceans, mollusks, sand worms	Otter trawling Scottish seining	A *right handed* flatfish Spawns from March-August Eggs float Average adult is 16-18" long
Herring *Clupea harengus* (called Sardines or Brit according to size) 	107,823,000 Rank of 1st	$5,977,000 Rank of 4th Price per lb: 5¢ Rank: 30th	A pelagic plankton feeder Travel in schools, range far & wide following local currents Some seasonal migration takes place with older mature herring showing more regard for offshore migration. Young herring often stay in near shore year round	Weir/trap fishing Stop seining Purse seining Midwater trawling The height of the commercial catch for smaller herring extends from April until October. For larger herring up to 25 miles offshore, the peak season is July-October.	Spawns spring to fall at 4 yrs. of age Average female produces 30,000 eggs which sink and clump together sticking to rocks, seaweed, etc. Two year old herring are marketable as sardines
Alewife or Freshwater Herring *Pomolobus pseudo-harengus* 	2,561,000 Rank of 13th	$149,000 Rank of 22nd Price per lb: 6¢ Rank: 29th	Travel in schools to and from spawning areas Feeds on plankton Is a pelagic fish	Dipnetting during movement to spawning grounds Many are also caught in near-shore weirs and seines	An *anadromous* fish: lives at sea as an adult, spawns in fresh water Female spawns at 3 or 4 years of age and produces 60,000-100,000 eggs The young live in freshwater until about 2-4" long and then begin to move into salt water The average adult is 10" long and weighs 1/2 lb.
Menhaden or Pogy *Brevoortia tyrannus* 	18,806,000 Rank of 3rd	$450,000 Rank of 16th Price per lb: 3¢ Rank: 31st	Travel in schools Are plankton feeders, eating primarily microscopic plants Is a seasonal migrator: moving northward into the Gulf of Maine in summer and south to the Chesapeake area in winter	Purse seining	Spawns from June to October Eggs are bouyant Sexual maturity is reached at age 3 or 4 yrs. Average adult is 12-15" long and weighs 1/2 to 1 lb. This fish is primarily caught for its oil and to be processed into fishmeal
Smelt *Osmerus mordax* 	No statistics available	No statistics available	Adult smelts live in harbors and estuaries, moving to deeper water in hot water Move in schools according to age (year class) Are pelagic feeders, eating small shrimp, worms, small fry of herring, mummichogs and alewives, also small mollusks and crabs	Dipnetting in streams during spawning migrations Also hand lines through the ice in harbors in winter	An *anadromous* fish: spawns in fresh water between March and May Mature females (2-3 yrs. old) produce 40,000-50,000 eggs which sink and stick together in clumps Fry return to estuaries when 1¾" to 2¾" long The average adult is 7 to 9" long and weighs 1 to 6 oz.

Species	Landings in Pounds	Economic Value	Habitat/Habits	Commercial Fishing Method	Other Information
Mackerel *Scomber scombrus* 	538,000 Rank of 23rd	$78,000 Rank of 28th Price per lb: 14¢ Rank: 24th	Travels in schools according to year class Range from the surface to depths of 600 feet Prefer temperatures between 44-68 F. Are plankton feeders, eating microscopic plants, animals and the floating eggs of other species Are thought to migrate south in winter and north in summer	Purse seining Midwater trawling	Spawns in salt water during early spring-early summer Mature female (3-4 yrs. old) produces 400,000-500,000 eggs which drift at a depth of about 5 fathoms Grow rapidly: Are 8-9" long by end of 1st yr. (are called "spike" mackerel End of 2nd summer, 10-11" long & are called "tinker" mackerel. Growth slows after 2nd winter Average size adult is 14-18" long.
Tuna or Bluefin *Thunnus thynnus* 	62,000 Rank of 31st	$108,000 Rank of 26th Price per lb: $1.74 Rank: 6th	A wanderer of the open sea, travelling in small schools according to age Prefer warm temperatures of 50-60 F. and migrate seasonally, south in winter, north into the warmer parts of the Gulf of Maine in summer Feed primarily on other fish: herring and mackerel and also squid	Harpooning Hook and line	Spawns in spring and early summer in warm water (54-63 F.) Eggs float Young fish grow rapidly, weighing 10 lbs. at age 1 yr. Are sexually mature at age 4-5 yrs. (35-100 lbs.) Average adult is 14 ft. long and weighs 100 lbs. (May weigh 300 lbs. at age 10 yrs.)
Swordfish *Xiphias gladius* 	584,000 Rank of 22nd	$1,190,000 Rank of 12th Price per lb: $2.04 Rank: 4th	Is an open seas wanderer, preferring temperatures of 60-70 F. (is found in the Gulf of Maine only in summer) Is a fish eater, charging into schools of smaller fish, lashing its "sword" back and forth and then feeding on the resulting mutilated fish	Harpooning Midwater longlining	Spawns in warm temperatures. Not known to spawn in Gulf of Maine Eggs are bouyant Adults can be 12 feet long and over 1,000 lbs.
Spiny Dogfish or Grayfish *Squalus acanthuis* 	1,172,000 Rank of 18th	$96,000 Rank of 27th Price per lb: 9¢ Rank: 27th	Show patterns of migration: appear on offshore banks in early spring, moving into harbors and bays in June and July, remaining until September Move in large "packs" often by year class Are voracious feeders, eating almost all species of smaller fish and also crabs, squid, and worms	Otter trawling Gillnetting Hook & line Only recently has there been a market for this and other shark species	Young dogfish are born alive at 7-10" in length. The female carries a litter of 4 to 6 young for 18-22 mos., delivering them in winter or spring. Average adult size is 3-4 ft. in length and 7-10 lbs.
Redfish, Rosefish or Ocean Perch *Sebastes marinus* 	13,805,000 Rank of 5th	$3,032,000 Rank of 6th	Prefers water depths of 240-1050 ft. and temperatures of 33-50 F. Are most often found on the outer banks and in deep depressions in the Gulf of Maine Feed on small crustaceans and mollusks	Otter trawling	Spawns from April-until August Females (7-10 yrs. old) carry fertilized eggs internally and 25,000-40,000 larvae are born alive Are slow growers, reaching maturity and market size at 7-10 yrs. of age (8-10" long)

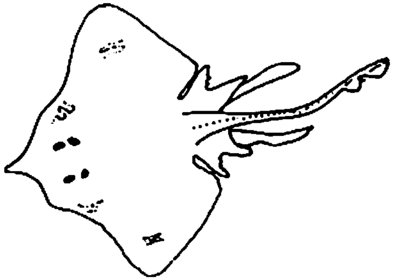
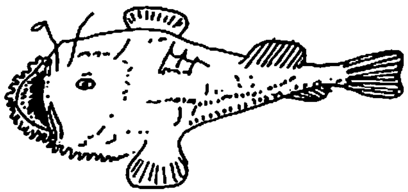
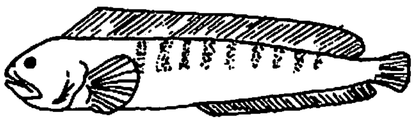
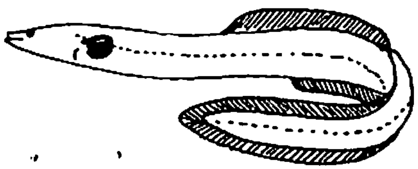
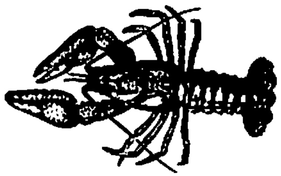
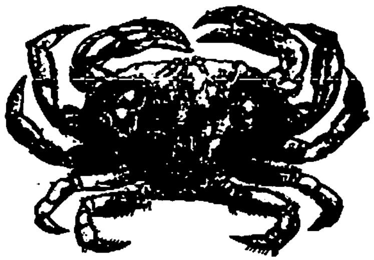
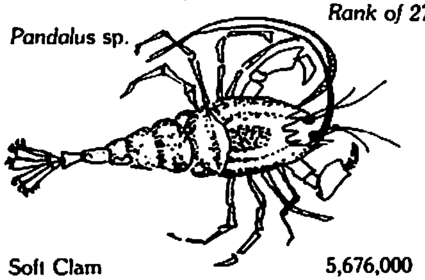
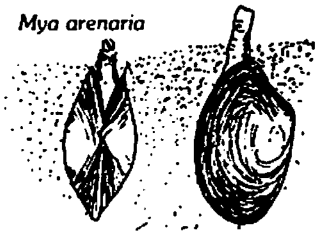
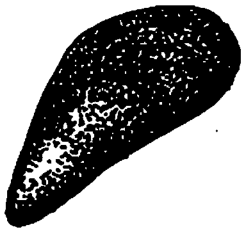
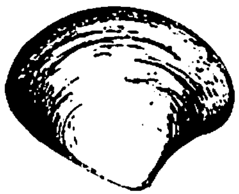
Species	Landings in Pounds	Economic Value	Habitat/Habits	Commercial Fishing Method	Other Information
Skates Barndoor Skate *(Raja laevis)* Big Skate *(Raja ocellata)* Little Skate *(Raja erinacea)* Smooth tailed or Prickly Skate *(Raja senta)* 	390,000 Rank of 25th	$61,000 Rank of 29th Price per lb: 16¢ Rank: 23rd	Is a bottom dweller, preferring muddy to sandy or gravel bottoms in water depths of 120-360 feet They can live in a wide range of temperatures 32-70 F. Feed on bottom dwelling fish, crustaceans, mollusks	Otter trawling Longlining The market for skate includes the sale of meat from the "wings" as "scallops"	Spawn over much of the year, depositing eggs in black, leathery cases which carry young until an inch or two in length. Empty cases are often found on beaches 
American Goosefish or Monkfish or Anglerfish *Lophius americanus* 	754,000 Rank of 20th	$424,000 Rank of 17th Price per lb: 56¢ Rank: 11th	Is a camouflaged bottom feeder, eating fish that pass too close to its gaping mouth. Also feeds on diving ducks like cormorants. Usually feeds only once every few days Ranges from tidal waters to depths of 1800 feet Prefers temperatures cooler than 65 F. Does not move about very much, remaining more or less stationary waiting for its food to come to it	Otter trawling Longlining	Spawns in June and July Mature females produce over 1 million eggs in a long mucous-like string. These egg "ribbons" float The average adult grows to be 3 or 4 ft. long and up to 50 lbs.
Wolffish or Ocean Catfish *Anarhichas lupus Linnaeus* 	No statistics available	No statistics available	Are basically solitary and scattered Stays close to the bottom, hunting food around seaweed and rocks Feed primarily on small mollusks and crustaceans Can be found in water depths from the low tide mark down to 510 feet or more Prefers temperatures of 34-50 F.	Longlining Otter trawling	Spawns Nov.-January Eggs are laid on the bottom
Eels 	102,000 Rank of 29th	$108,000 Rank of 25th Price per lb: $1.06 Rank: 9th	Feeds on small fish, crustaceans, and mollusks Often hide among rocks, shells and debris on the bottom Burrow in the mud of harbors and rivers in winter	Metal mesh "eel pots" Spearing into the mud in winter	A *catadromous* species — lives as an adult in fresh or brackish water but swims to the Sargasso Sea in the Atlantic Ocean off Florida to breed

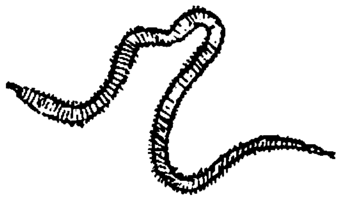
Table II

Commercially Important and Underutilized Shellfish, Crustacean and Worm Species

Species	1980 Landings in Pounds and Rank in total Maine Fishery	1980 Economic Value and Rank in total Maine fishery	Habitat/Habits	Commercial Fishing Method	Other Information
Northern Lobster *Homarus americanus* 	21,981,000 Rank of 2nd	$41,705,000 Rank of 1st Price per lb: $1.90 Rank of 5th	Are found from Labrador to Virginia Live in the subtidal zone from shallow depths to deep water at the edge of the continental shelf Can even be found in brackish rivers (salinities of 20-25%) Are cannibals and scavengers but will not eat extremely rotten material	Lobster traps, either round or square, made of wood or wire	Lobsters can grow to be 3 ft. long and 45 lbs. The average market size is 1-2 lbs. attained by age 4 years
Rock Crab *Cancer irroratus* Jonah Crab *Cancer borealis* 	1,253,000 Rank of 17th	$213,000 Rank of 21st	Are found from Labrador to South Carolina Lives in the intertidal zone north of Cape Cod, subtidally south of Cape Cod Are primarily scavengers, but will eat any live prey they can catch including small fish, mollusks, etc.	Are caught primarily incidentally in lobster traps	Rock crab and Jonah crab are very similar except for the following differences: 1. The "teeth" on the margin of the shell are smooth in the Rock crab, jagged in the Jonah crab. 2. The Jonah crab tends to live in deeper water than the Rock crab.
Shrimp (Boreal Red Shrimp) *Pandalus* sp. 	*153,000* *Rank of 27th*	$126,000 Rank of 23rd Price per lb: 82¢ Rank: 10th	Pink or reddish in color Are found from the North Pole south to Cape Cod, R.I. or Delaware, depending on species Are usually found in water 100 ft. (30m) or more, deep, although young are sometimes found in shallower water in the Bay of Fundy	Fine mesh midwater trawl	
Soft Clam *Mya arenaria* 	5,676,000 Rank of 10th (for meats only)	$8,554,000 Rank of 3rd (for meats only) Price per lb: $1.51 Rank: 8th	Are found from subartic waters to Cape Hatteras Live in the mud intertidally to subtidal depths of 30 feet (9m) Can tolerate low salinities (5%) Is found on muddier bottoms than the hard clam or quahog	Are dug on mud flats using a short handled rake called a "hoe" (In the Chesapeake Bay, these clams are harvested with hydraulic dr[illegible]	

Species	Landings in in Pounds	Economic Value	Habitat/Habits	Commercial Fishing Methods	Other Information
Sea Scallop *Placopecten magellanicus* 	3,233,000 Rank of 12th (for meats)	$10,752,000 Rank of 2nd (for meats) Price per lb: $3.33 Rank of 2nd	Are found from Labrador to Cape Cod in subtidal water of depths of 12 feet or more	Are caught by scuba divers or snorkelers or are dredged commercially by scallop drags	Only the muscle that moves the two shells is sold for meat. The rest of the body is discarded.
Blue Mussel *Mytilus edulis* 	2,332,000 Rank of 14th	$546,000 Rank of 15th Price per lb: 23¢ Rank: 17th	Are found from the North Pole south to South Carolina Can live in brackish estuaries where they are exposed at low tide. Can also be found in depths of several hundred feet offshore	Are harvested by drags similar to scallop drags	Mussels attach themselves to each other and to rocks, pilings, etc. by use of a tough thread called a *byssus* that is produced by the mussels themselves Mussels reach their optimum size in 1 yr. in prime habitats, in 2-5 yrs. elsewhere. Mussels are presently being raised in aquaculture enterprises in New England. These mussels are more often free of "mussel pearls" than are wild mussels. These pearls are formed as the result of a parasitic worm which irritates the mussel. The worm is carried in the digestive tract of the eider duck which feeds on mussels, depositing the worm onto mussel beds in their feces.
Quahog or Hard Clams *Mercenaria mercenaria* 	No statistics available	No statistics available	Are found from the Gulf of Mexico north to Cape Cod and locally in warm bays to Bar Harbor, Me. and reappearing in the Gulf of St. Lawrence Occur in the intertidal zone or subtidally to depths of 60 ft. (18m) Prefers salinities above 15%. Prefers sandy or muddy bottoms	Harvested with long handled rakes, tongs or by "treading" (feeling for the clams with bare feet in very shallow water)	Quahogs are not commercially important in n. New England, however they are harvested in the southern part of the Gulf of Maine Commercial names for this clam are based on size: Littlenecks (to 1½ in.) Cherrystones (to 2 in.) Chowder (to 3 in. or more) Quahogs can live to be 20-25 yr. old These clams were used by coastal Indians for wampum
Oyster *Crassostrea virginica* 	No statistics available	No statistics available	Are found from the Gulf of Mexico to Cape Cod, locally north to southern Maine, also in the Gulf of St. Lawrence Prefers salinities between 5-30% and is not tolerant of prolonged exposure to salinities greater than or less than these Can be found intertidally or subtidally at shallow depths Are very sensitive to water pollution	Harvested with either hand tongs or dredges. Oysters have been "farmed" extensively in southern New England, N.Y., & N.J. and some oyster aquaculture has been undertaken in s. Maine	Oysters are not commercially important in n. New England however there have been some aquaculture efforts undertaken in northern New England Young oysters ("spat") settle into beds preferring especially old oyster or other shells

Speties	Landings in Pounds	Economic Value	Habitat/Habits	Commercial Fishing Method	Other Information
Squid *Illex illecebrosus*	No statistics available	No statistics available	Are found from the Artic Ocean south to Cape Cod and in very deep water to the Gulf of Mexico Are commonly found in inshore waters in the summer Feed on herring mackerel and small shrimp	"Jigging" with pole and line at night, using hooks	Have long been used for bait in the North Atlantic Cod fisheries Recently have been harvested and shipped abroad where they are considered a delicacy
Blood Worms *Glycera* sp.	118,000 (figuring 172 blood-worms per pound) Rank of 28th	$1,404,000 Rank of 11th Price per lb: $11.90 Rank: 1st	Are found from the Gulf of St. Lawrence to the Gulf of Mexico Range from the intertidal zone to subtidal deep waters	Are dug from inter-tidal mud flats with clam "hoes"	Blood worms are harvested to be sold as bait
Clam Worms or Sand Worms *Nereis* sp.	354,000 (figuring 82 clam worms per pound) Rank of 26th	$1,095,000 Rank of 13th Price per lb: $3.09 Rank: 3rd	Are found from Gulf of St. Lawrence to Delaware Bay (depending on species) Feed on many kinds of invertebrates (animals without backbones) including other clam worms, and also on algae Are active burrowers, and often form sandy tubes, glued together with mucus Are tolerant of a wide range of salinities	Are dug from inter-tidal mud flats with clam "hoes"	Breed in swarms on the surface of the water on the dark of the moon from June-Sept.



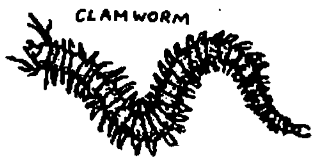


Table III

Summary of Rankings of Various Species

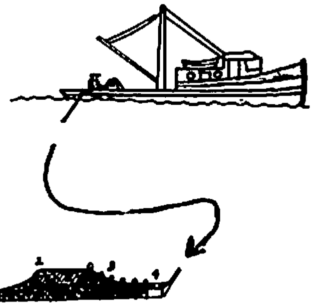
We can see by the following comparisons of ranks that species that are valuable to the total Maine fishing industry may not necessarily be quite so valuable to the individual fisherman, and vice versa. Also fish that are caught in huge numbers may not be particularly valuable to the total industry and very low in price per pound value to the individual fisherman (e.g.: herring ranks 1st in total number of pounds landed, but ranks 4th in terms of economic value to the fishing industry and 30th — next to last — in price per pound value to the fisherman!).

Category	Species	Rank	Category	Species	Rank	Category	Species	Rank
Economic value to the State of Maine (Total dollars in 1980)	Lobster	1st	Landings in Pounds (1980 figures)	Herring	1st	Price per lb. paid to fisherman (Average 1980 prices)	Bloodworm	1st
	Scallop meats	2nd		Lobster	2nd		Scallops	2nd
	Clams meats	3rd		Menhaden (Pogy)	3rd		Sandworms	3rd
	Herring	4th		Dab	4th		Swordfish	4th
	Dab	5th		Ocean Perch (Redfish)	5th		Lobster	5th
	Ocean Perch (Redfish)	6th		Pollock	6th		Tuna	6th
	Haddock	7th		Cod	7th		Halibut	7th
	Cod	8th		Haddock	8th		Clams	8th
	Pollock	9th		White Hake	9th		Eels	9th
	Gray Sole (Witch Flounder)	10th		Clams meats	10th		Shrimp	10th
	Bloodworms	11th		Gray Sole (Witch Flounder)	11th		Anglerfish (Monkfish)	11th
	Swordfish	12th		Scallop meats	12th		Gray Sole (Witch Flounder)	12th
	Sandworms	13th		Alewives	13th		Haddock	13th
	White Hake	14th		Mussels	14th		Dab	14th
	Mussels	15th		Cusk	15th		Cusk	15th
	Menhaden (Pogy)	16th		Winter Flounder (Blackback)	16th		Winter Flounder (Blackback)	16th
	Anglerfish (Monkfish)	17th		Crabs	17th		Mussels	17th
	Winter Flounder (Blackback)	18th		Grayfish (Dogfish)	18th		Cod	18th
	Cusk	19th		Sea Moss (an algae)	19th		Ocean Perch (Redfish)	19th
	Yellowtail Flounder	20th		Anglerfish (Monkfish)	20th		Crabs	20th
	Crabs	21st		Yellowtail	21st		Cusk	21st
	Alewives	22nd		Swordfish	22nd		Pollock	22nd
	Shrimp	23rd		Mackerel	23rd		Skates	23rd
	Halibut	24th		Silver Hake	24th		Mackerel	24th
	Eels	25th		Skates	25th		White Hake	25th
	Tuna	26th		Sandworms	26th		Silver Hake	26th
	Grayfish	27th		Shrimp	27th		Grayfish	27th
	Mackerel	28th		Bloodworms	28th		Sea Moss	28th
	Skates	29th		Eels	29th		Alewives	29th
	Sea Moss (Not a fish, an algae)	30th		Halibut	30th		Herring	30th
	Silver Hake	31st		Tuna	31st		Menhaden	31st

Table IV
Commercial Fishing Methods

Method — **Description**

Otter trawling or dragging

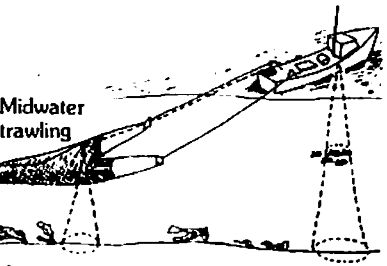


In this method, a large, bag-like net is towed over the bottom. The mouth of the net is very wide, with the body of the net tapering to a narrow, heavier twined bag called the *cod end*. The cod end is tied together at its tip by the *cod end knot* or *pucker strings.* This is untied when the net is hoisted above the deck so that the fish concentrated in the cod end will usually fall out onto the deck. Since the net is dragging along the bottom, it usually has pieces of scrap rope lashed to the underside of the cod end to help prevent chafing. At the mouth of the net, walls made of twin netting (called *wings*) help hold the sides rigid and keep the mouth of the net open. The bottom of the net, called the *sweep*, travels over the sea floor, scaring up bottom dwellers. To help preserve it, the sweep is composed of either chain (for softer bottoms) or heavy rollers (for rough, uneven bottoms). The upper edge of the net is called the *head rope*. The head rope has several floats attached to it to aid in keeping the net open. The upper edge of the net preceeds the lower edge during towing to deflect any fish that may swim upward, back into the net. From the upper and lower edges of the wings, extend cables that attach to the *otter boards* or *doors*. These doors are five feet long or larger, rectangular in shape, and very heavy. The purpose of the doors is to keep the net open by providing a barrier to the flow of the water. The doors are fastened to the boat by heavy cables which are winched up on board when it is time to bring the net in.

Generally, the net is towed for varying lengths of time at speeds of about 3-4 knots (approximately 4-5 miles an hour). At the end of a haul, the doors are winched up first and secured to the sides of the vessel. Then the net is winched in and suspended above the deck. The cod end is then loosened and the fish fall onto the deck.

There are basically two types of bottom trawlers: the Eastern or Side Rig and the Western or Stern Trawler. The Eastern rig evolved from the sail-powered fishing schooners, with a pilot house in the stem, crews quarters forward and the work deck between the two (amidships). The net is brought in over the side of the vessel and the cod end is swung out over the deck by the use of a main boom. Hauling in is done with the boat drifting sideways, with the net side to the leeward to prevent the net from drifting into the propeller. The Western rigs are commonly used today on both ships as they are generally believed to be safer and more efficient. This trawler has its pilot house and crews quarters foward and the work deck in the stern. The net is set and hauled in over the stern, enabling the vessel to head into the seas (safer).

Midwater trawling

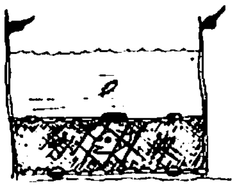


The net used in midwater trawling is similar to that used in otter trawling, except that the mesh size of the net decreases toward the cod end. The net is towed at intermediate water depths depending on the species of fish sought after and the depth at which the school is swimming. Midwater trawling requires more sophisticated technique and extra equipment such as *head rope sounders* which indicate the depth of the net, and special adjustable trawl doors. The vessel is usually equipped with electronic fish finding devices (e.g. fish scopes and sonar) and must be manned by a skipper and crew with expertise in combining all the various factors of net depth, vessel speed, etc. to insure a successful catch.

Scottish seining

This is a more passive method of bottom dragging, working on the principle of herding fish into groups on the bottom. The net is similar to an otter trawl rigged for soft bottoms (chains as opposed to rollers), except that the wing sections are much longer than on the traditional otter trawl net. The net is "set" with long tow ropes that are arranged in a triangle with the net mouth at the base of the triangle and the boats' towing position at the apex. The net is winched in after it has been set in this manner and the long tow ropes act to herd fish toward the mouth of the net. This method helps save on vessel fuel as the boat does not actually tow the net over a long distance of bottom, but requires quite a bit of expertise on the part of the skipper and crew.

Gillnetting

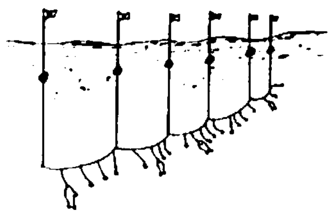


Gillnetting was introduced to the U.S. in the 1880's from Norway and works on the principle of trapping fish by the gills in the mesh of a net suspended in the water, provided that the mesh is the proper size for the species sought after. In recent years, there has been a marked increase in gillnetting thanks primarily to the use of nylon monofilament twine. This material is practically transparent making it difficult to be seen by most fish species even in daylight. The gillnet is set with an anchor on each end and a buoy line with radar reflective buoys to aid in retrieval. The net is held in a vertical position in the water by lead weights on the bottom line of the net and floats on the top. A commercial gillnet is usually 10 to 20 feet in height and about 60 feet or more in length. Gillnets can be set at practically any depth, including on the surface, on the bottom, or anywhere in between, depending upon where the anchor-buoy lines the nets are placed.

The nets are hauled in by a friction type of lifter mounted on the side rail of the vessel and the nets are pulled across a picking table so that the crew can untangle the fish.

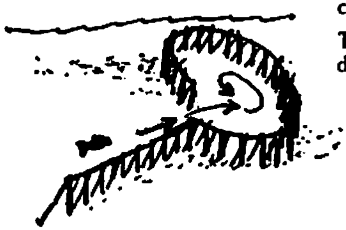
Boats used in the gillnetting fishery are usually large "lobster boat types" that can make relatively quick trips to and from the fishing grounds.

Longlining

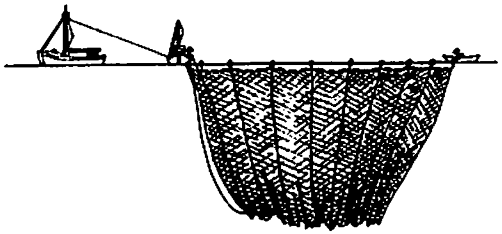


Longlining, once called "trawling," was used extensively in the sailing schooner dory fisheries for cod, halibut and other species. In most fisheries, except halibut, it has largely been replaced by dragging (otter trawling). Old fashioned "tub trawling" and modern automated longlining are used today primarily for catching halibut. "Tub trawling" consists of a long line, usually 600 feet in length, with hooks attached via four leaders about every six feet. Each hook is individually baited and the entire line is coiled carefully into a wooden tub so that it will come out easily when set. The end of the bottom or ground line is anchored and a buoy line is attached. The automated longline runs on hydraulics and compressed air and does everything but take the fish off the hooks. These systems are presently quite expensive, running between $7,000 and $80,000 but are so time and labor saving that they promise a good future for the longlining fisheries.

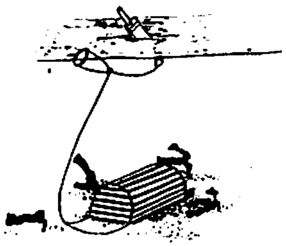
Method	Description
Weir	A weir is a type of fish trap built in tidal areas. It is a maze of stakes, brush and netting with a single opening through which fish enter. They swim about within the maze, eventually ending up in a larger open space called the *pocket* where they tend to congregate. Small boats tend the weir, bailing out the confused fish trapped in the pocket. The floating fish trap is an outgrowth of the stationary weir, but is constructed entirely of twine. It has the advantage of being able to be moved to deeper water. Fish are prevented from escaping out the bottom by a floor of netting.



Seining	There are a number of types of seining. *Stop seining* is used in small coves and involves the stretching of a net across the mouth of the cove, entrapping the fish within. *Purse seining*, developed in the 1850's, is done with a long net that is set in a circle around a school of fish. As the two ends of the net are brought together, a line running along the bottom of the net is pulled in, closing off the bottom of the net as in the drawing shut of a string purse. The fish are trapped in the large bag which is hauled on board. The fish are then bailed out of the net into the hold of the boat or into a *carrier vessel*.



Lobstering	Lobsters and Rock crabs are caught primarily in traps or *pots*. These traps are made of either wood slats or wire and mesh nets and are usually "round" or square. The traps are built with two or more compartments or "rooms." In the compartment nearest the trap entrance, the bait is placed. Since lobsters do not like to stay near their food once they have eaten, the traps provide a compartment, called the *parlor* to which the lobsters may retreat once they have eaten all they want of the bait. The entrance ways to the trap itself and to the parlor are made of mesh netting that allow the lobster to enter but discourage it from leaving, by being "funnelled" inward. Traps are "set" or put out by fishermen usually in the traditional "lobster boat" (although a large variety of vessels are utilized). The traps are connected by a long line to two buoys, a main buoy that is colored distinctively for each fisherman and a smaller *"toggle buoy"* whose purpose is to keep the line taut at low tide. The traps are hauled in by hand or by mechanical winches to a side deck of the vessel. The trap contents are then examined, the trap is rebaited if necessary and dumped back into the water. Only lobsters of a certain size may be legally kept: the minimum size is 3 3/16 inches (81mm) as measured along the back part of the shell (the carapace). Lobsters smaller than this size are called "shorts" and are supposed to be thrown back.



Dragging for Scallops and Mussels	Dragging for scallops and mussels is done with a piece of equipment made of chain and wire called a drag. This is dragged along the bottom. The drag is dropped off an apparatus on the stern of the vessel which is called the *rocket launcher*. (In some older vessels that have been converted from Eastern rig draggers, the drag is lowered off the side of the boat with a boom). Once the tow is complete the drag is winched aboard the vessel and the catch raked out into a culling board. On vessels dragging for mussels, there is usually a *mussel washer* that cleans and separates the mussels. Scallops are *shucked* or opened while still at sea or in port as only the muscle that holds the two shells together is sold in markets. The body and shell are usually discarded.
Harpooning	This method is used primarily in the harvest of tuna and swordfish. A vessel is outfitted with a lookout tower and with an extension off the bow called a *pulpit*. The harpoonist stands out on the pulpit and throws a harpoon, which is attached to a radar reflective buoy by a long line, into any tuna or swordfish that comes within range. Many tuna and swordfish harpoonists make use of spotter planes to aid them in locating fish.

Background Information: Fisheries Development

In the previous section we discussed the problem of scientific management of fishery resources in the Gulf of Maine, an issue that has been greatly magnified by the passage of the so called "200-mile limit law." On the bright side of things, this law has also been largely responsible for the revival of the ailing fishing industry in northern New England. After a 24-year decline (from landings of 350 million pounds in 1950 to a low of 138 million pounds in 1975) the fisheries in Maine have seen a gradual improvement (182 million pounds in 1977, 244 million pounds in 1980). In 1980, these 244 millon pounds of landed fish, shellfish, crustaceans, worms and seaweed provided some 90 plus million dollars worth of income to Maine fishermen, *and* generated over 150 million additional dollars in income for "support services" such as on shore processors, transporters, retailers, etc.

In addition to the new law, there has also been a marked increase in worldwide demand for fish products which has helped to further the growth of northern New England fisheries. Most analysts are optimistic about the future of the fishing industry in our area, but warn that several significant problems exist which hamper the growth of the industry and which should be of concern to all citizens of the northern New England region.

For example, it is crucial that fishermen and others of the "harvesting sector" be kept informed of the latest innovations in harvesting technology. High energy costs, new management requirements, and a generally unhealthy national economy make it necessary for fishermen to be as efficient as possible in their harvesting endeavors. The University of Rhode Island has recently begun experimentation to develop nets which require less energy to tow. In Maine, efforts are being made by the Fisheries Technology Service of the Department of Marine Resources to make old ways of fishing more energy efficient and more productive, and new technologies involving such methods as long lining and jigging are being explored.

Both the UNH/UMe Sea Grant Study and "The Maine Coast: Issues Considered" recommend that agencies and institutions as the Marine Advisory Program (UNH/UMe Sea Grant), the Cooperative Extension Service of the University of Maine, the Department of Marine Resources and the Vocational Technical Institutes of the State of Maine undertake to keep members of the "harvesting sector" informed of, and trained in, the most up-to-date methods of harvesting. At this time, the Washington County Vocational Technical Institute operates a "Marine Vocational Center" at Eastport, Me. which offers training programs in boat building, marine finishing, marine engine repair, and commercial fishing. In addition, the extension services of the Marine Advisory Program, the University of Maine (Cooperative Extension) and the Department of Marine Resources have extensive literature available on the latest research in fishing gear, vessel design, etc. While much is being done to close the gap between research institutions and the fishermen themselves, the problem is far from being solved.

Another serious problem is the inadequacy of piers and related port facilities. A report prepared by the Maine Department of Transportation in the late 1970's concluded that "the generally poor availability and condition of the physical facilities that the industry depends on for its existence does not reflect the importance of maintaining a prosperous fisheries economy in Maine." Another study done by a consulting firm in Portland in 1978, states that "existing port and infrastructure facilities are generally inadequate in terms of conditions, numbers, location and operational characteristics. Any expectation of increased activity or efficiency levels in harvesting, processing, or marketing functions must involve expansion of these facilities, especially harbors, wharves, processing sheds, waste collection and treatment systems, freezers and cold storage warehouses."

This lack of port facilities seriously impedes the efficient handling of fish, gear, and supplies, and discourages value-added activities. In addition, it presents berthing and maintenance problems and creates concern over the safety and protection of substantial investments in vessels and equipment. Furthermore, the condition and location of port facilities can have a strong influence on fisheries marketing and processing patterns in the state.

The largest obstacles to improving port facilities are cost, government regulations, and the shortage of available land and shore space. For the most part, individual fishermen cannot make the capital investment needed to upgrade and expand port and pier facilities. Additionally, it would not only be fishermen who would benefit from the construction of high quality piers, waste disposal systems, transportation networks, cold storage areas, dredging activities, etc., but rather *all* users of the port would profit. Therefore, central planning and state financial assistance would seem to be the best avenue to take towards accomplishing this much needed task.

In "The Maine Coast: Issues Considered," the Advisory Committee on Coastal Development and Conservation (CCDC) makes the following recommendations:

1. The State should support the development of much more than one major public fishing port facility complex to expand and improve the efficiency of fish handling, processing and related value-added and support activities in Maine.
2. The State should also support the development or improvement of appropriate public facilities for the landing of fish and shipment to processing and marketing centers.
3. The State should develop a funding mechanism to implement the above recommendations which will determine the location and nature of specific port development projects on the basis of initiatives and commitments from municipalities and private industry.

Since this report was written (1978), Maine voters have approved a $10 million bond issue for developing fish piers within the State of Maine, thus providing the financial incentive for such an undertaking. The problem, however, has not disappeared with the passage of this bond issue. The largest part of the work remains with decisions on location, construction format and quality control still to be made. At present, however, there is much discussion over, and in some cases, firm planning for, fish piers in Portland, Rockland, Eastport, and elsewhere in Maine. Why not take some time with your group to examine the plans for a fish pier nearest your own community to determine what progress is being made.

Marketing of fish products in northern New England, particularly Maine, is yet another important issue facing those interested in developing the fishing industry. According to many studies, marketing problems in Maine are largely the result of "fragmentation of ownership" within the industry and geographical dispersion of the fisheries products. Basically, what this means is that because the fishing industry in northern New England is primarily composed of small, usually one or two vessel fleets, that hail from ports all along the 3,000-plus mile coastline, the successful marketing strategies followed by large, integrated firms (called "agribusinesses" in the rest of the food industry) are more difficult to implement. Thus the marketing potential for fish products brought in by these scattered individual fishermen is greatly limited. At the present time most of the fish caught by Maine and New Hampshire fishermen are shipped to the huge Boston market. With a few exceptions (notably small fish markets and opportunities to buy fish directly from the harvester), most of the fish you see in grocery stores has been to Boston and back to Maine again!

These studies *do not*, however, suggest that consolidation of the smaller fisher-businessmen into huge corporate conglomeration is the answer to the problem. Rather "the creation of new market institutions which will enhance the competitiveness of a still fragmented industry is required." What are some of these "new market institutions" that will allow the fishing industry in northern New England to maintain its nature of small, individual and independent enterprises while at the same time developing greater marketing power in the area? One such institution is the cooperative or "co-op." Co-ops have been successful in agriculture for many years, but are only beginning to be formed in the fishing industry. The key to their success is the pooling of resources to achieve greater economic strength and versatility. As of 1978, Maine had twenty fishing cooperatives, most of which are made up of individual fishermen in a particular region who joined together to distribute or market their collective catches and to buy equipment at a discount. Another type of cooperative that has been appearing in recent years is the "cooperative joint venture" in which a number of small firms or individuals band together and share a single facility such as a freezing or cold storage building, ice making plants, processing equipment, refrigerated trucks, etc. Most studies recommend that the State of Maine should encourage the formation of cooperatives by providing technical assistance, and by examining regulations relating to insurance, taxation, ownership, etc. to eliminate any possible barriers to the creation of fishing cooperatives.

Another marketing system that could greatly aid the growth of the fishing industry in Maine and New Hampshire is the fish auction. Fish auctions already exist in Boston and New Bedford and are key elements in the marketing of fish in Japan, Great Britain and in other northern European countries. The benefits of a fish auction are many:

1. It aids in the consolidation of fish flowing to market to better insure a reliable supply needed by processors and distributors.
2. It improves the relationship between harvesters and the procors/marketers by providing an open and easily accessible marketplace.
3. It enhances quality control by rewarding good quality with higher prices.
4. It would provide a source of accurate and timely market information of fishermen.
5. It would reduce the reliance on the Boston market to set prices for Maine landings.

Presently there is serious discussion about instituting a fish auction in Portland. The plans for such an undertaking could be examined in detail by your group. More information regarding the Portland fish auction can be obtained by contacting either or both of the following groups:

The Maine Fisherman's Cooperative Association, Inc.
P.O. Box 4812 DTS
Portland, Maine 04112

The Marine Advisory Program
UNH/UMe Sea Grant Program
Coburn Hall, University of Maine
Orono, Maine 04469

There are numerous alternatives available to fishermen that could help the marketing situation in northern New England. A recent study, published by the Texas A&M University Sea Grant College Program entitled *Marketing Alternatives for Fishermen* (March 1980) analyzed the *national* marketing scene for fish products and recommended the following alternative marketing strategies:

1. Organized exchanges (for example, fish auctions).
2. Forward contracting (a formal, written agreement between a buyer and a seller relating to the delivery, pricing and acceptance of a specified time and place. This is done prior to delivery of the product).
3. Vertical Integration through Ownership and Joint Ventures (when the individual fisherman or a group of fishermen, for example in a cooperative, own a section of the processing and/or marketing sector for the products he (or they) harvests). A fisherman who owns and operates a retail fish market, or a cooperative that owns a cannery are both examples of vertical integration through ownership. Joint ventures refer to the ownership of processing and distribution facilities by a group consisting of several harvesters *and* a processing or marketing firm.
4. Group bargaining (this refers to a situation where a group of fishermen agree on the price and other market conditions they want and bargain with the buyer or buyers as a group. This technique is utilized more on the west coast of the United States than on the east or south coasts).
5. Marketing Orders (represents a cooperative endeavor between a government body and an industry in which a committee representing the producers, for example, farmers or fishermen, and the handlers make the principal marketing decisions within the restrictions of the law. Everyone within the particular industry is governed by the program instituted by the marketing order. Marketing orders are common in the agricultural businesses, but are not yet being used by the seafood industry. A seafood marketing order could give a fishermen a way to work together to solve seafood marketing problems that are too large for individuals to solve alone. A seafood marketing order could legally authorize the following: a) regulation of the quality of the product, b) regulation of the quantity of the product, c) standardization of containers and packaging, d) provisions for production and market research, development and promotion, e) regulation of unfair trade practices, f) regulation of price posting and g) establishing minimum prices and providing information).
6. Marketing Boards (similar in structure and objectives to the marketing order but usually cover a wider range of activities than a market order would, such as exercising exclusive control over export product marketing. The Marketing Board represents the greatest involvement of government in the industry).

Each of these alternatives address the various marketing problems facing the fishing industry with a varying amount of success, i.e., one alternative may be a better solution for a particular problem than another. Also each alternative involves a different amount of financial commitment on the part of the individual fishermen and a different amount of government involvement. Thus, in analyzing various solutions to various marketing problems, one should take into consideration the degree of individual financial commitment involved, the amount of political action required, and the involvement of the government resulting. Table V summarizes the various marketing alternatives, which marketing problems each addresses most successfully, and the degree of financial, and political commitment, and government intervention involved.

One final fisheries development issue that we will consider here is the growth of marine aquaculture in northern New England, particularly Maine. The first marine aquacultural ventures were established in Maine in the early 1970's, and in ten years, more than fifty individual businesses, which vary greatly in scale, have been established. Almost two-thirds of these are three years old or less, attesting to the expanding nature of the industry. In 1979, sales of aquacultural products topped $450,000 and are expected to increase dramatically.

At both the federal and state levels, aquaculture has been receiving increasing attention. The U.S. Congress recently passed the National Aquaculture Act, a national plan for aquaculture written for the U.S. Department of Aquaculture. This plan provided incentive for the Maine Aquaculture Association, with assistance from the State government and the University of Maine to institute its own development plan, entitled "A Development Plan for Maine's Aquaculture Industry." This document discusses several areas where further work needs to be done: 1. biotechnical research, 2. market developments and coordination, 3. credit and business climate needs, and 4. legal and institutional needs. In the area of biotechnical research, there are several specific questions that need answering:

1. Are there technical systems which would reduce handling costs during the growing and shipping phases of shellfish aquaculture?
2. As the industry grows, how can diseases be controlled?
3. How can hatcheries increase the quality and quantity of their products?
4. How can over-wintering losses be reduced?

In the area of market development and coordination, the problems are very similar to those of the seafood harvesting industry. Alternative solutions to these problems need to be formulated. Can you and your group think of any ways that the aquaculture industry could help solve some of their marketing problems?

Credit and business climate are influenced by the condition of the state and national economies. Obviously, high interest rates and inflation will have some effect on the expansion of the aquaculture industry.

Finally, legal and institutional protections and/or requirements also influence the development of aquaculture in northern New England. For example, Maine law provides for leasing requirements and protections, while New Hampshire has no such provisions. Consequently, the industry has not taken hold in New Hampshire despite an interest by many individuals.

We can see, then, that the development of the fishing industry (including aquaculture) in northern New England is an important coastal issue that affects the entire economy of the region. This development is being hampered by a variety of problems which have been discussed in some detail in this section and will be summarized here:

1. Keeping fishermen (and aquaculturists) informed of recent advances in harvesting/aquaculture techology.
2. Improving the presently inadequate pier and port facilities for the fishing industry.
3. Helping provide solutions to the various marketing problems facing the industry.
4. Encouraging, through financial and other assistance, further research into the following areas:
   a. The social and environmental ramifications of new harvesting and aquacultural technologies.
   b. The social and economic advantages and disadvantages of various marketing strategies.
   c. The effects of other uses of the coastal waters (e.g. energy production, transportation, recreation, etc.) on the fishing and aquacultural industries.
   d. The biological characteristics of commercial "wild" fish species and "farmed" species.
   e. The economic and social advantages and disadvantages of various management techniques on fish stocks.

These are but a few of the issues facing the fishing industry in northern New England today. Why not take time with your group to discuss these and other concerns of the fisheries of our region.

The study recognized ten specific problems which can be placed into three general categories:

Demand related problems

1. Perishability — Because seafood is highly perishable, most individual fishermen must sell their catch at the dock immediately, regardless of price. During periods of peak seasonal catches, prices are driven down. Fishermen who can either store or process their catches themselves can help reduce this problem.

2. Limited Market Access — The small, widely distributed nature of the fishing industry in northern New England creates this problem for fishermen. For most, there is only one market — Boston.

3. Low level of demand (both domestic and foreign) — By and large, American consumers eat very little seafood compared with other foods. Lack of knowledge about the nutritional attributes of seafoods, methods of preparation, and preservation, and the characteristics of quality is one contributor to this low level of demand. Also the availability of high protein substitutes (e.g., meats), high American incomes, and the relatively low price of imported seafood products also help to account for why Americans eat so little domestic seafood. Foreign demand is also limited by various factors: a. political barriers such as import duties and trade restrictions, b. lack of concentrated volumes of sufficient size to meet foreign orders, c. foreign tastes and preferences which differ from those of the U.S.

Market Structure and coordination problems

4. Lack of price and quantity information — Fishermen often leave their docks with the knowledge of a certain price in mind and return to find that, in fact, the price for their catch is much lower than expected. This situation is due to the lack of a formal price reporting system at the retail level and only a limited reporting system at the wholesale level. Most fishermen are far removed from their markets and thus have poor access to market information.

5. Lack of uniform product standards and descriptions — It is difficult to stimulate seafood production of the type and quality desired by consumers without proper grades, standards and nomenclature.

6. Limited competition — Lack of market access for a large number of fishermen lowers competition among buyers and enables buyers to offer low prices for the products.

7. Small scale of first buyer operation — Most fish buyers operate a small scale business. This smallness often causes the problems of financial instability, limited dockage and storage capacity, inconsistent marketing channels due to high turnover of these businesses. These problems lead to limited market access for the fishermen causing them to receive widely fluctuating prices.

Supply-Related Problems

8. Supply variability — Landing variations result from biological and environmental variables and regulatory programs. Catch variability and the associated highly sensitive dockside demand causes wide price variations. Inadequate unloading and handling facilities and lack of storage facilities magnify the problem.

Table V
Marketing Alternatives for Fishermen

Alternative	Problems Most Successfully Addressed*	Financial Commitment Involved	Political Commitment Involved **	Degree Government Involvement
Organized Exchanges	Market Access Market Information Market Competition (High degree of of success)	Low to Moderate	Low	Low
Forward Contracting	Supply variability (Medium degree of success)	None	None	None
Vertical Integration Through Ownership & Joint Ventures	Market Access Scale of Market Operations Structure of Harvesting (High degree of success)	High	None	None
Group Bargaining	Does not address any problem as well as other alternatives	Low	Low	Low
Marketing Orders	Low level of demand Uniform Product Standards Supply variability (Medium degree of success)	Low	High	High
Marketing Boards	Market Information Structure of Harvesting (High degree of success)	Low	High	High

**Marketing Problems Defined*

** (political action by fishermen)

9. Structure of Harvesting Industry — As has been discussed before, the fishing industry in northern New England consists of many small producers widely dispersed throughout the region. Each produces relatively small volumes of many species which results in a high-cost assembly system. The problem is worsened by the lack of consistency in on-board handling practices among fishermen. These factors make it difficult and costly to provide a stable uniform flow of seafood for the market.

10. Volume of Imports — The United States imports a large amount of seafood products from abroad which causes prices for domestic products to decline. Domestic production needs to increase substantially before the U.S. market can lessen its dependency on foreign imports, needed for a continuous supply. Efforts to control imports need to be closely coordinated with domestic fishery expansion to insure balance is maintained between production and consumer needs.

Impacts on the Coastal Environment

The operations and development of commercial fisheries are not without environmental impacts. The most notable of these impacts are: waste generation (from boats and processing plants), habitat modification (by the construction of piers, dockside facilities, and processing plants), and reduction of fish, shellfish and crustacean populations (through overfishing).

The problem of waste discharge from fish processing plants has recently come under fire from the Department of Environmental Protection. Sardine processing plants have been charged with polluting local waters because of their practice of dumping fish oils and unused portions of fish (heads and tails). By and large, these materials are organic in nature and act as fertilizers for bacteria and plant life in the marine environment. Excessive bacterial growth can lead to contamination of clam flats and to reduced amounts of dissolved oxygen in the water, which is necessary for the existence of marine animal life. Blooms of marine plant life also create problems by presenting large amounts of material that needs to be decayed. Again, this leads to reduced dissolved oxygen levels in the water as increased numbers of decay bacteria consume a great deal of this important gas.

The sardine plant situation is worthy of discussion as the plants themselves are claiming that it would pose to them an undue financial hardship if they actually had to comply with the Department of Environmental Protection's regulations. Many of these plants are located in economically depressed regions where any increase in unemployment would be quite serious. This is a clear case of borderline economics versus environment and needs careful consideration.

Fishing vessels are also responsible for the discharge of wastes into the marine environment, notably organic materials (dead fish, scallop carcasses, etc.) and gasoline and oil. Port areas and heavily fished regions could be affected, although it is generally not known how serious a problem this actually presents.

Habitat modification occurs as a result of trawling, scallop dragging, worm and clam digging, construction of lobster pounds, and development and maintenance of port and pier facilities. Mechanized scallop harvesting entraps and crushes other benthic organisms besides scallops and increases water turbidity by stirring up bottom sediments which reduces light penetration and smothers bottom dwellers. Worm and clam digging can disrupt tidal flats by exposing intertidal organisms to freezing, predation, and physical damage. Lobster pounds result in the loss of intertidal habitats, may obstruct fish passage and can alter sedimentation patterns.

Disturbances to breeding areas of seals, seabirds, eagles, and osprey by commercial fishing and clamming operations could result in lowered reproductive success of these species.

Fish weirs and stop seines may trap marine animals and diving seabirds resulting in the deaths of these individuals.

The impacts of piers, breakwaters, boat launches and docks include habitat modification, and dredging effects. The problems associated with dredging are discussed in detail under "Cargo Port Development and Navigation."

Finally, overfishing results in reduced stocks of commercial fish species, sometimes to the point where it becomes uneconomical to fish for a certain species. The classical example of overfishing is one that historically occurred, but no longer takes place, in the Gulf of Maine: whaling. Some species have been hunted practically to the point of extinction. While it is unlikely that whaling operations, even had they continued at the scale of the late 19th century, could have been able to literally kill every last whale directly, extinction of whale species could, even today, occur *indirectly* as a result of severely reduced populations. There needs to be a certain number of individuals remaining in order for a population to maintain stability because there is a percentage of *natural* mortality (disease, birth defects, etc.) that will claim some lives. Once a population is reduced to extremely low levels, this natural mortality will eventually drive the species to extinction. In the case of whales, several species populations have been reduced by man to such low levels that they are today endangered by the threat of extinction. Only time will tell whether or not these populations will be able to recover.

This very same situation could occur with *any* species of animal or plant. In the case of most commercial fish species, however, what would likely occur first is "economic extinction." What this means is that the population of a certain commercial species is reduced to such a point that it becomes uneconomical to fish for that species any longer. In other words, it begins to *cost* more money to go out and fish for that species than can be made doing so. Thus, *management* of fish stocks is truly an important concept, necessary to help prevent the overfishing of certain species that could very conceivably occur.

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Background Information: Industrial and Commercial Development

Coastal areas of our country have traditionally been the first sites of industrial and residential development. The early settlers of this nation concentrated themselves along the coastlines because they depended upon the sea for transportation and foreign trade. Today, the major urban centers of our country are located in the coastal zone and the shoreline continues to be looked at as a prime location for industrial and commercial development. In this section we will take a look at the following kinds of industrial and commercial development currently existing on, as well as proposed for, the coast of northern New England: cargo port development; energy development and transportation; marine product research and development; tourism and recreation; other industrial and commercial development.

Cargo Port Development

Many studies have been undertaken by the States of Maine and New Hampshire in recent years that analyze the feasibility of, and locations for, cargo ports along the northern New England coast (see references). These studies addressed the following questions:

1. Should Maine and New Hampshire encourage the development of one or more cargo ports along their coasts? Is there a sufficient national or worldwide market for the products likely to be shipped from cargo ports in Maine and New Hampshire to warrant the expense of such
2. On what scale should cargo ports be developed, if they should in fact be developed? Should development be directed at renovation of existing facilities or should an entirely new port complex be constructed?
3. Where should cargo ports be located? Should there be more than one planned for the region, or only one?
4. How shall the development of of cargo ports be financed?

By and large, these studies concluded that there *does* exist a large enough market for products from northern New England, particularly forest products (lumber and woodpulp) from Maine, to warrant the development of cargo port facilities in the area. Presently the majority of exported products from Maine and New Hampshire is shipped from large ports such as Saint John, New Brunswick, Boston and New York. This has in large part been due to the shift towards "containerization" of the shipping industry (shipping products in large containers rather than in bulk). Containerized shipping requires extensive on-shore storage facilities, expensive shoreside cranes and high speed ships. Small ports such as exist in Maine and New Hampshire have been declining over the years mainly because they did not have sufficient cargo to supply a large containership on a regular basis, plus they could not make the investments necessary to switch to large scale containerization. However, some recent factors are presently increasing the need for improved cargo port facilities in Maine and New Hampshire:

1. It has been found that it is more economical to ship certain products in bulk rather than in containers. Special ships designed specifically for carrying these so-called "neobulk" cargoes have begun to appear alongside the containerships in the shipping industry. "Neobulk" cargoes include many of the forest products such as lumber and wood pulp, which constitute northern New England's largest export. Thus ports which deal almost exclusively in one of the neobulk cargoes stand to benefit from this new development in the shipping industry.
2. The rapid increase in fuel prices has had several effects that favor the development of container "feeder operations." First, long distance overland hauling of containers to seaports by trucks has become very expensive. Economics are beginning to favor water transportation in many instances. This means that it is becoming worthwhile, economically, for large containerships to make stops at several smaller ports to pick up containerized cargo (when a sufficient number of containers have accumulated at such ports), *rather* than having all containerized cargo transported by truck to the existing large container ports (Boston, New York, etc.). Thus the smaller ports become "feeders" to the containerized shipping industry by supplying containerized cargo in a less frequent schedule than do the huge container ports. This allows the smaller port, which handles less cargo on a weekly basis than a large port, to still participate in the containerized shipping business. Second, the shipping industry is beginning to build fewer huge, energy consumptive containerships and more, smaller energy conservative ships. This means that in order to handle the same (or greater) volume of cargo as is presently being handled, the industry must put a greater number of these smaller ships out onto the seas. The smaller port, again, can participate in the containerized shipping business by supplying cargo to these smaller ships, which require smaller scale port operations.

Thus, to summarize, the recent move to the containerized shipping industry towards "feeder operations" and smaller ships favors the growth of the smaller port, as does the increase in shipping of "neobulk" cargoes. In light of these changes, it appears that development of one or more cargo ports in northern New England would be a worthwhile economical investment.

The second consideration of the various studies has been the selection of a site (or sites). In New Hampshire, Portsmouth has been the most popular choice and the Port Authority there is now developing a master development plan. The plan recognizes that bulk shipment of oil and gas will continue to be the major use of the port, as it is at present, but also anticipates increases in containerized cargo. In Maine there has been quite a bit of controversy over the selection of a site, with Portland, Searsport and Eastport being the top three contenders. By and large, most studies favor the building of a *new* facility over improving existing ones and felt that Searsport was the most appropriate site. This conclusion has been supported by the following facts:

1. Searsport presently handles substantially more non-petroleum products than any other port in the state. Market analyses show that forest products dominate the export/import scene for Maine and Searsport already had port business established regarding these products. It is likely that Portland will continue to grow and thrive as an oil and gas importing facility, however, Searsport is more likely to continue to be favored as a dry cargoes port (especially forest products).
2. Searsport is in a better location, geographically, to serve as the state's major dry cargoes port. Approximately 70% of the State's waterborne forest products *exports* came from Penobscot and Washington Counties and nearly all forest products *imports* were destined for Penobscot County. The Searsport area is much closer to this traffic than either Portland or Eastport.
3. The Searsport Island location offers great development opportunities for cargo handling facilities as well as other related industries that could benefit the operation of the port. Over 300 acres are available on the island for such purposes, far exceeding the amount of available land in Portland for port expansion. Plus proposed fish pier developments in Portland and Eastport may not be compatible with cargo port development in those areas.
4. Sears Island offers deeper water alongside the berth than Portland. Dredging would have to be undertaken in Portland whereas it may not have to be at Searsport.
5. The cost of a port facility at Sears Island would be significantly less than the cost of a comparable facility at the Canadian National Railroad/Maine Department of Transportation site in Portland. The cost of developing a facility at the #3 wharf in Portland may be somewhat less than a Searsport facility but the disadvantages associated with the #3 wharf are many, namely the depth of the channel is only 28-30 feet, and the "Million Dollar Bridge," which is downstream of the wharf, restricts the width of vessels that could call at the wharf. These factors are summarized in the "Advantages" column for the building of a new cargo port facility at Searsport (see Table I). Table I also summarizes the advantages and disadvantages of various other cargo port alternatives available to the state, and contains other comments pertinent to proposed development at Searsport, Portland and Eastport.

Table I

Advantages and Disadvantages of, and Other Comments Regarding Cargo Port Development At Three Sites in Maine (Searsport, Portland, Eastport)

Site and Type of Development

New Port Facilities at Searsport

Advantages

1. A large amount of land is available on Sears Island (300-350 acres) for development of new port facilities.
2. There is 40 foot and deeper water adjacent to the island within a reasonable distance offshore. This lessens the need for dredging.
3. The Searsport area has an established dry cargo market with significant volumes of such cargo presently being shipped through the State.
4. Searsport is centrally located in the State and is in an excellent location to receive forest products for shipping.
5. Other industrial developments are proposed for Sears Island which would help pay for needed road and railroad access. (e.g. Central Maine Power has proposed building two power plants on the island and has included the building of a rail and highway connection to the island to serve the plants.)

Disadvantages

1. There is a current lack of rail and adequate roadway access to the island. This access would have to be constructed on a causeway to the island.
2. The offshore island location would require a substantial quantity of fill.
3. The cost of such a facility is relatively high. Estimates range between $27 and $40 million.

Other Comments

The Maine Department of Transportation Study (Fay, Spofford & Thorndike, Inc.) recommends this option for the reasons already discussed in the background information section and summarized under the "Advantages" column for this option.

Site and Type of Development

Improvement of Existing Facilities at Searsport

Advantages

1. Making one major improvement on the existing facilities (e.g. widening the "apron" to enable heavier loads to be brought onto the piers and to allow vehicles and equipment room to maneuver) could be undertaken at relatively low cost.

Disadvantages

1. Too many improvements need to be made in the existing facilities to make them attractive to a greater volume of traffic. To make all the improvements necessary would make this option more costly than an entirely new facility.
2. An upgraded facility would not be as efficient as a brand new one and would therefore not be as attractive to the potential shipper.

Other Comments

Upgrading of existing facilities are essentially "stop gap" measures and would not remedy the major problems currently associated with Maine's cargo handling operations, particularly old facilities and lack of expansion space. The costs for continually upgrading various portions of existing facilities will only increase in the future, making this an expensive option in the long run.

Site and Type of Development

New Cargo Port Facilities at Portland
A. Wharf #3

Advantages

1. Excellent access by land available to this site.
2. A cargo facility could be built here with little or no filling and construction on piles required, thus saving money.
3. Good rail access to site.
4. Relatively low cost for development. Estimate = $19 million.

Disadvantages

1. The site is located upstream of the "Million Dollar Bridge" which presents a restriction on the size (width) of vessels which can pass through.
2. A channel of depths of 28-30 ft. at this site restricts the size (draft) of vessels that can use this site. Dredging would be required.
3. The river channel is too close to the site. A vessel docked at the wharf might protrude into the channel.
4. The railroad tracks pass right through the property eliminating some land from use for storage facilities.
5. Major expansion is limited by the proximity of Rte. 1 and Commercial St. development.

Other Comments

The sites in Portland are advantageous, location wise, with regard to manufactured goods, but not so much so with regard to forest products which presently dominate on the Maine export/import scene. Most of the major forest products producers are located in central and northern Maine and would thus find Searsport more convenient. Portland has some disadvantage in being close to the major port of Boston. Some potential users might find it only a *little* more inconvenient, from a distance standpoint, to use Boston, which has, however, a superior shipping schedule.

Site and Type of Development

B. Canadian National Railroad pier site
(partly owned by Maine Dept. of Transportation)

Advantages

1. Excellent rail and highway access.
2. Is downstream from the "Million Dollar Bridge" — the bridge does not pose any restrictions to vessels.
3. This site is located closer to deeper water than Wharf #3.

Disadvantages

1. Poor harbor bottom conditions exist at this site. A major structure could not be built on fill because of the poor bottom soil; it would have to be build on pilings (expensive).
2. Long range expansion impossible due to surrounding development.

Other Comments

Same as above — for Wharf #3.

Site and Type of Development

Improvements of Existing Facilities at Portland (Maine State Pier)

Advantages

1. The major improvement needed (widening the "apron") could be undertaken at relatively low cost ($8.9 million).

Disadvantages

1. Lack of space for long range expansion.
2. As with improving facilities at Searsport, one improvement at this site eventually leads to another, making a complete renovation desirable but very expensive in the long run.

Other Comments

Same as for Wharf #3 and Canadian National Railroad Pier Site.

Site and Type of Development

New Cargo Port Facilities at Eastport

Advantages

1. A number of shippers have expressed interest in port facilities at Eastport for the transport of the following products: general forest products, wood pulp, food products such as fish, blueberries and potatoes.
2. The Eastport site is located near relatively deep water, thereby decreasing the need for dredging.
3. There is a large unemployed population in the Eastport area which could supply the labor force for the construction and operation of port facilities.

**Note that in 1981, freighters stopped at Eastport five times to haul paper products from the Georgia Pacific in Woodland, Maine to Europe.*

Disadvantages

1. Not enough cargo passes through Eastport to warrant a container "feeder" operation to be built there. The cost/benefit ratio is too low.
2. A container feeder operation at Eastport would compete with existing cargo traffic at Searsport. The studies indicated that it would be better to consolidate cargo port efforts at one site in the State rather than to divide them over several locations.
3. Eastport is not in a centralized location as is Searsport.

Other Comments

1. The studies recommended that Eastport continue to be considered in a Statewide port development plan under the following circumstances:
   a. Involvement of private shippers and other interests in the planning and funding of Eastport port facilities (rather than total reliance on State funding and planning).
   b. Eastport should be included in a Statewide industrial development program. This program would help attract industries to a seaport area and assist these industries to compete in overseas markets.

Impacts on the Marine Environment

Cargo Port Development

The major impacts of port operations and navigation improvement projects are associated with the construction and maintenance of wharves and piers, and dredging.

The construction and maintenance of wharves and piers destroys some intertidal habitat. This can be significant in very developed harbors like Portland, Boothbay, Rockland, Lubec, and Eastport in Maine and Portsmouth in New Hampshire. Intertidal life in these areas has become quite restricted due to loss of habitat. In addition, piers can change local current patterns and may affect benthic animal life by modifying sediment type and distribution (i.e. certain benthic animals need a specific soil type. If this soil type is changed by altered deposition patterns due to different current circulations, these animals may not be able to survive). Piers and wharves also shade the bottom in shallow areas which lowers the productivity of the areas by reducing the amount of available sunlight to benthic plants. A reduction in the productivity of benthic algae represents a decrease in available food along the entire food chain.

Dredging is done in Maine primarily to maintain commercial navigation channels. Elsewhere, dredging is used to obtain sand, shell or gravel deposits, or to establish a commercial, industrial or residential facility.

The most frequently dredged areas in Maine are Portland Harbor, Kennebec River, Penobscot River, Rockland Harbor and the Royal River. The material that is dredged up is generally disposed of in deep ocean areas but sometimes the so-called "dredge spoils" are dumped on land areas, beaches, in bays, estuaries and rivers.

The impacts of dredging operations can generally be grouped into two categories: impacts resulting from the physical removal of sediments and impacts resulting from the disposal of the dredge spoils. Removal of sediment by dredging can cause the following environmental impacts:

1. Loss of natural habitat.
2. Alterations of water circulation patterns.
3. Increased turbidity (decreased water clarity).
4. Release of trapped pollutants and organic matter.
5. Loss of beach sediment supplies.

Disposal of dredged material onto upland areas results in the creation of barren habitats. Disposal into open water areas creates conditions of increased turbidity and excess sedimentation in areas downstream from the disposal site.

Loss of natural habitat by dredging occurs not only because bottom sediment (and all plants and animals dwelling therein) is removed, but also because the area that results after the dreding project is completed is very different from the original in physical and chemical characteristics. Also, since dredging results in an unstable sediment condition, rapid deposition may occur in the area, causing the need for repeated dredging. Regular recurrent dredging prevents a community of long lived marine residents (e.g. lobsters, clams) from ever getting re-established in the dredged area.

The most long term impacts of dredging are associated with altered water circulation patterns, notably changes in water temperature, salinity, dissolved oxygen and sediment distribution. Studies of dredged areas have shown that marked changes in the kinds of plants and animals living there occurs because of the changes in sediment types.

Turbidity, or loss of water clarity due to excess sediment, is another common result of dredging operations. The dispersal of large quantities of silt during dredging may have detrimental effects up to a half mile from the site. This silt eventually settles on the bottom but is easily resuspended by strong bottom currents. This fine silt can smother stationary bottom dwelling animals or clog the breathing apparatus of filter feeders such as clams and mussels. Turbidity also decreases the amount of light that can penetrate the water column, thereby limiting plant growth and subsequently effecting the entire food web. Also decreased plant growth (known as "lowered primary production") results in reduced oxygen supply (recall that plants give off oxygen during photosynthesis). Low levels of dissolved oxygen have been responsible for massive kills of benthic plants and animals and could create stressful conditions for benthic organisms surrounding the dredge site. Studies have shown that the larvae of oysters and clams are very sensitive to excess silt in the water, with growth retardation and abnormal behavior being reported as results of being exposed to excess silt.

Dredging in a polluted area (which is what *usually* occurs) can release heavy metals and other toxic substances into the water. This can have several detrimental effects including lowering dissolved oxygen levels, and making the pollutants available for pick up by marine organisms.

Benthic organisms are not the only marine creatures to suffer from dredging operations. Fish populations can be effected in a number of ways: spawning grounds may be smothered with sediment, which can either prevent spawning altogether or covers the eggs and larvae; spawning grounds may be removed completely; dissolved oxygen levels are reduced; gills can be damaged by excess sediment in the water; and underwater landmarks which may be used for navigation purposes by migratory fish may be removed.

Finally, dredging operations can cause depletion of the sediment supply for local beaches. Recall that sediments which are removed from beaches by storm waves, etc., are usually deposited a short ways offshore and are returned to the beaches by gentler summer wave conditions. If this sediment is dredged up and disposed of elsewhere, the beach is robbed of its "summer supply" of sand and hence will not be rebuilt, resulting in a condition of severe shoreline erosion.

The disposal of dredge spoils is also a significant problem. The dumping of dredge spoil on submerged bottoms may suffocate benthic plants and animals and raise the bottom to a different intertidal height which could affect intertidal plants and animals. Dumping fill in the intertidal zone can increase sedimentation in downstream areas. Also dumping of spoils dredged from a polluted area can release toxins and heavy metals in an otherwise clean area, thereby effecting the flora and fauna in the vicinity of the dumpsite.

Development on land associated with cargo ports also has its impacts on the nearby marine environment. Roads and railways built on causeways on or over tidal areas restrict tidal flow to areas landward of the causeways. The resulting change in drainage patterns may cause alterations in temperatures and salinities, increased sedimentation and decreased tidal flushing rates, all of which can have detrimental effects on intertidal organisms. Paved roadways and other hardtop surfaces increase surface runoff of precipitation, often washing oil and gasoline off these surfaces into the nearby marine areas. Likewise, the use of herbicides to control plant growth along roads and railways, can pose problems to the plants and animals of nearby marine environments as these substances wash off into surrounding areas with rainfall. Little is known at the present about the effects of specific herbicides used on marine creatures, however, many other chemicals which are or have been used for herbicide and pesticide purposes are known to concentrate in food chains and cause such problems as reproductive failure or abnormalities in fish and birds, short term poisoning, and/or long term buildup of these substances in the tissues of fish (and, possibly, ultimately in the humans who eat them) and marine mammals.

These impacts on the coastal environment need to be taken into consideration when planning for cargo port development in northern New England.

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Background Information: Energy Development and Transportation

The siting of heavy industry on the northern New England coast, has been, and continues to be, a very controversial subject. According to several recent studies, the industries *most likely* to seek sites along our coast involve the development and transportation of energy, its raw materials and products, notably:

1. liquified natural gas (LNG) terminal(s) and regasification facility(ies),
2. oil terminal(s),
3. oil refinery(ies),
4. construction yard(s) for drilling platforms for the outer continental shelf (OSC) oil drilling projects,
5. nuclear power plant(s),
6. coal fired electric power plant(s),
7. coal storage and handling yard(s).

The production of electricity by tidal power was generally *not* considered to be a heavy industry by most of the studies, but it will be included in this section, anyway, for sake of simplicity.

Let us take a look at these various different industries and the prospects for their locating in northern New England within the next twenty-five years.

Liquefied Natural Gas (LNG)

Natural gas comprises 34% of the total energy consumption in the U.S. Since 1970, domestic discoveries of natural gas have decreased despite more intensive drilling efforts and efforts have been undertaken to import liquefied natural gas from other nations so as to increase available supplies in this country. The importation of LNG requires three types of facilities: a terminal, a regasification plant to change liquid natural gas to its gaseous state, and a pipeline to carry the gas to market.

In 1976, the Tennessee Atlantic Pipeline Company (Tenneco) revealed its plans to locate a LNG regasification plant in St. John, New Brunswick. If these plans are approved, the LNG will be regasified in New Brunswick and be transported to southern markets via a pipeline that would run through Maine. During the next 25 years, it is also possible that a regasification plant and receiving terminal will be planned for coastal Maine to "plug into" the proposed pipeline.

Petroleum

It is projected that by 1985, petroleum products will supply nearly 42% of this country's energy needs. Despite conservation efforts and other measures to reduce oil consumption, analysts predict that the U.S. will *increase* its requirements for petroleum products by 4.5 million barrels per day by 1985.

Whether the United States can dramatically increase its own exploitation of petroleum resources or whether it continues to import foreign crude, it will have to increase development of refining capacity in order to meet this expected rise in demand. Because of the East Coast, particularly the Northeast coast, demands larger amounts of petroleum products than most other areas of the country, it is reasonable to expect that several new refineries will be proposed for the area in the very near future.

Two types of petroleum related facilities are very possible for the future in coastal Maine: crude oil terminals and oil refineries. Most of us are aware of the controversy over the locating of an oil refinery by the Pittston company, in Eastport, Me. This battle has been raging for over ten years and the latest obstacle to Pittston's plans has been refusal by the Canadian government to allow oil tankers access to Head Harbor Passage through which the tankers would have to travel in order to reach the projected refinery site. Whether or not Pittston is ultimately successful in its quest for the Eastport refinery, it is highly likely that an oil refinery *will* be located somewhere on the Maine coast. The reasons for this projection are many:

1. The federal government is strongly in favor of increasing the refining capabilities of the northeast coast,
2. Maine has deep water anchorage to make supertanker traffic possible,
3. The demand for petroleum products will likely increase in northern New England.

It is also expected that any oil refinery will be served by its own marine terminal. Therefore, even if a more inland site is ultimately chosen for an oil refinery, a coastal terminal and pipeline will likely be constructed to support the refinery.

Nuclear Power Plant

According to the power industry, Maine has ideal conditions for the construction and operation of additional nuclear power plants: cold water, relatively low population densities, and more or less stable bedrock geology (compared with the earthquake zones of the West Coast, for example). There are already tentative plans for a nuclear plant at Richmond, Maine and another on Sears Island near Searsport. A coastal site is preferred by the industry because cold water is needed for cooling off the reactor, while low population densities mean generally more abundant and cheaper land. It is very likely then that the power generation industry will propose construction of several nuclear power plants along the northern New England coast in the future.

Coal Fired Electric Generation

Ever since the so called "Energy Crisis" of the early 1970's, there has grown increasing interest on the parts of government and industry to use coal to fire electric generating plants. Because water transport of coal is less expensive than rail transport, it is likely that such coal fired plants will be located in coastal areas and will have marine coal handling facilities associated with their construction. Rail transportation will continue to be the major mode for inland movement of coal, thus the coastal coal handling facilities will also need rail access for transporting coal to inland industries (eg., pulp-paper processing plants).

At present there are plans for a coal fired electric plant to be located on Sears Island together with a coal receiving and handling facility. Central Maine Power, the company proposing this development also plans to construct a causeway from Searsport to Sears Island in order to provide rail service to the Island.

Construction of Outer Continental Shelf Platforms (offshore oil drilling rigs)

After years of legal suits filed by environmental groups, it now appears likely that exploration for and exploitation of oil reserves on the Georges Bank *will* take place. Thus far, exploratory drillings in the area have not yielded any large commercially important finds. In the event that such a find is made, it is very likely that one or more construction yard(s) for drilling platforms will be located along the coast of Maine. Two types of platforms are commonly built: Steel and concrete. Concrete platforms have played a major part in the development of the North Sea oil fields because of their superior performance in rough weather. Since the weather conditions on the Georges Bank are as bad or worse than in the North Sea area, it is likely, in the event of an extensive oil or gas discovery on the Georges Bank, that concrete drilling platforms will be used there. Maine is the prime candidate for a coastal construction yard for concrete drilling platforms because of its relative abundance of coastal land available and because the state is rich in sand and gravel reserves needed to produce concrete.

In the case of some of these industries above, sites have already been chosen (e.g., Eastport for the Pittston oil refinery and terminal, Searsport for a coal fired electric plant, coal handling facility and nuclear power plant, Richmond for a nuclear power plant). What are the recommendations of the various studies regarding heavy industry siting along the Maine coast, in general? What are the environmental consequences of heavy industry siting along the coast?

Let us first co[illegible]der the recommendations for industry siting. There are nu[illegible]s factors to be considered in the process of deciding whe[illegible] not any heavy industry should be located on the coast [illegible] so, what type of industry and where should it be located [illegible]e need to look at what laws currently exist regarding heavy industry siting and what state and/or federal agencies would be involved in approving the industry and site.

In Maine, the following regulatory statutes exist which would have jurisdiction over the siting of energy facilities on the coast:

1. Public Utilities and Carriers Law
2. Shoreland Zoning Act
3. Municipal Planning and Zoning
4. Land Use Regulation Commission
5. Site Location of Development Act
6. Protection and Improvement of Air
7. Protection and Improvement of Waters
8. Oil Discharge Prevention and Pollution Control
9. Alteration of Coastal Wetlands
10. Great Ponds Act
11. Alteration of Rivers, Streams, Brooks
12. Mining and Minerals
13. Public Lands

There are an additional two statutes that do not have *regulatory* authority, but are entitled to *advise* in the selection of a site:

1. Maine State Energy Resources Act
2. Act for State Register of Critical Areas.

The principal state agencies involved in the management of energy resources and facilities are:

1. The Department of Environmental Protection
2. The Public Utilities Commission (PUC)
3. The Land Use Regulation Commission (LURC)
4. Geological Survey
5. Office of Energy Resources
6. State Planning Office

There are, in addition, several regional and federal agencies that play a role in the siting of an energy facility in Maine. These include:

1. New England River Basins Commission (NERBC)
2. Northeast Solar Energy Center
3. New England Regional Commission (NERCOM)
4. New England Federal Regional Council Energy Resource Development Task Force
5. National Governors Association (NGA)
6. Massachusetts Energy Facilities Siting Council

As you can see, approving an industry and choosing a site for it can be rather complicated, what with all these laws and agencies to deal with. In addition to all of this, there are also local zoning ordinances to contend with.

Bearing these regulations, agencies and local ordinances in mind, several studies were undertaken by various groups and committees which give general recommendations regarding heavy industry siting on the coast of Maine. These recommendations are discussed below:

1. Heavy industry and to a large extent, related light industries should be concentrated in only two or three areas or "zones" of the coast, leaving the rest of the coast (98%) free of heavy industry and dedicated to other uses such as preservation (actually the "lack of use"), recreation, tourism, and residential development.

On the above point, all of the studies agreed. There was some differences of opinion as to *where* these zones should be located.

The report of the Governor's Task Force on Energy, Heavy Industry and the Maine Coast (1972) made the following recommendation regarding siting of the heavy industry zones:

"1. New heavy industry in the coastal zone should be confined to two zones, one in the Portland-Casco Bay area and one in the Machias Bay area, except as noted hereafter.
2. Oil development should for now be limited to the Portland area zone, and deferred even there until corrective action in light of the Tamano spill has been taken with regard to navigation training and equipment stockpiling. Oil development in the Machias Bay zone should be deferred until Maine has greater reason to believe that spillage can be prevented and contained."

The study prepared by the Maine Department of Conservation with the assistance of the Office of Energy Resources, entitled "Where Should Heavy Industry be Sited in Coastal Maine?" (1974) concluded:

> ". . . the following groups of municipalities be designated as heavy industrial development areas: a) Machiasport-Cutler; b) Searsport-Stockton Springs-Penobscot; and c) Portland-South Portland; . . . and . . . that any heavy industry involving bulk storage or handling or transfer facilities for crude oil be located in the Portland-South Portland heavy industrial development area."

Finally, the Report to the Governor by his Advisory Committee on Coastal Development and Conservation (CCDC), entitled "The Maine Coast: Issues Considered" (1978) recommended that:

> "If oil terminals, oil refineries, coal storage yards, coal fired power generation plants, liquefied natural gas facilities or drilling platform construction plants are located on the coast, . . . they should be located in Portland or the Upper Penobscot Bay areas . . . and . . . the Machias Bay area, because of its remoteness and exceptional natural resource value should not be favored by heavy industrial development."

(Note: These recommendations listed above constituted only a portion of the total roster or recommendations made by these three groups.)

At the present time, planning efforts regarding the development of energy facilities on the Maine Coast have focused on the Casco Bay area and have included considerations for future use of the existing South Portland oil storage complex, and an oil spill assessment in the Bay. This assessment takes a look at the below tidal natural resources, examines current patterns and characterizes benthic communities in the area. The major thrust of the planning effort has been toward improving clean-up strategies in the case of an oil spill. Construction of a facility to handle and dispose of oil spill debris is presently underway.

In addition, current planning efforts are examining the prospects for an increased use of coal in Maine's energy future. The Penobscot Valley Regional Planning Commission has studied the environmental impact of coal storage yards and has also examined the impact on housing of the proposed coal fired power plant to be located on Sears Island. The Maine Department of Transportation is planning a study that will review the impact of coal transportation and storage along the coast.

The concept of utilizing the tides to generate electricity has recently become very controversial in northern New England, particularly in eastern Maine. The Canadian government has proposed the building of two tidal power dams in the Bay of Fundy, one in Shepody Bay, the other in Minas Basin, both located at the head of the Bay of Fundy between New Brunswick and Nova Scotia. And in Maine, consideration has been given to tidal power projects at Half Moon Cove (Passamaquoddy Bay near Eastport), Lubec (Cobscook Bay Power Authority) and Vinalhaven (Fox Island Electric Cooperative). Of these, the Passamaquoddy project has been in the planning stages for the longest period of time. A tidal power facility at that location was conceived of shortly after World War I and in 1935-36, two dams were actually built and another partially completed before funds ran out and the project was abandoned. After the so-called "Energy Crisis" of the 1970's, there was a renewed interest in energy alternatives to oil and ever since 1973 there has been a nearly annual updating of information relative to the utilization of the Passamaquoddy region's tidal power.

The most recent controversy has been over the proposed formation of a "Cobscook Bay Tidal Power District". In June 1981, the Maine State Legislature passed an act, L.D. 1603 to create such an organization. A referendum vote was required by the nine towns which would be involved in the District (Lubec, Eastport, Pleasant Point, Pembroke, Trescott, Edmunds, Perry, Dennysville and Whiting) to be taken no later than April 1982. In effect, this District, if formed by passage of the referendum vote, would oversee the progress of a tidal power project in Cobscook Bay. A group called the Straight Bay Association formed to oppose the formation of Tidal Power District on the following grounds:

1. There is no demonstrated need for additional electricity in Maine (Maine is a net *exporter* of electrical power).

2. The amount of power generated by the proposed project (10 megawatts) is low when compared with the costs of the project. Other sources of electricty are more economical (eg. coal, hydro power.)
3. The tidal power project would not necessarily result in cheaper electricity for local people.
4. Taxpayers in the nine towns would have to foot the bills for District personnel salaries, etc., until such time as bonds can be floated. Also, taxpayers would be liable for all debts of the District.
5. Eminent domain could be exercised over private land needed for dams, transformers, powerlines, etc. Property values in the vicinity of the dams would go down.
6. The environmental consequences are too great (see "Impacts on the Environment of Heavy Industry"). Clam flats and fishing areas in Cobscook Bay will be harmed and/or destroyed.
7. The tidal project would provide very few jobs for local people because of the highly technical nature of the undertaking.
8. Control of expenditures and decision making would be in the hands of the District and state and federal agencies. Individual towns will have little say in these matters.
9. The towns were not consulted when the legislature was asked by a Tidal Power Committee to draft the law forming the District.
10. The financial outlook for the District is shaky. (Bonds will be difficult to sell due to national economic conditions; interest rates of bonds are likely to be higher than the 7.5% estimated by the Tidal Power Committee; compensation for lost jobs and lowered property value was not included in the cost/benefit ratios; there is no legal debt ceiling).

In November of 1981, five of the nine towns voted on the act to form a Tidal Power District and defeated it.

Serious questions have been raised regarding the environmental impacts of the other tidal power projects. (See "Impacts on the Coastal Environment"). Also the economics of such projects have been carefully scrutinized and, at the present time, it appears that the costs of such projects, especially the small ones, are greater than the economic benefits. However, as nonrenewable energy resources continue to grow scarce, this economic picture may eventually change.

So the use of tides of northern New England will likely continue to be an important issue in our "coastal future".

Before moving onto a consideration of the impacts of heavy industry on the marine environment, let us take a brief look at a few other heavy industries already located or likely to locate on the northern New England coast. For purposes of most of the studies dealing with heavy industry siting, *heavy* industry has been defined as "industry having one or more of the following characteristics: a) high fixed capital requirements per employee, b) substantial inputs of bulky raw or partially processed materials, fuel, electric power, or water, and c) substantial environmental impact". Examples of heavy industry include: pulp and paper, petroleum refining, industrial chemicals, primary metals, large scale electric generation and shipbuilding. *Light* industry, on the other hand, would be typified by most food processing establishments, electronics assembly, garment manufacture, leather products, boatbuilding and furniture construction.

Of the heavy industries listed above, the most important to the northern New England coast (excluding energy facilities which have already been discussed) is shipbuilding, most notably, the Bath Iron Works. BIW has been and still is an extremely successful shipbuilding enterprise, located on the Kennebec River in Bath, Maine. The proposed expansion of Bath Iron Works into Portland has recently become an issue fraught with controversy. In November, 1981 voters in Maine approved a multimillion dollar bond issue designed to stimulate businesses in the state. One of the businesses slated to receive substantial money from the sale of state bonds is Bath Iron Works. The issue, at this writing, is over whether or not state funds should go to help finance the expansion of a private enterprise with no stipulation that this money ever be paid back. The opponents of this procedure claim that it is unconstitutional, while its proponents say that there is nothing illegal about it as voters approved the spending in a state referendum. Plus, they claim, the benefits to the state and to the city of Portland in terms of extra tax revenues and additional jobs will more than compensate for the investment. The resolution of this issue will set a precedent in state policy regarding the relationship between public funds and private enterprise in Maine.

Impacts on the Coastal Environment

As stated in the definition of "heavy industry," the impacts on the marine environment of such development along the coast are "substantial". Let us first examine the major impacts of the development of energy related facilities and transportation.

The most important environmental impact of gas and oil development along the northern New England coast is the effect of oil and gas spills. Since 1976, the Maine Department of Environmental Protection (DEP) has reported on the occurence, location and size of oil spills along the coast of that state. Between 1976 and 1978, the DEP reported 950 spills of 175,465 gallons total, of petroleum products. Actually, the three worst spills in Maine history occurred before the DEP reporting system was instituted: the *Northern Gulf* spill in Muscongus Bay in 1963 of 5,000 tons of crude oil; the leakage in 1971 of 14 tons of #2 fuel oil and jet fuel oil into Long Cove (Penobscot Bay); and the 1972 *Tamano* spill of 325 tons of #6 fuel oil into Casco Bay.

Unfortunately none of these three large spills were assessed thoroughly from an ecological standpoint. For the most part, only the damage done to the commercial fisheries of these areas was investigated. In the Muscongus Bay spill, it was estimated that some 100-200 tons of soft clams and about 15 tons of impounded lobster were destroyed. Eleven years after the spill, high concentrations (4,000 parts per million) of oil were still being found in the area, and clam transportation studies showed that only 12.8% of these clams survived in Muscongus Bay, as compared with a survival rate of 78.1% of the transplanted clams in an unaffected control area. Of the transplanted clams that did survive in Muscongus Bay, their own growth rate was severely curtailed.

At Long Cove, although the amount spilled was small in comparison to the other two large spills, the *type* of petroleum product (#2 fuel oil and jet fuel) proved to be especially toxic. Within two weeks of the leakage, an estimated 4.5 *million* commercial sized clams had died in the area. Moreover, 86% of the clams of Long Cove and surrounding waters were dead within two years of the spill, and many of the surviving clams had developed malignant tumors. (It is known that certain components of petroleum are carcinogenic, or cancer-causing. It is not yet known what the effect is on humans who eat clams with malignancies.) Five years after the spill, the remaining clam population continued to show a significant incidence of tumors and a reduced growth rate. Also bloodworms dug from the area died during shipping and dealers stopped buying them.

The *Tamano* spill was investigated more fully and results showed that all plant and animal groups in the area were adversely affected to some extent, at least. Marine amphipods, which provide food for several higher organisms, were completely killed off in some areas of Casco Bay. Waterbirds also experienced high mortality.

The effects of oil pollution on the different plants and animals of an area vary. The extent of damage done depends on many factors, including the type of petroleum product (how toxic it is), the duration of the leak or spill, the environmental conditions present at the time of the spill, the time of year, the physical states of the organisms and the amount of other forms of stress present at the time of the spill. Some specific effects that have been documented by research include the following:

1. Small benthic organisms suffer from coating which causes asphixyation.
2. The young of many species are killed or deformed.
3. Growth rates of clams are reduced.
4. Barnacle and sea urchins larvae suffer abnormal development.
5. Lobsters experience delayed moulting.
6. The chemoreception (sensitivity to natural chemical changes) capabilities of lobsters and other marine creatures are hindered.
7. The reproduction of birds and fiddler crabs is adversely affected.
8. The behavior of waterbirds is altered, thereby affecting mating, nesting, migration, etc.

Probably the most damaging effect on marine ecosystems is the chronic low level exposure to petroleum products caused by the continuing presence of petroleum from a large spill or from several consecutive small spills. The oil or gas remains in the sediments a long time and becomes concentrated in the tissues of marine organisms and is passed along the food chain to higher organisms, including man who may eat seafood from areas contaminated by oil pollution.

The length of time that spilled oil or gas will remain in the marine environment depends primarily on the amount of wave action of an area. On rocky headlands where wave action is intense, oil is more quickly dispersed than in quiet, protected mudflat areas where the oil may persist for many years. On the other hand, wave and current action can carry petroleum from spills and leaks offshore (for example from the oil and gas drilling enterprises on Georges Bank) to the coast, thus contaminating areas not otherwise directly affected by spills offshore.

Thus, the development of oil and gas facilities, both offshore and along the coast (including drilling rigs, tankers transport, offshore pipelines, coastal storage facilities, and refineries) can all have rather serious impacts on the marine environment.

The other forms of power generation discussed include nuclear and coal fired electric power plants and tidal power. Both of these have been found to have adverse impacts on the marine environment.

The major impact of nuclear, oil or coal power generating stations is the discharge of hot water into the marine environment. Such power generating stations are usually located along the coast because they require cold water for cooling. This water is returned to the environment several degrees warmer than when it was taken out. This so called thermal pollution can cause several effects on marine organisms of the area. One effect is to increase the metabolic rates of the organisms which in turn increases their demand for oxygen. At the same time, warm water can dissolve less oxygen than cold water, so the amount of dissolved oxygen available to organisms is reduced. As a result, some organisms are severely stressed by these conditions and suffer altered behavior and growth patterns. In addition, rapid temperature changes can kill organisms. This happens when power plants in cold climates, such as northern New England, are shut down during the winter. The plants and animals that had adapted to the warmer temperatures created by thermal discharge are subjected to severe shock when plants are shut down in winter.

Another problem for marine organisms created by coastal power plants is "entrainment and impingement". This means that small organisms like plankton and the larvae and young of fish, crabs, clams, lobsters, etc., are sucked into (or entrained in) the cooling ducts of the plants and are trapped in screens (or impinged). Some organisms pass through the screens and are killed by mechanical, chemical or thermal stresses within the plant itself. Under some conditions this could have a significant impact of local fish populations.

Studies done at the Maine Yankee Nuclear Power Plant at Wiscasset have not shown any major adverse effects on the flora and fauna as a result of thermal discharge or plant operations. Benthic animals such as clams, and worms, and most forms of zooplankton, do not appear to be severely affected except when they occurred very close to the source of discharge. Studies concerning entrainment and impingement have also concluded that phytoplankton and the larvae of worms and other animals have not suffered much damange. It is thought that the low degree of adverse environmental impact of the Maine Yankee Plant, as far as marine life is concerned, is due to several factors: relatively small temperature changes, large bodies of water nearby which effectively help to dilute the thermal discharge and proper design and location of the power facility and discharge plume.

One negative effect that has been noted at the Maine Yankee Plant is the rearrangement of the dominant algae species of the area into much smaller bands in the intertidal zone. What the long term consequences are of this compression are, at this point, unknown. It should be noted that extensive studies on *all* groups of marine organisms regarding the effects of thermal pollution, entrainment and impingement, have not yet been carried out.

Of course, we have not discussed the more broad, general issues concerning electric power generation, particularly by nuclear powered plants, such as low level radiation, melt downs and other accidents, nuclear fuel storage, and nuclear waste disposal. These are not necessarily strictly coastal concerns and a discussion of these hazards is beyond the scope of this information. It should be pointed out, however, that these are *very important* concerns and should be assessed completely before any more future power plants are located on our coast. At present, the State of Maine has a law prohibiting the construction of future nuclear power plants until the problem of nuclear waste disposal is adequately dealt with. In addition, there is substantial support for a referendum vote in Maine to phase out the operations of the existing Maine Yankee plant over the next five years because of questions over its safety. This is a controversy that could be researched by your group and which should provide material for lively discussion!

Finally, let us consider the potential environmental impacts of tidal power projects on the coast of northern New England. Tidal power projects are generally of two types: dams utilizing both incoming and outgoing tidal currents to produce power immediately and impoundments using the incoming tides only to store water until power is needed later. Both types of projects can alter tide dynamics, water temperature, wave action, surface and bottom currents, sedimentation rates and erosion patterns. These changes in the physical characteristics of an area subsequently effect the living marine organisms. It is estimated that the proposed project for the Bay of Fundy could cause a *lowering* of the high tide levels and a *raising* of the low tide levels, causing a rise in the mean sea level in the Bay of approximately 9 feet. These changes would drastically effect the intertidal zone, causing a decrease in the expanse of the zone (i.e., less mudflat area would be exposed at low tide) and a change in the intertidal plant and animal zonation. This in turn would effect the overall productivity of the saltmarsh-mudflat community. Some studies conclude that about half of the intertidal plant communities in the Bay of Fundy would cease being productive.

Decreased marsh productivity, changes in intertidal area expanse, lessened tidal flushing and increased sedimentation could all severely damage commercial clam flats and worming areas. The presence of dams and turbines could hinder anadromous fishes like the salmon, alewife, smelt and shad in their return to freshwater rivers to spawn. Also, shorebirds and migrating and wintering waterfowl could suffer due to loss of feeding grounds and ice formation on impounded waters.

The above are all primarily localized effects of tidal projects. Some scientists now believe that projects in the Bay of Fundy and Passamaquoddy and Cobscook Bays could also have more far reaching effects, causing sea level changes and changes in tidal ranges *throughout the entire Gulf of Maine!* These scientists predict a rise in the average high tide of 1 foot 6 inches and a 6 inch rise in the height of the average low tide throughout the Gulf. What this will mean, say these scientists, is immediately erosion and beachfront damage, flooding of salt marshes and mudflats, and widespread destruction of bird and wildlife habitat. The increased tides could also change current patterns in the Gulf of Maine in such a way that colder water will be brought to the surface, ultimately effecting some commercial fisheries and causing a drop in air temperature. The increased upwelling of cold water from the bottom due to the altered current patterns could increase the nutrient content of surface waters and favor the formation of red tide blooms. In addition, tide changes could require the relocation of navigational aids, harbor and channel dredging because of shoals created by stronger currents, extension or relocation of wharves and the use of heavier moorings. These are but predictions of the adverse environmental consequences of tidal power projects, however, they must be considered carefully in the decision making process regarding the implementation of such projects.

Before leaving th[illegible] [illegible]ject of power generation, we should mention the impacts of conventional, riverine hydropower projects on the marine environment. Dams and impoundments anywhere along a major river typically alter the volume and rate of freshwater flow into an estuary. These changes, in turn, can modify the physical qualities of the estuarine waters, especially circulation, salinity, sedimentation temperature, shoreline erosion, flushing, ice formation, and nutrient levels. Impoundments also can act as settling basins, reducing sediment load and, thus, decreasing the nutrient and sediment supply to intertidal areas and beaches. These changes can have significant effects on the flora and fauna of estuarine areas, depending upon the nature and the duration of the conditions and the characteristics of the estuary involved. One important known effect is the hinderance created by dams to anadromous fish (salmon, etc.) returning to freshwater areas to spawn, and to the young of these fish seeking to swim to the sea where they will live as adults. Another effect is the reduced scouring action of river waters downstream of a dam. This can cause organic material to accumulate which favors the growth of plant life and disrupts animal populations. Thus we can see the alterations to the environment even quite far from the coast can have serious effects on the marine ecosystems of the Gulf.

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Background Information: Tourism and Recreation

Tourism and recreation are major industries in northern New England, ranking second in both New Hampshire and Maine in terms of gross revenues. In New Hampshire some $650 million is generated by the tourism and recreation industries and in the seacoast region of that state, 10% of the annual payroll is related to tourism. In Maine, tourism and recreation contribute over $1 billion to the state's economy. In both states nearly 80,000 people derive their livelihoods from tourist related businesses.

The tourism and recreation industries have many of the same characteristics as the commercial fishing industry and suffer from many of the same problems. They are mostly small businesses, usually operating seasonally, are independently owned, loosely organized, if at all, and are heavily dependent upon the price and availability of gasoline, weather conditions and the state of the economy. Many tourism and marine recreation ventures, such as campgrounds, marinas, small motels, etc. are high risk, marginally profitable enterprises with traditionally high failure rates.

The state governments of Maine and New Hampshire have long recognized the importance of the tourism and recreation industries to the economies of their respective states. In New Hampshire, a govenment agency, the New Hampshire Office of Vacation Travel, is funded by the legislature for the purpose of attracting out-of-state visitors to the state. Also the New Hampshire Travel Council is actively involved in a wide variety of tourism and recreation issues. In Maine, the State has subcontracted services from the Maine Publicity Bureau, a private organization composed of many travel related businesses, which is concerned with promoting, marketing and selling Maine as a vacation spot.

As far as *coastal* tourism and recreation is concerned, no regional coastal organizations exist at present for the purpose of promoting the seacoast areas of Maine and New Hampshire. In New Hampshire, the Greater Portsmouth Chamber of Commerce Tourism Advisory Board has recently drafted a proposal to establish a New Hampshire Seacoast Council on Tourism, which would have the responsibility of organizing seacoast merchants and businessmen, creating a central promotional system, and of formally interacting with other regional and national tourism organizations. In Maine, several local Chambers of Commerce (e.g., Boothbay Harbor, Camden) have been active in promoting tourism in their localities.

In both Maine and New Hampshire, state authorized outdoor recreation plans have been developed which contain some specific recommendations for improving the regional recreation picture, primarily from the standpoint of promotion of recreational activities. By and large these plans lack focus on marine and environmental issues.

During the past ten years, two studies have been undertaken in Maine to provide a better understanding of the Maine tourist industry and to examine the possible role of the State in influencing the tourism industry. In 1973, a study entitled *Tourism in Maine: Analysis and Recommendations*, attempted to answer the following questions about the tourist industry: Who are the tourists in Maine (where do Maine tourists come from, etc.), how long do they stay here, what overnight accomodations do they use, what activities do they undertake, where do they go in Maine, how much money do they spend, what costs and impacts do they cause, how much tax money do they supply? The report also recommended that the State try to pursue the following objectives relating to the tourist industry:

1. Increase support of the existing tourism industry with emphasis on attracting the "most desirable" tourist activities (e.g. conventions, sightseeing, skiing).
2. Give priority to local community problems attributable to tourism — public works, sign control, and tax relief to low income people impacted by high property taxes caused by second home development by out-of-staters.
3. Establish a nonprofit tourism organization to be financed by the State and private industry on a matching basis. (Note: this has been done with the state subcontract to the Maine Publicity Bureau).
4. Draw tourists to less congested areas of the state, with emphasis on second homes.
5. Reduce fuel consumption by encouraging longer visits to single destinations.
6. Encourage large-scale, four season projects in which economic feasibility and environmental protection can be achieved simultaneously and effectively.
7. Expand regional and statewide planning efforts to plan for and deal with tourism.
8. Review and streamline or strengthen environmental control mechanisms.
9. Provide a means for local options regarding development so that it is not forced on those who do not want it nor is it denied to those who do want it.

This study primarily identified and measured benefits and *some* costs associated with tourism in Maine. A second study, undertaken in 1977 built upon the first one and concentrated chiefly on presenting ways to maximize the benefits of tourism. The recommendations of this second study are as follows:

1. Establish within the State Development Office a "Travel Development Division" to provide technical services, overall planning, financial assistance and centralized promotion for the tourist industry and for local and regional governments.
2. Establish State travel development regions for tourism development and planning.
3. Provide State matching grants to various organizations to assist in development of new events and attractions, to support convention and business meeting activities, and to support promotional activities by State, regional and local organizations.
4. Enable towns to impose a tax on lodging to support tourism development and planning work, and to raise money to match State grants.
5. Develop a comprehensive, statewide travel information system to improve tourist awareness of travel and recreational opportunities. (Note: In 1978, the so-called "Billboard Law" — actually, the *Maine Traveler Information Services Act* — was enacted, giving authorization to the Department of Transportation to remove billboards from highways and to establish a travel information system.)
6. Establish a travel awareness program to inform Maine residents, government agencies and the travel industry of the benefits which result from tourism.
7. Organize a State Travel Commission as a body of travel industry representatives to supply industry input to State travel and establish policies.
8. Establish a State interagency travel advisory board to provide coordination among state activities which influence the travel and recreational industries.

These recommendations were reviewed by the Committee on Coastal Development and Conservation (CCDC) and the reactions of this committee were published in its report: *The Maine Coast: Issues Considered*. By and large, this committee endorsed the recommendations of the studies, particularly state funding contributions, on a matching basis, to private tourist related businesses for the purpose of the promotion of four types of tourist activities:

1. those in uncrowded inland or coastal locations,
2. conventions,
3. cultural activities, and
4. off-season activities.

The CCDC also supported the development of Tourist Information Services, in keeping with the Maine "Billboard Law". In addition to publishing its own recommendations regarding the two tourism studies, the CCDC held several public hearings on the issue of tourism in the State of Maine. By and large, persons involved in tourist related enterprises felt that business was down and suggested that the State play a more active role in promoting tourism. On the other hand, residents of some of the southern Maine counties felt that there were too many tourists *and* tourist related facilities in their area and that additional promotion would be an overkill. Most residents around the state felt that the State should compensate heavily touristed localities for the adverse effects of tourism by sharing sales tax revenues with these localities. The CCDC report also recommended that the state should help its towns to adopt more effective measures to plan for and prevent the environmental and service costs of tourism.

Thus, we can see that the tourist industry, and second most important industry in northern New England (and perhaps *the* most important coastal industry) suffers from the lack of organized promotional (or marketing) efforts, needs a statewide informational system, needs to be better coordinated and managed on a regional and state basis and must be more sensitive to the environmental and social impacts it imposes on communities in northern New England. Let us now examine some of these impacts on the coastal environment caused by tourism in our area.

Impacts on the Coastal Environment

Tourism and recreation activities in coastal northern New England have a significant impact on the environment through the discharge of wastes, disturbance of and encroachment on sensitive species of wildlife and through the alteration of natural eco-systems. Seasonal residences and tourist facilities (motels, hotels, restaurants, campgrounds, etc.) add to the development pressures in the coastal zone, and their waste-water and domestic sewage discharge contribute to the seasonal or permanent closing of clam and worm flats in heavily visited areas. Each year some 10,000 acres, or 21% of the State's clam flats are closed due to bacterial pollution. Such closures are largest in heavily populated and touristed areas. (e.g. In 1978, 9% of the clam flats in Washington County were closed due to bacterial pollution, while 71% of the flats in Sagadahoc County were closed the same year.) In Maine, the bacterial pollution problem is particularly insidious, because of the inadequacy of soil for septic systems and general lack of centralized sewage treatment facilities.

Water pollution due to domestic sewage disposal has many harmful effects on the marine environment, including the contamination of clam and worm flats (already mentioned), decreased dissolved oxygen, increased turbidity (cloudiness) of the water, and lutrophication (blooms of plant life at the expense of animal life).

The utlization of organic wastes by tiny organisms in the marine environment requires large amounts of oxygen, which can result in dangerously low levels of oxygen in the bottom sediments and in the water itself. Persistently low oxygen levels can cause most animals to die and/or recolonization can occur by species (usually undesirable) who are tolerant to such concentrations of oxygen.

Increased turbidity (cloudiness) due to suspended organic solids in the water is a problem because the amount of light penetrating into the water is decreased. This reduces the amount of plantlife that can survive and decreases the primary food source to the ecosystem. Increased amounts of sediments also affect benthic animals by smothering them or by making the bottom generally unsuitable for them to live.

Eutrophication or blooms of plant life at the expense of animal life occurs in areas polluted by organic wastes because these wastes act as organic fertilizers and can result in algae blooms and rapid growth of other plants. This increased amount of plant life creates a situation of increased vegetable decomposition which requires additional oxygen. Ultimately more oxygen is consumed by the decomposition of plant material than is produced by the increased plant life and oxygen depletion results with consequent kills of fish and other animal life. In Maine, euthrophic lakes are fairly common with Annabessacook Lake, Pleasant Lake and Togus Lake as examples.

Other impacts of tourism and recreation result from the disturbance of previously quiet areas. For example, power boating creates waves, which, in rivers, estuaries and lakes, may disturb nesting birds. This activity also creates short-term suspended sediment concentrations and deposits of gasoline and oil in the water. Camping and off-road vehicle traffic on sand dunes and in saltmarshes promotes erosion by killing the vegetation of these areas.

Human intrusion into fragile areas such as bogs results in destruction of rare plants, and also in the disturbance of breeding, roosting and resting areas for eagles, osprey, loons, and other sea and shorebirds and for seals. An example of such disturbance is the recently permitted development of beach front homes in the Kennebunkport area which will disrupt the nesting grounds of the uncommon least tern.

Other recreational activities in the coastal zone, notably sports hunting and fishing, can result in over harvest of some fish and wildlife species, and can cause some localized pollutions from the construction of boat launching ramps, sportsmen's camps, vehicular traffic on beaches and in saltmarshes.

Concentrated hunting in some areas can cause a lead poisoning problem in waterfowl and predatory birds. Lead shot is commonly used by hunters and in estuarine and freshwater areas where there is little tidal flushing action these lead pellets often accumulate in large numbers. Studies have shown that ducks that feed in these areas ingest the lead shot and suffer the effects of lead poisoning. Predatory birds (and possibly also man) who feed on dead or wounded waterfowl can also be poisoned. Lead shot concentrations has become a particular problem in Merrymeeting Bay.

Other effects of tourism on the northern New England coast, especially those attributable to increasing second home development, will be discussed in the next section on incremental or cumulative development.

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Background Information: Cumulative Impacts of Development

Over a period of time, there is a cumulative impact of small, disconnected, development projects which can eventually result in significant degradation or serious depletion of coastal resources. For example, at Seabrook, New Hampshire, continued development over a period of several years has resulted in the contamination of drinking water wells. This occurred because eventually there were too many people drawing fresh water from the underground water table. Consequently, the level of the water table dropped so low that salt water from the nearby estuaries and bays entered, resulting in what is known as "salt water intrusions," and rendering the groundwater undrinkable. In other areas of the coast, gradual residential and commercial development has led to a severe loss of open space, cut off access to the coast and created serious traffic problems.

The real problem associated with this so-called "incremental development" is that certain proposed development projects may be legally sound and relatively harmless to the environment and to the way of life of a community, *when analzyed on an individual basis*. It has only been in recent years that communities have begun to ask, "What will be the cumulative effect of *several* such developments?" Unfortunately in many coastal towns, the question is being asked too late, as these areas already are suffering the side effects of having allowed too many isolated, individual developments to take place. One could justly claim that one dock or one business or one home situated along the coast has little impact on the character of the coast. But what happens when every shoreline land owner constructs a dock or a home or a business, armed with the argument that the community "let so-and-so do it!"? Obviously the effect on the coast is quite different.

This problem is especially difficult to deal with because northern New England *seeks* additional sources of income through the development of businesses and added tax revenues through increases in the population. On the other hand, two of the area's largest *existing* industries — fishing and tourism — require unpolluted coastal waters, easy access to the coast, and in the case of tourism, natural, uncluttered vistas. Thus the question of when to allow development and when to prohibit it presents an extremely sticky situation. Yet the present experience of Seabrook and many other coastal communities in New Hampshire and southern Maine indicate that *something* must be done to help preserve the rest of the northern New England coast from the same fate.

By and large, most studies dealing with this issue recommend that there be increased planning and regulatory efforts on the parts of communities and the State as a whole, that the State and coastal localities should establish broad, long term, and comprehensive master plans regarding future development, and that the aesthetic, open space and access needs of an area be taken into consideration with the application of each new development project for approval. All proposed individual projects should be assessed from the cumulative impact standpoint, that is each should be considered not just as one isolated project, but actually as part of *many*. Included in the assessment should be the impact of all *existing* development.

Another consideration that needs to be made is the actual ability of coastal land and water resources to incur continued development. This concept of "carrying capacity" as it relates to human development traditionally has not been looked into in community planning in general. In natural ecosystems, the carrying capacity of an area refers to the number of plants and animals that can adequately be supported by that area. The carrying capacity of an area is exceeded when a factor is introduced that throws the system off balance. For example, in an area where the population of rabbits is kept in check by coyotes and many of the coyotes are removed by a predator control program (as often happens out west), the rabbits experience a population explosion to the point that they require more plantlife for food that can be provided by the area. The result is degradation of the environment due to destruction of vegetation and the ultimate mass die-offs of the rabbits, or, their expansion into other areas. There is ample research on the carrying capacities of natural communities, but an alarming scarcity of it as the concept relates to *human* communities. Some of the laws concerning development of wetlands, the plumbing code and lot size restrictions represent attempts to address the concept of carrying capacity, however, much more research is needed before we can fully understand how to measure the carrying capacity of land proposed for development.

Finally, another related problem involves public perceptions and sociological values. "The northern New England coast has a unique character which attracts unique individuals. Increased use has brought about increased regulation, increased costs and a loss of natural environments. Incremental development is a process which slowly, progressively, almost unnoticeably in some instances, can significantly change the character of a region. By doing so, however, we run the risk of destroying the resources which made it such a desirable area in the first place." (Dearborn, 1981)

Impacts on the Coastal Environment

The impact of incremental development have, by and large, already been discussed. However, let us briefly summarize those effects here. In the case of incremental industrial, commerical and/or residential development, the primary impacts are air pollution, water pollution, loss of natural habitat, "visual pollution" and "noise pollution." The more industrial or residential a particular area becomes, the worse these impacts get. In the case of air pollution, the five most important substances are sulfur dioxide ($SO2$), nitrogen oxides (NOx), carbon monoxide (CO), particulates and ozone. Sulfur dioxide enters the air primarily via the combustion of coal and oil burning power plants, by pulp mills and by residential and commercial heat generators. Sulfur dioxide emissions are the chief cause of "acid rain": sulfur dioxide in the atmosphere is changed to sulfuric acid which is dissolved by the water of rain and snow, making the precipitation highly acidic. Nitrogen oxides are also products of combustion and are also oxidized in the atmosphere to form nitric acid, another component of acid rain. Carbon monoxide is mostly produced by the burning of gasoline in automobiles and is primarily a problem in areas of high population. Carbon monoxide can also be produced by the burning of oil, coal or wood to generate heat or produce electricity. Carbon monoxide presents a health risk to humans as it is toxic. Particulates include soot, mists and sprays. They may be nontoxic materials such as dirt and dust or toxic materials such as lead, asbestos, and/or radioactive elements. They enter the air from many sources including automobile traffic, construction and demolition, smelters, fertilizing processes, power plants and wood burning stoves. They are also a health hazard, contributing heavily to lung disease. Ozone occurs in the atmosphere as a result of a chemical reaction between hydrocarbons (which are emitted as exhaust fumes from motor vehicles and from industrial processes) and nitrogen dioxide. The entire coast of northern New England suffers from excess levels of ozone with the petroleum bulk stations and terminals at Portland and the heavy automobile traffic of cities, and the entire coast during the tourist season, being the most common sources of hydrocarbons. Excessive ozone is thought to cause "tip burn" disease in the eastern white pine, which can lead to tree death, and is a contributor to lung disease in humans.

As far as water pollution is concerned, the primary offenders are domestic (residential) sewage which is mostly organic in nature; industrial waste which is chiefly inorganic — chemicals, heavy metals, excess heat, etc.; municipal (towns, cities, etc.) and commercial discharges, which can be a combination of both organic and inorganic materials. The largest amount of polluting effluent is discharges from industrial and municipal sources. and municipal sources.

The problems associated with water pollution are many. Organic pollution can cause bacterial contamination of drinking water, closing of clam flats, decreased dissolved oxygen levels in the water, and euthrophication. Discharges of oil, heavy metals, PCB's, and excess heat can cause death or retardation in growth and reproduction of many marine creatures, and can be of danger to human health when contaminated seafood is consumed.

Loss of natural habitat has a drastic effect on many plant and wildlife species including destruction of breeding, feeding and wintering areas and the subsequent extinction of some species from the vicinity. Some endangered animals and plants like the bald eagle, for example, are already suffering the effects of loss of habitat.

"Visual and noise pollution" primarily effect the traditionally serene and scenic character of the northern New England coast which is primarily responsible for attracting tourists and summer residents, upon whom the economy of the area depends heavily. Areas which have become overdeveloped, either industrially or residentially, have lost that "nostalgic charm" that so many visitors seek. Additionally, there is a similar negative effect on the long time residents of an area that has undergone excessive incremental development.

Clearly, careful *planning* is necessary to help prevent this problem.

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Background Information: Multiple Use Planning, Conflict Resolution, and Protection and Enhancement of Marine Resources

Section III has, thus far, focused on a brief analyses of two broad categories of concern for coastal northern New England: Fisheries Management and Development and Industrial (other than fisheries), Commercial and Residential Development. Within these two broad categories, numerous related issues were covered.

The question still remains: what can we do, as citizens (both coastal *and* inland) of northern New England *do* about these various problems that threaten our coastal future?

The obvious first response is to *be concerned*, and to follow up that concern with *becoming informed*. Finally, we should *become involved*. Those citizens in positions of authority to deal with these problems need input from the rest of us whose lives and/or livelihoods will be affected by the decisions made by our local state and federal governmental officials.

Emphasis should be placed on *multiple use planning and conflict resolution* with the *protection and enhancement of our marine resources* kept squarely in mind. Dearborn in Sea Grant's Long Range Plan writes: "One is immediately struck with the diversity of uses of the northern New England coastline. Commercial fishing, electrical power generation, residential housing development, agriculture, forestry, recreation, manufacturing, and commercial business all play an important role in the utilization of the region's coastal resources. However, their economic viability, even their very existence in some cases, is heavily dependent upon a coastal location. But the coastal zone is experiencing changes that are causing continued and new conflicts over the use of its resources . . . . Faced with this recent surge of development proposals, state and local governments, in an attempt to maintain a balance between private and public use of limited resources are reexamining their current land use policies, development incentives, and regulatory authorities. Because multiple use has become a cornerstone of coastal resource management, it is highly probable this strategy will continue for some time. However, it must be ascertained whether or not multiple use is compatible with the types of coastal and marine resources found in northern New England."

"The challenge ahead is to ensure that our local and state officials have adequate, factual information upon which to base their management decisions. Although the northern New England coastline is quite diversified, it still represents one of the least developed coastlines in the nation. We are entering a critical period where communities are attempting to expand tax bases, the public is demanding more coastal access, and business is seeking prime coastal locations". A concerted effort is needed in the area of coastal access and in addressing conflicts between regulatory authorities, between authorities and users of the coast and among users of the coast.

For example, public access to the coast is an issue of concern to both residents and visitors alike in northern New England. Nearly 96% of the shoreline is in private ownership and a recent poll in Maine indicated that over half of residents polled felt more public money should be spent to improve coastal access by developing swimming areas and constructing more boat launching ramps. Access is also required by sport and commerical fishermen and clammers, and tourists.

Presently there are numerous organizations and agencies in northern New England that are concerned with the access problem. In Maine, the Bureau of Parks and Recreation has responsbility 40 plus state-owned boating facilities. In New Hampshire, the Fish and Game Department is responsible for several public launch facilities, while the Department of Resources and Economic Development operates the seacoast park system and the three state-owned lauch ramps. In addition, many coastal towns and cities own or operate beach areas, parks and boat ramps. There have not been, however, any regional or statewide coordinated effort by involved groups to assess the access issue and develop comprehensive strategies to meet the public needs and demands.

In the area of conflict resolution, the State Planning Offices (SPO) of both Maine and New Hampshire have attempted to address various conflicts between regulatory agencies. In Maine, the Coastal Program of the SPO has worked on streamlining and coordinating permit procedures of the Department of Environmental Protection and the Army Corps of Engineers. The Coastal Program has also attempted to provide a statewide framework within which local governments and state agencies can make coordinated decisions regarding development projects. Also in Maine, the Marine Law Institute of the University of Southern Maine, is conducting two studies in this area of concern: One, regarding the differences in U.S. and Canadian laws and policies towards fisheries, and the other, an examination of the role of state management in the federal fisheries management program.

In New Hampshire, the Coastal Zone Management Program still lacks state approval, but has never-the-less undertaken an inventory of al laws and regulations applicable in the coastal zone and has developed a directory of federal, state and local statutes for each coastal municipality.

In addressing conflicts between regulatory agencies and users of the coast and among users of the coast, the present arenas for solution are the public hearing and legislative action. Neither is fully adequate for full discussions of altenatives to conflicts. More work needs to be done in this area to provide adequate opportunity for all involved in conflicts to speak their views and to work toward solutions.

As far as the protection and enhancement of marine resources is concerned, more planning work is needed in the areas of shoreline management, waste disposal and dredging in the marine environment.

The coastline of northern New England, some 4,100 miles in extent, is composed primarily of rocky headlands and mudflats (98%) with only some 89 miles (2%) made up of sandy shores and sand dunes. These sandy beach areas, because of their scarcity, have assumed a disproportionate importance to the area.

A rather large portion of the sandy shoreline has experienced some sort of development. There presently exist about 17 miles of seawalls, etc., and nearly 1200 acres of sand dunes have been developed to one degree or another. The sandy shore isnaturally an unstable one aand, this coupled with a long term gradual rise in sea level, has led to the various attempts to control erosion, namely bulkheads, seawalls, revetments, jetties or groins constructed of rock, concrete and pressure-treated wood.

The problem is really two-fold. First, these so called "erosion control" structures have negative impacts which work against their intended purposes. For example, a steel seawall at North Beach, N.H., has effectively controlled bluff erosion, but has actually *increased* of the beach in front of it. Near shore circulation patterns are also affected by these structures which can cause changes in the physical and biological characteristics of the area. One such change is evident at Wells Harbor where excessive sediment deposition has occurred behind the jetties which border the entrance channel. In addition, the shoaling problem in the barbor, which the jetties were intended to control has not been significantly reduced. Generally speaking, where seawalls, etc., have been in place for some time, there has been a noticeable loss of intertidal sand volume which results in the decrease of beach size. For example, construction of a rock revetment at Boars Head, N.H. has led to the reduction in size of Hampton and North Beaches.

Secondly, and probably more importantly, there is no organization, agency, or person in the region available to assist shoreline owners, commercial businesses or government officials with the problem of shoreline management, particularly with the proper siting and design of erosion control structures. The approaches to the situation have, at best, been piecemeal. In

Maine, the Board of Environmental Protection has instituted a rather restrictive policy prohibiting the construction of seawalls, etc. along all sand dune areas presently lacking such structures, except in unusual situations. Maine's Coastal Wetlands Law was recently amended to include protection for coastal sand dunes. And, Maine has enacted a Shoreland Zoning Act which requires municipalities to adopt certain requirements concerning the siting of coastal development projects. Finally, the state also has hired a coastal geologist to investigate some of the issues and problem areas discussed above. New Hampshire has done little in the area of shoreline management. At present, three agencies have the authority to monitor beach and bluff erosion and to make improvements which will have beneficial impacts. However, this authority has not been exercised to any great extent.

"Because of the scarcity of sandy beach systems in northern New England and their popularity for residents and visitors, it is imperative that the methods and resulting impacts of altering natural processes be given careful consideration." (Dearborn, 1981)

The various types of wastes that are being disposed of in the marine environment, and their impacts, have already been discussed in the subsection on "Industrial, Commercial and Residential Development." We need to consider here what is presently being done and what should be done about this problem in northern New England. Both New Hampshire and Maine have state agencies responsible for Water Supply and Pollution Control Commission and the Maine Department of Environmental Protection). In addition, the Maine Department of Marine Resources has the authority to restrict harvesting of contaminated shellfish and the New Hampshire Fish and Game Department has responsibility for assessing environmental damages cause by hazardous waste spills.

The federal position on ocean dumping is presently undergoing revision. Environmental agencies within the federal government recently took the approach that the environmental impacts of ocean dumping are not well known and that excessively strict control on such waste disposal (eg. the previous deadline of December 31, 1981 for cessation of ocean dumping of all hazardous wastes may create "unnecessary costs or impacts on some other sectors of the environment", i.e., landfills, etc.). Recent experiences in northern New England and around the nation with on-land waste disposal (eg. Saco, Me., Epping, N.H., Hookset, N.H., "Love Canal," "Niagara Falls, N.Y., etc.) have indicated that some alternative to this indeed is necessary and the marine environment presents a very attractive option to industry and government. Clearly, a great deal of research is needed soon in order that an accurate assessment of the dangers of ocean dumping be made.

Finally, the issue of dredging has already been discussed in some detail in the subsection of "Cargo Ports and Navigation". Again, we need to take a look at the present efforts at dealing with this problem and to assess what should be done in the future.

Both Maine and New Hampshire have state agencies which review dredging project permit applications on a case-by-case basis, taking into consideration the effects on marine organisms, the timing of the project, the toxicity of the material to be dredged and disposal site alternatives.

The Army Corps of Engineers, a federal agency, is also involved in the review of all dredging permit applications. In addition, the Corps recently undertook a multidisciplinary study (the Dredged Materials Research Program) investigating various aspects of the dredging problem.

Numerous questions still remain to be answered regarding dreding efforts in the future. These questions and other concerns around the broad issues of multiple use planning, conflict resolution an protection and enhancement of marine resources need to be taken into serious consideration by voters and policy makers of northern New England.

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Other types of industrial and commercial development affecting the northern New England Coast

Thre are numerous other types of industrial and commercial development that are not necessarily located along the coast but which, nevertheless, have serious impacts on the coastal ecosystem. These will be discussed briefly here so as to help your group see some of the relationships between activities that are carried out in inland areas and the coastal environment These activities include: the pulp and paper industry and other forest related enterprises, agriculture, mining, hydropower dams and industries located outside of the state.

The impacts of forest related activities on the marine environment can be very serious. The harvesting of wood and processing of pulp into paper generally effect freshwater systems through cutting practices and woods operations (erosion, siltation), pest control (chemicals), and dam maintenance (water level control). Clear cutting and other woods operations can cause erosion of soil which eventually ends up in streams and rivers and ultimately in the estuaries of the Gulf of Maine. The excess of soil materials in river systems can create silting problems in estuaries, necessitating frequent dredging or causing smothering of benthic animals and of the eggs and fry of anadromous fish who spawn in freshwater rivers and streams. Excess soil nutriets can create nutrient enrichment circumstances in estuaries which can promote the blooms of algae and phytoplankton (including the red tide organism) often at the expense of other animal species. Also the decomposition of bark and other woody debris that often ends up in rivers and streams can cause a decrease in the dissolved oxygen supplies of these bodies of water. The removal of trees from forested islands and coastal areas adversely effects many types of birds, including bald eagles, ospreys and herons which use such habitats for nesting.

The use of herbicides (to control the growth of unwanted trees and shrubs) and pesticides (used primarily to control the spruce budworm and gypsy moth) in forests can have serious effects on the marine environment. Herbicides can kill aquatic vegetation and fish, can lower oxygen levels in the water and can change the character of aquatic habitats.

The research on pesticides currently used is inconclusive as most of these are relatively short lived and generally do not accumulate in the environment as did DDT which was used in Maine from 1954 to 1967. Chemicals currently in use include Sevin (or Carbaryl), Orthene, Matacil and Sumithion. Present research indicates that some or all of these could be responsible for killing "nontarget" organisms (animals other than the pest sprayed for), causing nervous system malfunctions in fish and other animals (possibly reproductive and behavioral abnormalities). More research needs to be done in this area.

The main problem associated with paper mill operations is the discharge of hazardous wastes which include toxic heavy metals like manganese, lead and copper, and organic materials which increase oxygen demand.

The presence of heavy metals (chromium, lead, copper, zinc, manganese, cobalt, nickel, arsenic, mercury, silver, cadmium, vanadium) in the environment can present serious problems. It has been found that concentrations of heavy metals in the coastal sediments of the Gulf of Maine are comparable to concentrations found off much more highly industrialized areas of the country. These metals arrive in our marine environment via a variety of sources: from particulates in the air (from sources not necessarily in the state); from landfill sites; from oil pollution; from agricultural herbicide application; from industries within the state (e.g. paper mills, fish processing plants, mining operations, etc.); and from the discharge of sewage and sewage sludge. Effects on the marine creatures associated with the presence of heavy metals in the marine environment include growth inhibition, physical malformations, and reproductive abnormalities. Heavy metals are also a major concern from the standpoint of human health. Since heavy metals may concentrate in the tissues of marine food organisms, a person eating enough contaminated seafood over a period of time could develop heavy metal poisoning. For example, mercury has been found to be the cause of minamata disease in Japan.

Another industrial pollutant that has been found in the egg shells of bald eagles in Maine and could be accumulating in the tissues of marine organisms of the Gulf of Maine is PCB (polychlorinated biphenyls). The sources of PCB's are primarily industrial with the disposal of industrial sewage and sludge and burned plastics being the major contributors. Most likely they enter the Gulf of Maine from industries in regions other than northern New England. PCB's are long lived chemicals that are not soluble in water and so accumulate in sediments and in the tissues of organisms. They are toxic to most forms of marine creatures and also are transferred and *bioaccumulated* in food webs. (This means that as each higher organism in a food web eats a lower organism that is contaminated by PCB's, the higher organism receives a greater concentration of the chemical that was in the organism that it ate. Thus the top carnivore of a food web gets the largest dose of PCB). If concentrations of PCB are not great enough to kill organisms directly a number of *sublethal* effects can occur including growth inhibition, interference in chemical response systems of organisms, reproductive abnormalities (especially in animals higher in the food chain like birds). PCB's pose a potential health hazard to people because of their ability to bioaccumulate in the food web.

Agricultural and mining practices within the states of Maine and New Hampshire also have adverse impacts on the coastal environment. The major problems associated with agriculture are soil erosion, and runoff containing manure, chemical fertilizers and chemical pesticides. Some agriculture, for example blueberry harvesting, takes place along the coast.

Excess soil sediments in rivers and estuaries has a number of negative effects including: increased turbidity (reduces the amount of light available to aquatic plants and animals), and increased sedimentation (which suffocates small animals, destroys spawning areas, and reduces the food supply for larger fish and other organisms). Runoff from fields that carries manure and chemical fertilizers into rivers and estuaries can cause blooms of plant life in these aquatic communities and can increase the demand for oxygen among aquatic animals. In addition, excessively fertilized runoff can contaminate drinking water wells all along rivers that drain agricultural areas, posing health risks to humans.

Pesticides sprayed on agricultural lands are responsible for numerous problems in aquatic and coastal communities. The chemical Guthion, sprayed on blueberry barrens, caused a serious fish kill at a hatchery in Deblois, Washington County, in 1972, in which 10,000 brook trout and 11,000 fish eggs were destroyed. Other chemicals used on agricultural lands have also been cited in fish kills and in causing altered behavior and reproduction in aquatic animals and in birds. Also the persistent chemicals used in the past, but no longer allowed (e.g. DDT) continue to show impacts in adversely affecting the reproductive capacity of predatory birds (e.g., eagles, osprey, etc.). The effects on the health of humans of these chemicals are largely unknown at this time, but this is because little research has been done in this area and it is clearly a subject for concern.

Mining in upland and coastal areas also has some negative consequences so far as the coastal environment is concerned. Materials currently being extracted from Maine soils include sand and gravel, peat, limestone, granite, and mineral ores (copper, zinc, iron). Some proposals for the future include mining for copper and nickel. The major impacts on the marine environment include waste disposal into aquatic systems, particulate air pollution and alteration of habitats. For example, peat mining may alter the quality of water being discharged from bogs, notably in increasing the acidity (decreasing the pH) of the water and increasing the sediment content. Fish reproduction in downstream areas could be adversely affected by both increased acidity and siltation. Hard rock mining for limestone, granite and mineral ores usually produces large amounts of waste water containing rock fragments (called tailings). These waste waters if discharged into river systems can increase the acidity of the river water as well as contaminate aquatic food webs with heavy metals. The mining of limestone, sand and gravel produces dust which can drift into nearby aquatic environments and cause increased alkalinity of the water.

Finally, industries and population centers outside of the northern New England region, notably in the midwest, can create problems for marine ecosystems along our coast by emitting pollutants into the air. These pollutants, primarily sulfur dioxide, nitrogen oxides, carbon monoxide, particulates and ozone, are carried into our region by the prevailing winds, and are dissolved by rain and snow and fall onto our land and water. All areas of coastal Maine have been found to have unsafe levels of at least some of these substances (particularly ozone). Human health hazards due to air pollution are well known and include lung disease (cancer, emphysema, etc.), heart disease, skin disease, and others. A discussion of these problems is beyond the scope of this information as we are concentrating primarily upon the effects of these air pollutants on the marine environment, so let us turn our attention to the condition of acid rain (and snow!).

Acid precipitation is now recognized as a very serious environmental problem in northeastern United States. As mentioned it occurs primarily because prevailing winds carry air pollutants (chiefly sulfur dioxide and nitrogen oxides) from the industrial and heavily populated midwest to our states where these pollutants, dissolved in atmospheric rain, fall onto our region in rain or snow. The effects on freshwater environments is well known, with some lakes in the Adirondack Mountains and elsewhere being completely devoid of life as a result.

The effects of acid rain and snow on saltwater ecosystems are at present, largely unknown. As we have learned in previous sections, seawater has the ability to "buffer" or neutralize additions of acid. However, long term chronic exposure to acid precipitation could eventually cause marine ecosystems to suffer the same effects as what freshwater areas are currently experiencing:

1. Decrease in and ultimate elimination of fish species.
2. Decrease in all members of the food web: bacteria, phytoplankton, zooplankton, algae, etc.
3. Altered reproductive capacity of surviving species, both plant and animal.

Acid precipitation now threatens to disrupt the entire ecosystem of many freshwater areas. It could also do so to our coastal waters someday. Dealing with this problem involves the cooperation of states outside our region and thus presents a more difficult situation than if it were strictly an instate condition.

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