CHARTING OUR COURSE

An Activity Guide for Grades 6–12 on Water Quality in the Gulf of Maine

Maine State Planning Office
Maine Coastal Program
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FOREWORD TO TEACHERS

We live in a world of water. Looking at a satellite image of the Earth, we are reminded that the ocean is more than a source of food, transportation, and recreation. Covering nearly three-fourths of the Earth, it is our planet’s lifeblood.

Here in Maine, we cannot escape the presence of water and the influence it has on our lives. We are fortunate to border on one of the world’s most productive seas, the Gulf of Maine. This unique water body has shaped the evolution of our region, providing transportation routes and abundant fisheries for hundreds of years.

The sea’s influence on our history, economy, and environment are well-documented. What is less well understood is the reciprocal effect that our actions have on the Gulf’s health and productivity. In recent years, overharvesting, pollution, and intense population pressures have begun to affect the Gulf’s fragile ecosystem.

The Gulf of Maine is at a crossroads, facing the possibility of ecological degradation that has become a reality for other water bodies such as the North Sea and Chesapeake Bay. Maine need not choose that future. Through education and action, we can ensure that the Gulf’s endangered ecosystem flourishes.

The fate of the Gulf will, ultimately, dictate the fate of Maine. As the Gulf of Maine shaped our past, so will it shape our future. We can no longer afford to manage only the resources we see. If we restrict our focus to the stretch of coast that is visible, we limit our understanding of the vital role the Gulf plays in defining and enriching our lives.

Our vision of environmental and economic issues must be expanded to include our neighboring sea. We need to educate Maine citizens of all ages about the value and vulnerability of the Gulf.

We hope that you will join us in this effort.

John R. McKemey, Jr.
Governor
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INTRODUCTION

The Gulf of Maine is the centerpiece of Maine’s annual Coastweek celebration. Each fall for five years, local organizations in Maine have sponsored a week of educational and recreational events highlighting the beauty and productivity of our coastal resources.

Charting Our Course offers teachers and youth group leaders an opportunity to bring Coastweek into Maine’s classrooms, with educational activities that introduce to students their neighbor to the East, the Gulf of Maine. The guide is intended primarily for teachers of grades 6-12, but can be used (with some adaptations) by instructors of other age groups.

The guide begins with an overview of the Gulf, and a review of the hydrologic cycle and watersheds. The second part details the sources of pollution that threaten the Gulf and describes actions that can be taken to combat water pollution. The final section poses questions about the Gulf’s future. Some of the activities in Charting Our Course have been adapted from existing curricula: credits appear by these activities and detailed information on the original curriculum is listed in the Bibliography (Appendix B).

There are more activities in Charting Our Course than could fit into Maine’s Coastweek celebration, but we hope that you’ll integrate these exercises into your regular courses throughout the year (and keep the guide on hand for future Coastweek celebrations). You may wish to adapt the activities in this guide to meet the particular needs or interests of your class.

Activities are divided into sections entitled Materials, Procedure, Discussion, and Extension (additional or adapted exercises that you may wish to have students pursue). In the Discussion sections, possible answers have been listed in brackets after some questions. There are often many answers to the discussion questions and the listed responses are suggested possibilities, not comprehensive answers. Words that appear in boldface type are listed in the Glossary (Appendix A).

Maine is fortunate to have many excellent resources that focus on our coast’s natural history (for a sampling of these curricula and educa-
tional programs, see Appendices C and D). Not many regional curricula examine resource management issues, though, or discuss the effects of human actions on coastal ecosystems. We hope this curriculum guide will supplement existing resources and provide Maine teachers with a tool to help students

- understand the importance of the Gulf of Maine’s resources;
- learn about the pressures facing the Gulf; and
- develop the skills and commitment necessary to make sound decisions regarding the Gulf’s future.

We welcome your feedback on this guide (Appendix G contains an evaluation form that you can detach and return), and hope that it enhances your school’s celebration of Coastweek.

David H. Keeley
Director
Maine Coastal Program
I. THE GULF OF MAINE

Background Information

The Gulf of Maine is a “sea within a sea,” part of the Atlantic Ocean that stretches from Cape Cod Bay off Massachusetts to the Bay of Fundy between New Brunswick and Nova Scotia. The outer edge of the Gulf is separated from the open ocean by a series of shallow areas known as banks. Only one deep channel connects the Gulf to the open Atlantic, the Northeast Channel. The cold Labrador Current and the warm Gulf Stream rarely flow into the Gulf: both are blocked by the banks, the current motion of the Gulf’s waters, and the earth’s rotation.

Georges Bank is the largest and most famous bank. Its average depth is 195 feet, but parts of it are less than 12 feet deep. The Georges Bank region helps make the Gulf of Maine one of the world’s most productive water bodies, supporting a vast array of species. A large quantity of biomass is evident in the Gulf’s green waters, which are colored by abundant phytoplankton floating in the water. Phytoplankton forms the base of the Gulf’s food chain on which hundreds of species of plants and animals rely.

The productivity of the Gulf is enhanced by huge volumes of freshwater that flow into the Gulf from four major rivers (the Kennebec, Androscoggin, Penobscot, and St. John), as well as a host of smaller ones (e.g., the Saco, Piscataqua, Merrimac, and St. Croix). This inflow of freshwater (which is particularly strong during spring when snows melt) dilutes the salinity of seawater; warms the surface waters; and adds nutrients, minerals, sediments, and pollutants to the Gulf.

As the freshwater reaches the Gulf, it is thrown westward by the earth’s rotation. The large volume flowing in causes the Gulf’s surface water to move in a huge counterclockwise spiral. This motion decreases after the heavy spring runoff but never disappears. Tidal currents and gravity currents maintain the circulation, which helps to distribute nutrients. Nutrients are also circulated by upwelling, a process in which colder, denser, more fertile waters from the ocean floor are drawn to the Gulf’s surface. Upwelling is fueled by currents, tides, weather, and the topography of the ocean floor.

The Gulf’s waters are constantly changing with the tides and seasons, and with climatic fluctuations. Water temperature cycles are important because they affect migration patterns, success in spawning, survival of young, growth rates, and even the activities of predators.

ACTIVITY

Gulf Highlights

 Procedure:
Make a copy of the Gulf of Maine Map (Figure A) for each student. Instruct students as follows:
1. With a colored pencil, mark the coastline that borders the Gulf of Maine;
2. Highlight the areas that separate the Gulf from the open ocean [banks];
3. Indicate the only deep-water connection between the Gulf and the Atlantic [Northeast Channel];
4. Identify the largest and most famous bank. [Georges Bank]
5. For what resource is Georges Bank internationally renown? [groundfish: cod, haddock, and flounder]
FIGURE A
The Gulf of Maine

[used with permission from Science and Natural History: A Maine Studies Sourcebook (Vol. 4), Down East Books]
6. The Gulf’s estuaries (places where rivers meet the sea) serve as nurseries and feeding grounds for the fish and shellfish that inhabit the Gulf. Highlight the major estuaries in Maine.

7. Does the cold Labrador Current or the warm Gulf Stream ever flow into the Gulf? [only rarely] Why or why not? [the entrance is blocked by banks, current motion, and the earth’s rotation]

8. Name the different values that the Gulf offers the entire New England region (e.g., cultural, social, ecological, economic). [fisheries; recreational resource for boating, tourism, whalewatching; climate moderation; transportation; commerce; maritime heritage; and source of oxygen]

9. What are some of the organisms most commonly found in the Gulf? [see Figure B] Why is the Gulf considered one of the world’s most productive water bodies? [density of nutrients and amount of marine life]

[adapted with permission from Science and Natural History: A Maine Studies Sourcebook (Vol. 4), Down East Books]

**ACTIVITY**

**Creating A Gulf of Maine Mural**

**Materials:**
Mural paper; construction paper; tape; string; and paints or markers.

**Procedure:**
Have students create a wall-sized mural of the Gulf of Maine in a school hallway. (If this is not feasible, students can use copies of the small map at their desks, marking them with colored pencils or markers.) Include water depth; tidal rivers that enter the Gulf; bays; estuaries; the underwater banks; and the Northeast Channel. To identify these features, use navigational maps (see Appendix F) and the Gulf of Maine Map (see Figure A).

Once students have completed the mural base, have them research and make cut-out paper models of common plant and animal species that inhabit the Gulf (see Figure B). Have students place cut-outs on the mural in the appropriate places and report to the class on the life cycles and
feeding patterns of their organism. String can then be used to connect predator species to their prey. When the string food web is complete, its importance can be discussed [If an organism is removed, such as the mussel, what would happen to the rest of the web? Which organisms feed on the mussel, and which organisms—in turn—feed on those predators? Trace the effect throughout the food web.] The activity “Searching Out Nonpoint Sources” (Chapter IV) has additional activities that may be done with this mural.

1. phytoplankton
2. zooplankton
3. seaweed—kelp, Irish moss, dulce, rockweed
4. polychaetes: bloodworms, sandworms
5. fish: bluefish, striped bass, Atlantic menhaden, Atlantic cod, haddock, hake, winter flounder, Atlantic mackerel, Atlantic sturgeon, Atlantic salmon, red fish, Atlantic menhaden, skate, shark
6. mollusks: mussel, clam, scallop, squid
7. arthropods: green crab, lobster, horseshoe crab
8. echinoderms: sea urchin, starfish, sea cucumber
9. birds: herring gull, osprey, loon (seasonal), bald eagle
10. marine mammals: porpoise, harbor seal, whale (humpback, fin)
Background Information:

Water can be seen as our most recycled natural resource. All of the earth's water is linked together in a system called the hydrologic cycle, a dynamic process fueled by solar energy and gravity. Water evaporates from the Gulf of Maine, bays, lakes, rivers, and other surface water; from soils; and from vegetation (through transpiration). It even evaporates into the atmosphere while it is falling to the earth as precipitation. The atmosphere holds the water vapor for a short time before it condenses and returns to land or surface water as rain, snow,
sleet, and hail. The water that falls as precipitation is absorbed directly by plants; soaks into the groundwater; or runs off the land into surface waters (e.g., rivers, lakes, the ocean). Solar energy then fuels further evaporation and the cycle continues (see Figure C).

ACTIVITY

Solar-Powered Water

➤ Procedure:
Using the accompanying graphic (Figure C), students can discuss and chart the hydrologic cycle.

➤ Discussion:
The following questions can be used to supplement their existing knowledge of the cycle.

1. What are the natural elements (processes) of the hydrologic cycle?
2. What happens to precipitation that falls on the surface? Where does it go? How does it change?
3. What role do plants play in the cycle?
4. How do human activities influence or interfere with the cycle?
5. How might human activities threaten the groundwater component of the cycle?

➤ Extension:
Research how long it might take for a drop of water to pass through the entire hydrologic cycle. Have students design and construct a graphic or mural of the hydrologic cycle for their community. Make sure to include the community’s water resource system and human impacts on the cycle.
PART 1: THE GULF OF MAINE—AN OVERVIEW

III. WATERSHEDS

Background Information

A watershed is defined as the land area that receives precipitation and conducts water drainage in the hydrologic cycle. Its parameters are defined by the ridges or mountains that separate major river systems. The watershed basin can be seen as a bowl: water poured on the rim either flows into the bowl or down the outside. The part of the bowl within the rim is identified as a single watershed. Watersheds vary in size depending on local land formations.

Watershed systems are composed of specific and identifiable wetland habitats in which a variety of vegetation and animal life have adapted to live. Freshwater marshes, swamps, bogs, and ponds are termed palustrine environments because they share the characteristics of small size, shallow depth, and no active wave formation along shorelines. These habitats have varying degrees of open water that range from open ponds to the completely moss-covered surface of...
FIGURE D
Watersheds of Maine Rivers
bogs. Surface water runoff accumulates in each of these wetland habitats.

The **lacustrine** [lake] systems play an important role in the watershed. Lakes are distinguishable by their size and extensive areas of deep water. Lakes function to contain, and slowly release, flood waters brought about by heavy rains or melting snows. This water-storage function helps prevent erosion from occurring downstream. The **riverine** system comprises streams and rivers that connect the upland streams and wetlands with the ocean. Riverine systems carry nutrients throughout the watershed system.

The sites where rivers encounter the sea are known as **estuarine** systems. Estuaries, which are made up of salt marshes, mudflats, gravel, and rocky areas, play a vital role in the overall health and productivity of the coastal ecosystem. They collect nutrients that feed abundant vegetation which—in turn—provides the basis for a complex food web nourishing a rich assortment of organisms. In addition, estuaries provide the necessary habitat for many types of fish and wildlife, and serve as a sophisticated air and water purification system. Without them, the variety and quality of coastal life would be greatly diminished.

Estuaries also act as nature's own pollution-control mechanism and help to control erosion. Rainwater runoff from the land is purified as it passes through tidelands to the sea. When freshwater meets saltwater, pollutants can drop out of the water column. Soil micro-organisms may then absorb automotive and industrial pollutants and transfer them to the food chain, endangering organisms higher up the chain. Coastal wetlands also serve as a sediment trap for stormwater and runoff and a nutrient trap for sewage. Wetlands can absorb some pollutants and sediments but if they are overburdened, their natural filtration system breaks down.

**ACTIVITY**

**Mapping Watersheds**

> **Materials:**
> Map (Figure D); colored pencils or markers; map of Maine.

> **Procedure:**

In this activity, students will identify (and outline) the watershed areas (or river basins) for six rivers, rate them for area, and note the location of their mouths. The rivers to be studied are: the St. Croix; Union; Penobscot; Kennebec; Androscoggin; and Saco. All of these rivers run partially or entirely through Maine. Two other important rivers that enter the Gulf but are not shown on this map are the Merrimac and the Piscataqua.

Provide a copy of the Major River Basins map (Figure D) to each student. Have students outline each watershed (using a different color for each area and shading it in.) Remember that a watershed consists of a primary “stem” river and all the smaller rivers, streams, and brooks that feed into it.

To locate a watershed, trace the stem river up from its mouth along the coast. Every time that a stream enters it, follow the stream to the end and make a mark. When all these tributaries are identified, shade in the enclosed area that constitutes a watershed.
FIGURE E
Word Search for Maine's Major Rivers

Major river basins
Androscoggin
Kennebec
Penobscot
Piscataqua
Presumpscot
Saco
Sheepscot
St. Croix
St. John

Other coastal names in the puzzle:
Acadia  Lubec
Bangor   Machias
Bath     Monhegan
Boothbay Pemaquid
Camden   Popham Beach
Castine  Topsham
Deer Isle York
Discussion:
1. Which of the rivers running only within Maine has the largest watershed? [Penobscot]
2. What is the name of the large river shown at the top of the map? [the St. John] How would the watershed for this river compare to the ones that you have just outlined? [larger] Where does this river enter the Gulf of Maine? [St. John, New Brunswick]
3. Look at the watershed systems of the Androscoggin and Kennebec river. What estuarine system do these two rivers share? [Merrymeeting Bay]
4. Name each of the bays into which the six marked rivers flow? [use a map of Maine]
5. Discuss the component wetland habitats of a water system (e.g., ponds, bogs, marshes, rivers, and estuaries).

Extension:
Prepare a copy of the word search puzzle (Figure E) and have the students locate the names of major river basins. When students have found all the words on the word search puzzle, ask them to identify the major river basins on a road map or atlas of Maine.

ACTIVITY
Creating a Mini-Watershed

Materials:
Newspaper; waterproof marker; a sheet of plastic; plastic box; paper towels; spray bottle filled with water; and food coloring (add a drop or two to the water).

Procedure:
Use the supplies listed above to construct a model of a watershed. To make the model, crumple two sheets of newspaper and place them next to each other in a plastic box. Drape a plastic sheet over the crumpled paper, fitting it in between the two pieces to form a valley, and shaping "hills" over the high places. Be sure that water will generally flow toward the valley and to the front side of the box. Fold the front edge of the plastic sheet up enough to prevent water overflow from the plastic box. You now have a model of the hills and valleys that constitute a watershed.

To demonstrate how the watershed works, explain to students that the plastic represents the crests of hills and the valley that lies between them. You can use the marker to draw rivers in the basins. With the box in place to catch runoff, spray water onto the model. Point out how the water runs down one side or other of the ridge and forms a stream in the valley. This is how water and snow run off the land on either side of a high ridge line. Call attention to how rapidly the water travels over the hard surface, and discuss how different soil types and paving surfaces (e.g., concrete or asphalt) promote or discourage runoff. [Water cannot percolate into asphalt or concrete the way it can into soil, so runoff on these surfaces is greater.]

[adapted from the Massachusetts Water Resource Authority's publication Water Watchers]
FIGURE F
Salt Marshes—Food for the Sea

ACTIVITY
Salt Marshes: Food for the Sea

➤ Materials:
Figure F (diagram).

➤ Procedure:
Pass out to each student a copy of the Salt Marshes: Food for the Sea diagram.

➤ Discussion:
Have students read and discuss the following questions:

1. What species live in and around a salt marsh? [look at diagram]

2. Why is salt marsh grass important to the ecosystem? [as it decays, the detritus forms the basis for the food chain; it
provides a nesting site for birds and a home for small organisms.

3. Why is an estuary called a nursery for other animals? [it is a calm, productive place where many animals breed and live during the first stages of life]

4. How is a salt marsh productive? [look at the variety of plants and animals and discuss the density of populations]

5. What makes a marsh a harsh living environment? [changing salinity, tidal fluctuations, water temperature]

6. Do salt marshes change? In what ways? [sediments are deposited, stream flows change] How have people changed salt marshes? [filled them for development; drained or sprayed them for insect control, changed or developed areas adjacent to the watershed]

➤ Extension:

1. Have students create a display on the importance and productivity of salt marshes. See Appendix C for further resources.

2. Have students research a fish or shellfish that directly depends on an estuary for survival in some life stage.

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ACTIVITY

Estuawareness: A Field Trip

➤ Materials:
Rope for the transect; containers for collecting.

➤ Procedure:
Visit an estuary. Some of the larger estuaries in Maine include Scarborough Marsh, the Wells Natural Estuarine Research Reserve, and the Merrymeeting Bay estuary. However, most coastal areas have small estuaries and associated salt marshes.

Obtain permission to visit an area from private landowners or the public managers. (To visit the Wells Reserve, call 646-1555; to visit Scarborough Marsh, call 781-2330.) Before taking students on the field trip, talk to them about the importance of these fragile ecosystems and the need for them to treat natural habitats with care.

Activities at the Estuary:

1. Transect: Place a rope or string from upland shrubs and trees down to the water’s edge. Have students walk along the transect and list the plant varieties and population numbers, making notes about the succession of plants.
2. At the water’s edge, collect algae and look for living organisms on the algae using a magnifying lens. Return algae to its original location.

3. Have students find or observe three 3-part food chains (e.g., algae-periwinkle-dog whelk; mosquito larvae-mummichog-great blue heron). Discuss the transportation of nutrients through the food chain.

4. Collect a water sample and bring it back to school to observe under a microscope. Have students sketch the plankton that they see.

➤ Discussion:

1. What animals might feed on the organisms that you see under the microscope? [mussels, clams, fish]
2. Why do you think a salt marsh is rich in micro-organisms? [detritus]
3. How have people used salt marshes in the past? [as dumps because they were seen simply as swamps; as hay fields because saltmarsh hay is free of weeds; for fishing, hunting, and collection of mulch]

➤ Extension:

Have students explore the watershed that their schoolyard falls into. Use a U.S. Geological Survey map for your area (see Appendix F). Follow elevation lines to find watershed boundaries. Use the marsh symbol to identify wetland areas. Check old town and city maps, and local history books, and talk with community members to learn about development. Have students research and discuss the following questions:

1. What watershed is our community in?
2. Are there estuaries in our community? Where are they in relation to ponds and streams?
3. Have wetlands that once existed in our community been filled for development?
4. How might the filling actions affect our water supply?
5. Map and measure a mini-watershed on the schoolground or in a nearby park. Look for land formations that direct the flow of water.

[adapted from the Massachusetts Water Resources Authority publication, Water Watchers]
Pollution in Watersheds

For centuries, people commonly viewed the sea as a "bottomless pit," capable of handling infinite wastes. Since the ocean covers nearly three-fourths of our world, it was thought that it would dilute or disperse any materials we might dump into coastal waters.

This belief that the "solution to pollution is dilution" has been shattered in recent years as many harbors and bays reach their assimilative capacity and show evidence of serious damage. Being at the top of the food chain, we humans are often the last to feel the direct effects of pollution, but the harm to other fauna and flora is becoming evident:

- one-third of Maine’s shellfish beds are closed due to excess levels of fecal coliform bacteria (from sewage);
- chlorine, a biocide used in sewage treatment plants, has been implicated in the decline of Maine’s smelt, alewives, and salmon fisheries; and
- levels of carcinogens in the bottom sediments of Casco and Penobscot Bays rival the contaminant levels in the country’s most polluted urban harbors.

Maine’s marine waters are tainted by trace metals, hydrocarbons, artificial compounds (such as PCBs) and sewage. How do these pollutants enter the coastal ecosystem? We are accustomed to think of marine pollution in terms of rare and dramatic incidents such as oil spills, but the majority of contaminants in the ocean accumulate gradually and insidiously from chronic sources, both point and nonpoint (see the following section).

The precise effects of these contaminants are still largely unknown, but the potential hazards are clear. Pollution may disrupt the delicate balance within the marine ecosystem, killing off some species and prompting others to grow out-of-control. It threatens human health, and can cause economic, aesthetic, and recreational damage along our shorelines. Determining the exact impact of particular contaminants is difficult for several reasons: the dynamic circulation patterns in the ocean spread pollution; and pollutants often have a "time-lapse" reaction in which their effects are not immediately evident. Some contaminants degrade very slowly (e.g., DDT, PCBs, or other synthetic organic chemicals) whereas others (e.g., domestic sewage and plant nutrients) break down fairly quickly.

The following sections outline some of the types of pollution that threaten the Gulf of Maine, and discuss the connections between our actions on land and the ultimate health or degradation of our coastal waters.
IV. NONPOINT SOURCE POLLUTION

**Background Information**

Nonpoint source pollution can be defined as contaminated runoff from sources that are difficult to identify and locate (e.g., farms; acid rain and airborne contaminants; and poor land development). The soot, dust, oil, animal waste, litter, sand, salt, and chemicals that constitute nonpoint source pollution often come from everyday activities—fertilizing lawns, walking pets, changing motor oil, and driving. With each rainfall, pollutants from these activities are washed from lawns and streets into stormwater drains and—eventually—into the ocean (see Figure G).

While rarely visible, nonpoint source pollution is a chronic and ubiquitous form of coastal contamination. The U.S. Environmental Protection Agency estimates that 60 percent of the pollutants in the
FIGURE H
Nonpoint Source Pollution Contaminants

<table>
<thead>
<tr>
<th>Pollutant Types</th>
<th>Sources</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>sediments</td>
<td>construction sites</td>
<td>clouds water, decreasing plant productivity; increases water treatment costs; affects species composition</td>
</tr>
<tr>
<td></td>
<td>agricultural lands</td>
<td></td>
</tr>
<tr>
<td></td>
<td>logging areas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>snow-dumping sites</td>
<td></td>
</tr>
<tr>
<td>excess nutrients (e.g., nitrates, phosphates)</td>
<td>livestock</td>
<td>prompts phytoplankton or algal blooms; causes eutrophication/depleted oxygen and odor; affects species composition</td>
</tr>
<tr>
<td></td>
<td>gardens, lawns</td>
<td></td>
</tr>
<tr>
<td>acids, salts</td>
<td>roads, landfills</td>
<td>can injure or kill marine life or be passed up food chain</td>
</tr>
<tr>
<td>heavy metals</td>
<td>parking lots/runoff</td>
<td></td>
</tr>
<tr>
<td></td>
<td>snow-dumping sites</td>
<td></td>
</tr>
<tr>
<td>organic chemicals (pesticides, oil detergents, etc.)</td>
<td>forests, farmland</td>
<td>toxic effects on wildlife and humans; possibly carcinogenic</td>
</tr>
<tr>
<td></td>
<td>anti-fouling boat paints</td>
<td></td>
</tr>
<tr>
<td>pathogens (e.g., coliform bacteria)</td>
<td>domestic sewage</td>
<td>increased water-treatment costs; causes typhoid, hepatitis, cholera, dysentery</td>
</tr>
<tr>
<td></td>
<td>animal wastes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>leaking septic/sewer systems</td>
<td></td>
</tr>
</tbody>
</table>

ocean are not from point sources (e.g., sewage treatment, oil refineries, paper mills), but from various forms of runoff. The accompanying chart (Figure H) outlines types of nonpoint source contaminants, their sources, and their effects.

Mitigating nonpoint source pollution is difficult, even if the multiple sources can be identified and located. Often solutions entail major changes in land-use practices at the local level and expensive methods to minimize runoff (e.g., planting, porous pavement, and detention basins). Nonpoint source pollution does offer individual citizens an ideal opportunity for combating marine pollution however. By changing their everyday actions, individuals can help reduce the cumulative impact of nonpoint source pollution.

ACTIVITY
Too Many Nutrients

➤ Materials:
Two 1-gallon jars; tap water (several days old); straw, hay, grass, or algae; and plant fertilizer.

➤ Procedure:
Ask students to fill each of the two gallon jars with aged tap water. In each, place a little mat of straw, hay, grass, or algae in order to start a culture.

Add a teaspoon of plant fertilizer to one jar (the experimental jar). Add nothing to the other jar (the control jar). Record observations of both jars. [The experimental jar will eventually grow more algae on
the sides and in the water which, in turn, will support a population of grazing protozoans. These algae and protozoans can be easily seen under low-powered microscope. Add small additional amounts of fertilizer every two weeks to the experimental jar.

**Discussion:**

1. What would be some of the sources of nutrients that cause some rivers and estuaries to become subject to eutrophication? (inefficient septic tanks; sewage effluent; agricultural runoff)

2. How could septic tanks on islands, around coastal bays, and along estuaries contribute to the problems of eutrophication? (wastes from the septic systems can overfertilize plants; the accelerated plant growth then depletes the oxygen level in local waters, killing off marine wildlife)

[reprinted from the *North Carolina Marine Education Manual, Unit 2: Seawater*]

**Activity**

**Searching Out Nonpoint Sources**

**Materials:**
Local map.

**Procedure:**
Have students identify the types of nonpoint source pollution in their community. Look at a local map to find areas where pollution may originate. Conduct a water-quality test using school equipment or contact local environmental agencies to obtain results from any water-quality tests that have been made. Look for the following potential sources of pollution:

1. farmland (sediments, pesticides, herbicides, animal wastes)
2. stormwater runoff from large parking lots or roads (debris, chemical wastes, oil, animal wastes)
3. construction sites (runoff from paint, solvents, construction debris, and soil erosion)
4. residential areas where there might be improperly installed or maintained septic systems (bacterial contaminants and nutrients)
5. streams that might be eroding (sediments, debris)

Have students do a neighborhood survey to determine the methods and products used in lawn and garden care. What chemicals are used? Are people recycling or composting?

**Discussion:**

1. How would pollutants from each of these sites travel into the watershed? (seepage, direct runoff)
2. Discuss each type of pollution and group them into the following two catego-
While rarely visible, nonpoint source pollution is a chronic and ubiquitous form of coastal contamination.

ries. What effect might each category of contaminants have on a specific organism?

*Natural Pollutants:* pathogens, excess nutrients, and sediments. [carry disease, deprive aquatic life of essential oxygen due to excessive plant growth]

*Chemical Pollutant:* acid, salts, heavy metals, pesticides, detergents [are deposited in still waters and estuaries where they may taint the food chain; can change the natural acidity of water]

**Extension:**

1. Monitor nonpoint source pollution on your schoolground. Look for evidence of erosion and sites where runoff may occur. Collect samples of water and test for pH (acidity). Allow the water to evaporate and observe the sediments that remain. Compare rainwater from the schoolground with tap water.

2. If students have created a Gulf of Maine mural, they can now identify some of the sources of pollutants (with stickers, cut-out paper pieces, or markers). Do they think the pollution from various sources stays in the site where it is first used or does it spread? If so, how and where? [it spreads through runoff/gravity into groundwater, streams/rivers, and storm sewers. Ultimately, some of it may reach coastal waters] What organisms might be affected by the various types of pollution? [nutrients increase the growth of algae; pathogens and chemical pollutants can harm or kill organisms living off bottom sediments; humans may be affected by eating tainted seafood]

**ACTION**

1. List actions you can take in your own life to reduce the number of pollutants that you add to the environment. Refer to the following suggestions and generate your own ideas;

- Recycle used motor oil. Contact the Bureau of Oil and Hazardous Materials Control at the Department of Environmental Protection (Station 17, Augusta, ME 04333, ph: 289-2651) for information on service stations in Maine that will accept recycled oil.

- Do not pour household chemicals down drains or toilets as they are not removed in sewage treatment and can end up contaminating coastal waters. Use non-hazardous alternatives whenever possible (see Figure I).
• If you must buy toxics, purchase only as much as you will use.

• Never dump household chemicals on the ground or down catch basins or storm drains where they will be carried into local streams.

• Walk pets in grassy areas or parks. Pet wastes on pavements can be carried into streams by stormwater. If possible, pick up after your pets.

• Don’t dispose of leaves or grass clippings through your stormwater collection system. These can be carried into local streams where they contribute to pollution.

• Landscape your yard to prevent runoff. Use as few pesticides as possible: try "natural" (non-toxic) approaches to pest control wherever possible and organic gardening techniques. For more information on organic gardening, contact the Maine Organic Farmers’ and Gardeners’ Association, PO Box 2176, Augusta, ME 04338 (622-3118).

• Minimize use of anti-fouling paints on boats and use pump-out facilities to empty boat holding tanks: Never release garbage or raw sewage into coastal waters.

2. Create a display with information on nonpoint source pollution for your community.

3. Write to local or state representatives to find out what measures are being taken (or considered) at local and regional levels to address nonpoint source pollution.
V. OIL AND TOXIC CHEMICALS

Background Information

Each year, more than 7 million tons of oil and petroleum are added to the world’s oceans. Roughly 40 percent of these petroleum products enter marine waters from rivers; another 20 percent result from tanker accidents; while the remainder comes from municipal and industrial discharges, offshore oil production, refineries, and natural seepage from vents in the ocean floor.

The presence of oil and natural gas deposits under parts of our continental shelves has prompted heated debates over the potential benefits and risks of offshore drilling in the Gulf of Maine. The lure of cheap energy—close to major markets—is pitted against the risk of spills, tanker collisions, and well ‘blow-outs’ on Georges Bank, one of the world’s richest fisheries. In response to Congressional pressure, the U.S. Department of Interior has postponed an auction to lease drilling rights on Georges Bank until October 1989.

While the use, storage, and disposal of many hazardous wastes is governed by the federal Resource Conservation and Recovery Act (1976), there are no regulations governing the use or disposal of household hazardous wastes. Examples of household hazardous wastes (or toxins) include insect sprays, paint thinners, oven cleaners, bleaches, gas, oil, antifreeze, and rust removers. These substances bypass existing treatment facilities and enter coastal waters without treatment because septic systems cannot handle toxins and municipal treatment facilities only process natural wastes.

It is estimated that every American improperly disposes of 50 pounds of household toxins each year. The cumulative impact of these chemicals on the environment has not been well-researched but it is thought that they may contaminate groundwater, damage sewer systems, and poison wildlife—upsetting the balance of natural ecosystems.

Non-toxic alternatives to many of these household chemicals do exist and are outlined in the following activity (see Figure I).
ACTIVITY

Household Toxins

Materials:
Recopy the Substitutes for Household Hazardous Chemicals chart (Figure I) for students.

Procedure:
Have the students compile a list of items in their home that need to be considered hazardous wastes when they are disposed of (e.g., pesticides, paints, solvents, oil). Have each student think about the last they disposed of a household toxin. Where did it go? Down the drain? Discuss how disposal of such hazardous wastes may affect groundwater and, eventually, ocean quality (see Extension). Discuss how it might be possible to reduce demands for some of these items. Figure I lists some less hazardous substitutes that can be used. Ask students to share this information with their families.

Extension:
Discuss with students how organisms concentrate toxic materials in the food chain. [It takes 1,000 pounds of phytoplankton to produce 100 pounds of zooplankton to produce 10 pounds of small fish to produce a 1-pound large fish to produce 1/10 pound of human.] Therefore, if a molecule of PCB (polychlorinated byphenyls) enters every phytoplankton, how many would enter the human eating the large fish? Very small concentrations at the bottom of the food chain can result in large concentrations at the top levels of the food chain.

Ask students to survey family members, neighbors, and acquaintances about their use of household toxins. Have students design the survey, administer it, and then tabulate and chart the responses.
FIGURE 1
Substitutes for Hazardous Household Chemicals

<table>
<thead>
<tr>
<th>Product</th>
<th>Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>silver polish</td>
<td>soak in boiling water [check] with baking soda,</td>
</tr>
<tr>
<td></td>
<td>salt, and a piece of aluminum foil.</td>
</tr>
<tr>
<td>oven cleaner</td>
<td>baking soda and water</td>
</tr>
<tr>
<td>bathroom cleaner</td>
<td>baking soda and water</td>
</tr>
<tr>
<td>drain cleaner</td>
<td>plunger; flush with boiling water, 1/4 cup</td>
</tr>
<tr>
<td></td>
<td>baking soda, and 2 oz. vinegar.</td>
</tr>
<tr>
<td>rug cleaner</td>
<td>cornmeal sprinkled on rug, then vacuumed up</td>
</tr>
<tr>
<td>floor or furniture polish</td>
<td>1 part lemon juice, 2 parts olive or vegetable oil</td>
</tr>
<tr>
<td>mothballs</td>
<td>cedar chips, lavender flowers, herbs</td>
</tr>
<tr>
<td>ammonia-based cleaners</td>
<td>vinegar, salt, and water mixtures for surfaces;</td>
</tr>
<tr>
<td></td>
<td>baking soda and water for bathrooms.</td>
</tr>
<tr>
<td>abrasive powder cleansers</td>
<td>rub areas with 1/2 lemon dipped in borax-rinse.</td>
</tr>
</tbody>
</table>

[Environmental Hazards Management Institute, 10 Newmarket Road, PO Box 932, Durham, NH 03824]

ACTIVITY

**Oil and Water Don’t Mix**

> **Materials:**
Different kinds of oil (e.g., 3-in-1 oil, olive oil, corn oil, motor oil); containers (twice as many as kinds of oil); eye-droppers; bird feathers; sponges; paper towels; spoons; and cotton swabs.

> **Procedure:**
Divide the members of the class into a number of small groups. Each group will need samples of different kinds of oil. Half the containers can be filled with freshwater; the other half with saltwater. With eyedroppers, have the groups add 5 drops of each kind of oil to containers of freshwater and saltwater, observing what happens. Ask them to make similar observations after 15, 30, and 50 drops. Do the oils behave differently? How? Why? [the oil collects in saltwater because of its density]

Have students dip the bird feathers into the oil-water mixture and note what happens. Why are oil spills threatening to bird populations? [restricts growth and reproduction; blocks sunlight penetration so plants at bottom of food chain are killed; destroys the insulation value of the feathers so birds freeze easily]

With sponges, paper towels, spoons, cotton swabs, or objects of their making, have students attempt to clean up oil from the water samples. Have each group
Penobscot Bay Oil Spill Could Mean Big Trouble

by Stephen M. Rappaport

Last Wednesday, the Affinity, a Singapore-flagged tanker, steamed into Penobscot Bay with a cargo of more than 170,000 barrels of thick No. 6 fuel oil, part of which was off-loaded in Bucksport and part in Searsport. On Friday, the huge vessel sailed back down the bay, with still more oil in her tanks, bound for Portland.

Her trip was nothing unusual. Just two days earlier, the Liberian tanker Nordic Trader discharged 220,000 barrels of No. 2 heating oil at Bucksport. In the space of a week, vessels carrying more than 16 million gallons of oil sailed almost unnoticed into Penobscot Bay, discharged their cargoes, and went on their way.

Last Friday, in Prince William Sound off the southern coast of Alaska, the 987-foot tanker Esso Valdez struck a clearly marked reef and began spewing more than 10 million gallons of crude oil into the water. Now, nearly a week after the accident, federal and Alaska state officials confront an enormous ecological crisis, and the owners of the vessel have said they are overwhelmed by the magnitude of the cleanup.

According to Commander Michael Perkins, commanding officer at the Coast Guard Marine Safety Office (MSO) in Portland, precautions enforced by the Coast Guard make an accident like the Esso Valdez stranding unlikely in the Penobscot Bay region. If there were a significant oil spill, Perkins said, federal and state authorities have a response plan in place but serious environmental and economic consequences would be inevitable.

“Our major efforts are aimed at prevention,” Perkins said... That effort includes careful control of ship movements, as well as inspection of tank vessels and terminal facilities on at least an annual basis.

Tank vessels must notify the MSO at least 24 hours in advance of entering local waters. Using computers, the MSO is able to check out the history of every licensed tank vessel. “If we find that a vessel is due for its annual or six-month inspection, we’ll send some personnel out to do the inspection,” Perkins said. “If we find that the vessel or her master has a history of accidents or oil spills, we’ll send someone before she comes into port. If the record is bad enough... we can restrict the ship’s movements to times of good visibility and good weather, or require extra tugs. We can even refuse to let a ship enter port.”

Perkins also said that the Coast Guard places great reliance on the Penobscot Bay pilots who are required to bring each tanker up the bay. “They are highly qualified and very experienced,” Perkins said.

If there were an oil spill, Perkins said, the Coast Guard and the state Department of Environmental Protection (DEP) would work together to deal with the problem. ...Initially...Coast Guard and state personnel would be sent to the site to assess the damage. Booms, absorbant materials, and skimmers stored at local Coast Guard bases... would be deployed. If necessary, private contractors would be called in from Portland.

If there were a major spill, or if a significant spill occurred in open water, the Coast Guard could fly in its cleanup strike force from its base in Mobile, Ala. According to Perkins, the strike force, equipped with skimmers, booms, and other technology, could fly into Bangor within 12 hours and be at the site of the spill and working within 24 hours.

According to Perkins, that might not be soon enough. “Once a spill has gone on for a couple of hours,” Perkins said, “there’s not much we can do.”

David Sait is the DEP official responsible for coordinating the state’s response in the event of an oil spill. He recognizes the risks posed by tankers in area waters and is extremely cautious about the ability of the state and federal governments to deal with a major spill.

“Any spill the size of the Valdez spill will have horrendous consequences, whatever the response,” Sait said. ...According to Sait, the resources in Maine for dealing with a major spill are limited and would be exhausted within a day to a day and a half.”...The passage of time makes a cleanup more difficult. “Each day it gets bigger,” according to Sait, “because it spreads, and spreads, and spreads.” The entire project becomes “a mammoth coordination effort,” he said.

...Ronald Patterson, terminal superintendent for C.H. Sprague & Co. in Bucksport, said Tuesday that he thought the risk of a major oil spill was small. “Our record speaks for itself,” he said.

Sait is not quite so optimistic. “The frequency of accidents is very low for the number of ships, but they do happen, “ he said. “I see a lot of near misses. It only has to be a near hit.”

According to Sait, the likelihood of a disaster like the grounding of the Esso Valdez is “not all that high” but there is a “quantifiable” risk of a serious spill in Maine waters. “It’s not a matter of if,” he said, “but a matter of when.”
report on the success of their attempted methods. When the activity is finished, dispose of the oil/water mixture as you would a hazardous waste.

**Discussion:**

1. How are large-scale oilspill cleanups done? [skimmers, dispersants, containment booms]

Are those methods effective? [often not, it depends on weather, temperature, speed of response, type of oil, numbers of volunteers] Have students look up articles describing the Valdez spill in Prince William Sound to determine what methods were used.

**Extension:**

Ask students to read the article, “Penobscot Bay Oil Spill Could Mean Big Trouble.”

Then discuss with them the following questions:

1. Why is the emphasis on prevention, not cleanup? [cheaper, easier, far more effective] Do you think the methods of prevention described are sufficient? [experts disagree on this] Why or why not? [cleanup resources exist but not might reach the site in sufficient time; best-case versus worst-case scenarios: how many factors will work in favor or against a cleanup?]

2. If an oil spill strike team could make it to Maine’s coast in 24 hours, isn’t that enough time? If not, why not? [oil slick could spread significantly in just a few hours]

3. What else might be done to reduce the possibility of an oilspill off Maine? [reduced consumption] How can people reduce their use of oil and gas? [drive less, lower thermostats, use renewable energy for home heating]

**ACTION**

1. Follow these general rules of thumb in handling and disposing of hazardous household chemicals:

   - Read the label—know what you are buying and what the potential hazards are.
   - Store products in their original containers so the label can be referred to whenever the product is used.
   - Use alternative, less harmful products whenever possible.
   - Use the least toxic product you can find and never buy more than you need.
   - Some unwanted household chemicals can be disposed of by pouring liquids such as cleaning fluids into a plastic container filled with kitty litter or stuffed newspaper. Allow it to dry outdoors before taking it to a sanitary landfill.
   - Take used motor oil and antifreeze to a gas station with an oil recycling program. Be careful not to spill antifreeze on the ground as it is extremely toxic to pets and wildlife.

2. Discuss the relationship between demand and supply of fuels. List ways that students might use fewer nonrenewable fuels. [driving less, turning down thermostats, weatherizing homes] Have students brainstorm their own suggestions.

3. Have students research renewable alternatives (e.g., solar, wind, water) to nonrenewable fuels. Discuss the advantages and disadvantages of each and the time required to make a transition from nonrenewable to renewable fuel sources.
VI. LAND USE AND THE CUMULATIVE IMPACTS OF DEVELOPMENT

Background Information

We are fast becoming a nation of coastal residents. Demographic studies indicate that by the year 2000, as much as 80 percent of the U.S. population may live (and work) within 50 miles of the ocean or Great Lakes. Our coastal regions may become characterized by the kind of crowding John Steinbeck once observed at Coney Island where he noted that the “the surf is one-third water and two-thirds people.” Already in Maine, more than half of the population lives, and two-thirds work, in the coastal area (which constitutes only 12 percent of Maine’s land area).

Inappropriate and haphazard development along our coasts has already begun to pollute and destroy valuable resources. With growing numbers of people migrating toward our shores, irreparable harm may be done to fragile coastal habitats. Sound land use and appropriate development in Maine are essential if we are to maintain the Gulf’s water quality and productivity.

New development projects are reviewed only for the impact they may have on groundwater, soil erosion, traffic, wildlife habitat, and scenic areas. However, the review process never examines the cumulative impact of development, the combined effect that 20, 50, or 100 projects can have on a community’s resources. In fact it is impossible to assess—given our current understanding of natural resources—just how much development an area can sustain before it is irreparably harmed.

Coastal communities can mitigate incremental damage to their land and water resources through planning and growth management. Listed below are some of the tools that communities can use:

• **subdivision and site plan review ordinances** that allow communities to review industrial and commercial development and multi-family homes for impact on local resources;

• **zoning ordinances** that allow towns to guide the siting of future growth;

• **density restrictions** that establish limits on the number of units allowed on an acre of land;
• *setbacks* (*buffer zones*) that require development to be located a certain distance away from natural resources;

• watershed management districts and sewage treatment districts that provide a comprehensive plan for water management; and

• *conservation easements* in which landowners voluntarily restrict the future development of property.

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**ACTIVITY**

**Tracing the History of Land Use**

**Procedure:**

Students will conduct interviews with their parents, grandparents, relatives or older friends to learn about past land use in their area. Have students focus on land use near water bodies and research the increase in regional population over time. Give students copies of the following questions (to ask their older relatives and friends):

1. How long have you lived in this area?
2. What did you do for a living?
3. Fifty years ago, what was the land you now live on used for?
4. What did your parents and grandparents do for a living?
5. What roads existed when you were a child?
6. How would you compare the water quality in the nearest river (or estuary or bay) now with its quality when you were a child?
7. Has construction along the shore and wetlands occurred during your lifetime? If so, where and how much? In what areas has the most change taken place?
8. What uses of the waterways existed in the past that no longer exist today?

The results of the interviews should be reported to the class. Students may compile their results and convert them to percentiles using the following categories (or others as needed):

**Age:** 20-30 40-50 60-70 80-90

**Occupations:**

- fishermen
- seafood processing
- quarrying
- farmer
- business (specify ________________)
- self-employed (specify ________________)
- trades (specify ________________)

**Discussion:**

Students can discuss other elements from the survey:

1. Average length of time that the survey group lived in the area
2. What changes in land use have people in the area experienced?
3. How have transportation and development patterns in the area changed?
4. In what parts of the community or region have the greatest changes occurred?
5. What occupations appear to have had the strongest impact on land use and water quality?
6. What can we learn from the past that could be applied to today's land-use decisions?
ACTIVITY

Building a Coastal Town

➤ Materials:
Obtain a topographic map of a coastal area with no major city (see Appendix F). Photocopy the map for groups of 3-5 students and provide students with scissors; masking tape; paste or glue; and a large piece of paper on which to affix cut-outs.

➤ Procedure:
Look at the topographic map with students. Discuss and label the terrain, wildlife habitats, soil types, vegetation, and wetland environments.

Brainstorm with students a list of all the necessary elements of a town. Make a list on the blackboard. [Elements of the town might include single-family houses and condominiums; businesses; parks; a landfill or incinerator; a shopping area; cropland and farms; a fish pier; a recreational beach; a marina; a sewage treatment facility; an aquaculture hatchery or farm; a church; and a school.] Out of this list, choose ten elements as a class.

Tell students to design a town on the land designated on the topographic map. Divide the class into groups of 3-5 students. Have each group of students make cut-out models for the ten elements the class has chosen (e.g., a house, a church, a school). Before they affix the cut-outs to the map, the class as a whole should determine the pros and cons of each land use, and the considerations they should use in determining where to site different elements. These factors could be recorded on the board. The following are only a few of the many possible examples:

FARMS

<table>
<thead>
<tr>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
<tbody>
<tr>
<td>• provide food</td>
<td>• use pesticides that can harm people or the environment</td>
</tr>
<tr>
<td>• economic value</td>
<td>• source of natural soil erosion</td>
</tr>
<tr>
<td>• provide seasonal jobs</td>
<td>• use chemical fertilizers that can contaminate water supplies</td>
</tr>
<tr>
<td>• scenic value</td>
<td>• open space</td>
</tr>
</tbody>
</table>

Siting considerations: should not border on a water body that supplies drinking water or whose wildlife is sensitive to pesticides.
BUSINESS

<table>
<thead>
<tr>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
<tbody>
<tr>
<td>• provide employment</td>
<td>• produce wastes and sewage</td>
</tr>
<tr>
<td>• provide commerce</td>
<td>• may contaminate water (with</td>
</tr>
<tr>
<td>• create economic</td>
<td>pesticides, detergents)</td>
</tr>
<tr>
<td>stability</td>
<td>• use chemical fertilizers</td>
</tr>
<tr>
<td></td>
<td>(lawns, etc.)</td>
</tr>
<tr>
<td></td>
<td>• runoff from parking lots</td>
</tr>
</tbody>
</table>

Siting considerations: should be located near residence of employees, but not near a supply source for drinking water

ACTION

1. Contact the local town planner to get information and statistics on the following:
   • subdivision and site plan ordinances;
   • zoning ordinances;
   • buffer zones;
   • conservation easements; and
   • enforcement of ordinances. (descriptions of these planning tools can be found in the introduction to this section).

   Discuss observations that students have made in their community. Do they think that most buildings comply with the building ordinances? Have they noticed any situations that they think may not comply? Do they think that the existing planning measures are adequate? Why or why not? Discuss land-use decisions being made in your region. Which do students feel are appropriate or inappropriate?

2. Have students follow a proposed development through the planning process, by tracking its progress in local papers. What players are involved in the planning process? Have students attend a hearing concerning a proposed development.

Using the cut-outs, each group can then lay out a town that contains all ten elements. The cut-outs can touch on the map but should not overlap. [Suggest that students use loops of tape on the back of the cut-outs to affix them, so that they move the cut-outs later if they decide on another site]

Invite each group to display and describe the town they develop. Encourage discussion of each group’s choices. Remember to emphasize that
   • no essential land use can be excluded;
   • some wildlife habitat must be preserved;
   • and everyone within each group must agree on the siting of each element.

Look for the consequences of each proposed land-use plan. Discuss the trade-offs involved in siting particular elements (e.g., proper drainage, protection of wildlife or wetland habitats).

After the discussion, give students additional time for their group to come up with what they believe to be the best possible land-use plan, under the circumstances. Display the final land-use plans on the board (or around the Gulf of Maine mural if the class has made one). Discuss the merits of different approaches and point out that while their solutions may not be perfect, they can protect land and water resources through careful planning.
VII. WASTEWATER AND SEWAGE TREATMENT

Background Information

Boston Harbor, infamous for its poor sewage treatment, is not the only part of the Gulf of Maine jeopardized by inadequate wastewater treatment. One-third of Maine’s productive shellfish beds have been closed due to the presence of fecal coliform bacteria (from sewage). Inadequately treated sewage—whether from shoreside facilities or boats’ holding tanks—poses multiple threats. In addition to closing shellfish areas, sewage and animal wastes require oxygen for bacterial decay and can deprive fish and plants of necessary oxygen. Depletion of oxygen in the water can, in turn, produce foul odors and hasten the spread of pathogenic organisms (causing outbreaks of typhoid, hepatitis, and dysentery).

By law, all public sewage treatment facilities in the U.S. should have at least secondary sewage treatment that uses a combination of microorganisms and settling to treat water. These standards were established under the 1977 Federal Clean Water Act.

In practice, the Maine Department of Environmental Protection (DEP) estimates that 90 percent of Maine’s towns meet the secondary treatment standards but at least 14 coastal towns still discharge untreated waste directly into the ocean. Many other Maine cities still have combined sewer overflow (CSO) systems that drain from storm sewers and, during heavy rains (due to overloading), dump untreated sewage directly into the sea. Sewage also enters the Gulf of Maine from residential overboard discharge systems—80 percent of which DEP estimates may not function adequately. Chlorine released from these systems can kill the phytoplankton and zooplankton that form the base of the marine food web. Some domestic sewage is also released directly through “straight pipes” into the ocean, although this practice was formally banned a decade ago. In addition to improved sewage treatment, bacterial contamination of Gulf waters can be decreased by reducing the amount of wastewater that we generate (see the activity on water conservation in this section).
Number of water users in your household: ________

---

### Please Post in the Bathroom(s)

**Directions:** Place a checkmark in the proper column each time that any of the following activities is performed (make checks in sets of five, as shown).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Gallons per Use</th>
<th>First Day</th>
<th>Second Day</th>
<th>Total Uses</th>
<th>Total Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet flush</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tub bath</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-minute Shower</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brushing teeth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>—water running</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>—water not running</td>
<td>1/2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Please Post in Kitchen

**Directions:** Place a checkmark in the proper column each time that any of the following activities is performed (make checks in sets of five, as shown).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Gallons per Use</th>
<th>First Day</th>
<th>Second Day</th>
<th>Total Uses</th>
<th>Total Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-washing dishes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>—water running</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>—using basin</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dishwasher use</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothes washer use</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meal preparation</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Massachusetts Water Resources Authority]
Toilet: People use more water flushing the toilet than any other way.

- Don’t use the toilet as a wastebasket.

- Save water on each flush by displacing the water in the tank with two half-gallon plastic jugs filled with water and pebbles for weight.

- Check for leaks and have them repaired.

Bath and Shower:

- Take showers instead of baths, and make showers shorter.

- Install a water-saving showerhead and have your hot water tank wrapped with insulation (contact Central Maine Power for more information).

Sink: Don’t let water run down the drain while you do the following:

- brush your teeth or shave;

- wash and rinse dishes;

- wash fruits and vegetables; or

- wait for water to get cold to have a drink. Instead, keep a container of drinking water in the refrigerator.

General Household:

- Wash only full loads of dishes or clothes.

- Use low-volume or conservation settings if your machines have them.

- Do a home leak-check on all faucets and water lines to appliances, and repair any leaks.

- Water the garden and lawn at dusk when the day is cool (so less water evaporates).

- Mulch the garden to retain moisture in the soil.

- Wash the car using a bucket. Use a hose only when rinsing and always use a nozzle on the garden hose.

- Use “trickle” irrigation instead of sprinkling.

- Sweep walks and driveways instead of hosing them.
Tracing Your Water Supply

Procedure:
Ask students to research the water supply for their community and their homes by contacting their local water utility's district office. If there is a municipal wastewater treatment plant in the vicinity, arrange for a tour. Ask the water utility for information beforehand so that students can study the general operation of a water treatment plant before their visit. After the tour, have students draw a diagram of the community’s wastewater treatment plant.

If your school or community’s water supply comes from groundwater—obtained through a well(s)—have the class research the following questions.

Discussion:
1. From what aquifer does the school’s or municipality’s wells obtain water?
2. What methods are used to treat the water? What does treatment do to the water? [refer to information from the water utility]
3. Does the municipality have an adequate water supply for future needs?
4. Are there any present or potential sources of contamination to wells? [list possible sources]
5. What does the community do to ensure that its water is safe to drink?
6. How many phases of treatment does the sewage go through? [1, 2, or 3] Where does the sewage go after treatment?
7. Has the town (or city) ever experienced a water shortage or problem with water contamination?

8. Is the sewage treatment system a “combined” facility where excess rain can make the system overflow?

Home Inventory of Water Use

Materials:
Water Use Inventory and Family Water Conservation Sheet (Figures J and K); materials for creating a display.

Procedure:
Make copies of the Home Water Use Inventory and Family Water Conservation sheets for students. Ask them to inventory water use in their home for two consecutive days. In addition to using the inventory sheet, students can monitor their home water meters (if their houses have them). Contact the municipal water utility for a description of how a water meter records usage. Have students list all the water uses in their homes and determine how much water is used by their family in one week. Ask them to plan ways that their family could save water; then measure the amount of water used during a week when the family was following the conservation plan. Discuss their findings and brainstorm other ideas for reducing the amount of wastewater they generate (see Action section). Ask students to share their tips on water conservation with their community by setting up a display in the school, town hall, or library.
1. Use these simple guidelines to make sure that you do not waste water (or energy) without knowing it:

- Check your water meter while no water is being used. If the dial moves, your plumbing system has a leak.

- Run your dishwasher only when you have a full load. Use the cycles with the least number of washes and rinses.

- Don't run water continuously when hand-washing dishes.

- Add your garbage to the compost or trash instead of putting it down the garbage disposal. Disposals not only use a great deal of water: they also add solids to already overloaded sewer systems.

- Wash clothes only when you have a full load. Set the water level control appropriately. Permanent press cycles often use an additional 10 to 20 gallons of water.

- Install a water-conservation shower head. They are inexpensive and reduce water flow by at least 25 percent.

- Place two half-gallon plastic bottles filled with water in your toilet tank. This cuts the number of gallons per flush from five to four.

- Take short showers instead of baths. Remember, baths can use 30 to 50 gallons of water.

- Do not let water run while brushing teeth, or lathering face and hands.

- Water your lawn and wash your family's car only when absolutely necessary.

2. Do research on the Clean Water Act. What does it regulate? What is its current status? (e.g., are amendments to it proposed or have some recently been passed? What is the content of these amendments?)
VIII. MARINE DEBRIS

Background Information

Like overflowing landfills, debris on shores and in coastal waters is a symptom of our “throwaway society.” Waste generation has increased significantly in recent decades due to several factors: population growth; greater affluence; modern packaging practices; and the development and use of synthetic materials, particularly plastic. It is estimated that every year Americans throw away 40 million tons of paper, 28 billion bottles, 60 billion cans; and 4 million tons of plastic. Approximately half of our waste is recyclable, but only 10 percent is actually recycled. Some of the trash is disposed of responsibly, but 14 billion pounds worth is discarded on beaches, in rivers, or in coastal waters and ends up as marine debris.

Until recently, marine debris was not considered a “significant” form of coastal pollution: it was just thought to be an eyesore. But as the following article demonstrates, the hazards of marine debris—particularly plastics—are becoming apparent. Please read the article “Plastic Debris Plagues Maine Coast” for further background information on marine debris.

ACTIVITY

Hazards of Plastic

➢ Procedures:

Have students read the following background article on marine debris.
Plastic Debris Plagues Maine Coast

by Katrina Van Dusen and Flis Schauffler

An economist once quipped that we’d all be rich if we had only followed the sage advice that Mr. Robinson gave Benjamin Braddock (Dustin Hoffman) in the 1967 film, The Graduate: “plastics.” The plastics industry is doing well because it has created a durable, adaptable product that is put to myriad uses, especially in packaging. The prevalence of plastics, though, is causing an assortment of problems on land and in the ocean: long-lived plastic products are overloading landfills, littering beaches, and endangering marine wildlife.

According to the National Academy of Sciences, nearly one million pounds of plastic is discarded into the ocean daily. Of all the debris sighted on the ocean surface in a 1984 study, more than 80 percent was plastic. Where does all this plastic come from? It’s discarded along shore and at sea by commercial and recreational boaters, beachgoers, merchant ships, naval vessels, and plastic-manufacturing industries. Historically, merchant and passenger ships and naval vessels have disposed of trash at sea because of inadequate on-board storage space and limited facilities for shoreside disposal. Fishing and recreational boaters also contribute to the problem, both through intentional dumping and through loss of gear. Plastic debris in the ocean also accumulates from land-based sources, such as plastic-manufacturing operations, sewage treatment plants, ocean dumping of municipal solid waste (a historic pattern with some Maine islands); and littering by people along shore.

The threat posed by this plastic debris is becoming increasingly evident. Marine scientists now consider plastic to be the most widespread human threat to marine species. The National Wildlife Federation estimates that, worldwide, over one million birds and 100,000 marine mammals die each year as a result of ingesting plastic, or becoming entangled in it. Birds can die after consuming various small plastic particles, mistaking them for crustaceans or fish eggs, their normal prey. The indigestible plastic then blocks their intestines, causing ulcers and—ultimately—starvation. More than 50 of the 280 bird species known consume plastic. Turtles such as the endangered Loggerhead ingest plastic bags, mistaking them for jellyfish—one of their favorite foods. Marine mammals and fish also become entangled in plastics such as discarded fishing gear and six-pack yokes. Unable to move normally or feed, the entangled animals often die from exhaustion, exposure, or starvation.

Marine debris poses a threat to more than wildlife. It is a navigational hazard for both recreational boaters and commercial vessels. Plastic nets, ropes, line, and bags can foul propellers and clog water intakes on ships, disabling vessels and causing engine damage.

There is also growing concern that the aesthetic blight posed by beach litter will hurt states like Maine whose economies rely on the scenic appeal of their coasts. Maine need only look to New Jersey and New York to gauge the extent of this risk. According to a recent “Blue Ribbon Panel Report on New Jersey’s Ocean Incidents,” 70 percent of visitors to New Jersey’s shore described the water as “sometimes or generally not clean.”

What can be done to lessen the problems posed by plastics in the ocean? Efforts to address the issue range from local cleanup efforts to international agreements. Every fall since 1985, local communities along Maine’s
coast have participated in a shore cleanup. During this annual event, hundreds of volunteers collect tons of trash from sandy beaches, salt marshes, rocky shores, and islands. While the Maine Coastal Program coordinates the cleanup, the event is largely a grassroots effort, organized by enterprising individuals and community groups such as Audubon chapters, conservation commissions, school classes, and scout troops. In 1988, more than 1,400 volunteers collected 7 tons of debris along 114 miles of the state's shoreline, an average of 133 pounds per mile.

Beyond individual efforts and local cleanup efforts, what can be done to reduce the amount of marine plastics debris? Efforts will need to be undertaken at the state, national, and international levels. Maine could enact regulations mandating that certain plastic items be degradable and requiring all nondegradable plastic containers to be returnable. While bills to ban six-pack yokes have failed in the legislature, Maine is one of 11 coastal states that require these connectors to be photodegradable. (Photodegradability means that the connector—if exposed to sunlight and warm temperatures—will break down within seven months. But, of course, not all the discarded yokes remain in full daylight, facing south.) [ed. note: The 114th Legislature passed a bill in June 1989 banning use of all six-pack yokes in Maine.]

Steps should be taken at state and national levels to construct adequate dockside disposal facilities that will encourage large merchant, research, and fishing vessels, as well as recreational boaters and nearshore fishermen, to bring their trash to shore for disposal. The fishing industry is also exploring ways to regulate itself to minimize the loss of gear. Possibilities include identification, tracking, and bounty systems for lost fishing gear.

At the international level, progress on the ocean dumping issue was made last December. After nine years of discussion, Congress ratified Annex V, a provision of the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL) that prohibits ocean disposal of plastics, limits other garbage disposal, and requires ports to provide facilities for receiving ship's trash. The U.S. was the last signatory nation needed to enact the provision into law. Effective December 31, 1988 it is illegal for U.S. ships in international waters, and all ships in U.S. territorial waters to dump plastics overboard.

Even with international efforts to limit ocean dumping, the plastics problem in the sea is apt to be a serious one for decades, and probably even centuries, to come. It is estimated that the average plastic bag lasts 20 years, and the average six-pack yoke lasts 400 years, so plastics would pose a continuing threat to wildlife even if we completely stopped dumping them.

By one estimate, each of us uses almost 200 pounds of plastic annually, roughly 60 pounds of it in packaging. Given that close to one million people live in Maine's coastal counties, it is inevitable that some of these myriad plastics will find their way to sea.

A first step in halting this seaward migration of plastics will involve public education. If people understand that coastal debris is deadly, as well as ugly, they may litter less. Admonitions not to litter are often seen as farcical due — in part — to the overused "Hooty Owl" approach. The slogans may trivialize the issue, but the underlying idea remains critical: more than ever now, with greater numbers of people and nondegradable plastics, we need to stop littering.

A second step toward reducing marine plastic debris may involve reducing our reliance on that modern miracle, plastic. As we learn more about its hidden costs, we may decide that the threat that it holds for life in the sea outweighs its benefits.
Discussion:
1. Why is plastic more hazardous in the marine environment than paper, glass, or metal? [It floats, is durable—lasting up to 400 years, and is widely used and discarded]

2. What are three types of damage that plastic debris can cause? [Injury or death to wildlife, hazard to boats, and aesthetic blight on beaches]

3. What does photodegradability mean? [The ability of plastic to degrade over time in the presence of sunlight and warm temperatures] What are the limitations of photodegradable plastic? [Doesn’t degrade in the ocean or buried in sand or during winter]

4. Why would plastics continue to pose a threat to wildlife even if all dumping of plastics ended today? [Plastics have a lifespan of 20 to 400 years and huge volumes are already present in the marine environment]

ACTIVITY

Maine’s Annual Coastal Cleanup—A Field Trip

Materials:
Data cards, pencils, garbage bags.

Procedure:
During Maine’s Annual Coastweek Celebration (in late September), take students on a “shore cleanup” field trip that will allow them to do hands-on research, learn stewardship for coastal resources, and collect scientific data that may be used to influence state and national policies and laws.

Plan the field trip for low tide and contact the Cleanup Coordinator at the Maine Coastal Program office in Augusta (289-3261) to obtain data cards (for recording the types and amounts of debris found); pencils; and garbage bags. Arrange for disposal of the waste that you will collect at the shore (a local waste hauler might agree to collect the debris as a community service or—if the shore is town property—town officials may agree to have the trash removed).

Have students prepare for the field trip by doing some (or all) of the activities in this section. When your class is at the shore, divide them into groups of three or four and give each group a data card and pencil. Explain how they should record data [Instructions are on the data cards] and caution them not to touch anything that might be hazardous (e.g., unidentified canisters, 55-gallon drums, medical items).

Make sure that students all wash up thoroughly after completing the cleanup. Ask them to tabulate their data and determine the percentage of different items found, and the average weight of debris per mile. Have students estimate how long it will take for each type of debris to decompose. Data cards from their cleanup should be
mailed back to the Maine Coastal Program (Station 38, Augusta, ME 04333).

Students may wish to create a large mural of the shore on their classroom wall and place on it some of the marine debris they have collected. Students can put tags next to the debris indicating what hazards each item poses for wildlife, boaters, or beachgoers. Or they may wish to develop an exhibit on marine debris for their community.

> Extension:

1. You may want to consider having students “adopt” a stretch of shoreline and visit it regularly to determine the deposition rate of marine debris over time.

2. If you are not able to take students on a field trip, you may still wish to have them chart and discuss the data from Maine’s previous Coastal Cleanups. Using the following data table (Figure L) and graph paper, ask students to construct bar charts plotting the amounts of different debris types collected. (Types of debris can be on the horizontal axis and number of items on the vertical axis.)

---

**FIGURE L**

Maine’s Coastal Cleanup Results (1985-1988)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>368</td>
<td>495</td>
<td>793</td>
<td>1,410</td>
</tr>
<tr>
<td>Coastline Covered</td>
<td>29.6 miles</td>
<td>69.5 mi.</td>
<td>80.7 mi.</td>
<td>114 mi.</td>
</tr>
<tr>
<td>Debris Collected</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated number of pounds</td>
<td>1,560 lbs.</td>
<td>5,983 lbs.</td>
<td>7,118 lbs.</td>
<td>15,200 lbs.</td>
</tr>
<tr>
<td>Average number of pounds per mile</td>
<td>52.7 lb/mi</td>
<td>86.1 lb/mi</td>
<td>88.2 lb/mi</td>
<td>133.3 lb/mi</td>
</tr>
<tr>
<td>Estimated number of items</td>
<td>13,000</td>
<td>23,500</td>
<td>19,400</td>
<td>51,893</td>
</tr>
</tbody>
</table>

**Composition of Debris, 1988** (based on number of items collected)

<table>
<thead>
<tr>
<th>Item</th>
<th>Rank</th>
<th>% Composition</th>
<th>No. of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic</td>
<td>1</td>
<td>41.59</td>
<td>21,582</td>
</tr>
<tr>
<td>Styrofoam</td>
<td>2</td>
<td>18.04</td>
<td>9,363</td>
</tr>
<tr>
<td>Paper</td>
<td>3</td>
<td>13.03</td>
<td>6,760</td>
</tr>
<tr>
<td>Metal</td>
<td>4</td>
<td>10.38</td>
<td>5,386</td>
</tr>
<tr>
<td>Glass</td>
<td>5</td>
<td>9.74</td>
<td>5,056</td>
</tr>
<tr>
<td>Rubber</td>
<td>6</td>
<td>3.74</td>
<td>1,800</td>
</tr>
<tr>
<td>Wooden Items</td>
<td>7</td>
<td>2.30</td>
<td>1,192</td>
</tr>
<tr>
<td>Cloth</td>
<td>8</td>
<td>1.45</td>
<td>754</td>
</tr>
</tbody>
</table>

The 51,893 items collected in Maine’s 1988 Coastal Cleanup included 3,723 plastic bags; 2,409 styrofoam cups; 1,633 glass bottles; 617 milk jugs; 275 six-pack yokes; 86 balloons; 16 tires; and miscellaneous items such as carpet, bedsprings, stovepipe, and a refrigerator. Not included in the count were seven dead birds (six herring gulls and a cormorant); five dead mammals (three seals, one otter, and one unidentified mammal); and a loggerhead turtle (whose death was attributed to ingestion of a plastic bag).

Maine was one of 25 states to hold a coastwide cleanup in the fall of 1988. Nationally, 46,515 volunteers turned out to clean up 1,793,600 pounds of debris from 3,250 miles of shoreline.

[data compiled by the Maine Coastal Program at the Maine State Planning Office]
PART 2: SOURCES OF POLLUTION

on the vertical axis] Ask students to create a pie chart that shows the percentage of different debris types found. Why do students think plastics constitute over half of the materials found? They are the most durable and they float. Have students extrapolate from the 114 miles covered in the 1988 cleanup to get estimates for the amount of debris along Maine’s entire coast [e.g., If 3,723 plastic bags were found along 114 miles of shoreline, how many might be present along Maine’s 3,000-mile coast?]

ACTIVITY

Plastic Jellyfish

➤ Materials:
Cleaned plastic trash (from students’ homes); materials for creating a display.

➤ Procedure:
Ask the students to collect and save every piece of plastic waste produced in their homes during a two-day period. Have them bring these materials to school. Or, if the quantity is too great, ask them to bring a sample. Caution the students to clean the plastics (so that they are free of food or drink remains) before bringing them to school. Also, caution them not to retain containers that held toxins such as ammonia or chlorine bleach.

➤ Discussion:
Ask the students to separate these plastic waste materials into categories. Have students classify them in terms of how they might be perceived by marine wildlife as food (e.g., very likely, somewhat likely, or unlikely). Identify the species that might attempt to eat plastic. Students can also classify the materials according to the likelihood of aquatic animals becoming entangled in them and subsequently dying. Ask students to summarize what they have learned about the potential hazards that plastic wastes pose for marine wildlife. Students may also wish to separate out recyclable materials.

➤ Extension:
1. Invite students to survey their schoolground or community for plastic litter. If there is a serious litter situation, ask students to develop an action plan that will address the problem and raise public awareness.

[adapted from Aquatic Project Wild with permission]
ACTIVITY

All Wrapped Up in Packaging

> Materials:
Several examples of food packaging.

> Procedure:
Bring in an example of food packaging. Design a way to categorize packaging. For example, sort it according to "natural" packaging (e.g., bananas, peanuts); "older" packaging (e.g., paper bags, returnable bottles); and "modern" packaging (e.g., plastic wrap, styrofoam, plastic milk containers).

> Discussion:
1. Why is the product packaged? [is it to protect the product and consumer's health; to provide advertising or convenience; or to promote purchasing by making the product look larger or more appealing]
2. Is the packaging essential or wasteful? Why or why not? What criteria might you use when deciding to buy packaged goods?
3. What influence do you think packaging has on how well a product sells?
4. What happens to the packaging once the product is used?
5. Which packaging is/is not recyclable? Biodegradable? Made from recycled materials? Made from renewable resources?
6. What are the environmental benefits and costs of making and disposing of each type of packaging? [students might wish to chart these on the board]
7. Which packaging would you label most wasteful? Least wasteful? Why?

> Extension:
1. Have students brainstorm ways that they could reduce the amount of packaging they purchase. For example, could they purchase products in bulk? How would this help reduce packaging? [A 3-ounce tube of toothpaste requires 50 percent more packaging per ounce than a 7-ounce tube.]
2. Make a time capsule. Ask students to predict how long it will take for the materials shown in Figure M to decompose. If you have a place in the schoolyard, or in a parent or teacher's yard, bury each material in a marked spot for retrieval at a given time (this could be done at the beginning of the school year, and the materials dug up near the end of the year). The decomposition times can then be compared to the student's predictions. For the remaining materials that have not decomposed, have students construct a time line showing the total decomposition time for the materials.

[adapted from the Wisconsin Department of Natural Resources' Recycling Guide]
1. Brainstorm what you can do to encourage change in packaging procedures. List your ideas. For example:

- write to the manufacturers of an item with a particularly wasteful package and ask them to suggest ways that you can reuse or recycle a package that you think is wasteful (request a response);
- write to retailers encouraging them to carry beverage containers that can be reused or recycled.
- write to packaging companies urging them to use recyclable items (request a response);
- refuse to purchase over-packaged items in stores or to accept unnecessary bags and wrappings from the cashiers or baggers. Let store managers know why.

Evaluate your results: Did you receive responses to your letters? If so, did they address your concerns and answer your questions adequately? Who might you contact to assist in your goal? Would you personally be willing to do without some of the convenience and appeal of packaging? Why or why not?

2. Set up a recycling program in your classroom. Separate reusable paper and other reusable items; recyclable paper, cardboard, aluminum cans; and glass. Find places in your community that will accept these materials. Extend this to become a schoolwide recycling program. Contact the Office of Waste Reduction and Recycling (see Appendix D) for more information and classroom activities on recycling.
IX. THE GULF'S FUTURE

Background Information

To write a *background* section on the Gulf's *future* may seem paradoxical, but any consideration of future coastal management must be grounded in what we have learned from past experience. As the maxim goes, "the past is prologue."

Our understanding of the Gulf has been—and remains—woefully inadequate. Testifying before a legislative committee in 1988, Bigelow Laboratory research scientist David Townsend observed: "It is embarrassing to admit that so much of what we believe about our living marine resources remains virtually unchanged from the earlier half of the century and is—in fact—pure conjecture."

If we continue to make decisions regarding the Gulf in an informational void (or procrastinate making any decisions whatsoever), we risk contributing to the Gulf's ecological degradation. Further research is needed on the sources and effects of pollution and the biological and physical forces at work in the Gulf of Maine.

But we need to act before all the returns are in. We cannot delay for several decades while the scientists gather and weigh all the necessary data. Research is an essential complement to sound management, not a substitute for it. In the words of Anne Johnson, a policy specialist with the State Planning Office, "We can't wait until we have all the answers before we try to do something. It's an imperfect world. We need to act on imperfect knowledge."

We are fortunate to recognize the Gulf's value before threats to its health reach crisis proportions. Through widespread education, research, governmental action, and individual initiative, we can preserve the beauty and bounty of the Gulf. Author Rene Dubos once wrote that people should "think globally, but act locally." Here in Maine, we enjoy only a tiny percent of the vast waters that encircle three-fourths of Earth. But our Gulf is a microcosm of the larger ocean, and how we treat it affects the greater natural environment. As this guide has shown, each of us makes a difference—whether for better or worse. Through thoughtful action, we can ensure that it is for better.
ACTIVITY

Deciding the Future:
A Role-Play

Procedure:
In this activity, students will assume the roles of a variety of individuals who are interested in the following situation. They will develop these roles and present them at a mock public hearing.

Situation: There is a proposed international treaty that would ban dumping of all wastes from all vessels in the Gulf of Maine.

Setting: Public hearing organized by the State to sound out public opinion on this proposed treaty.

Describe the setting and situation to students. Assign a role to each student or pair of students. Roles may be duplicated.

Roles:

fisherman [concerned about another law, wants no governmental interference]

lobsterman [concerned about waste's effects on lobsters, but also worried about too many laws]

clam harvester [concerned about the effect of wastes on shellfish beds]

worm digger [concerned about the effect of wastes on mudflats]

landfill operator [concerned about having more waste hauled to the landfill from boaters]

owner/operator of small retail seafood business [concerned about disposal of fish wastes]

yacht club owner [concerned about inconvenience of additional waste disposal facilities at club]
coastal town manager [concerned about cost to town of increased waste disposal]

representative of international shipping organization [concerned with getting cooperation on the treaty]

Navy officer [concerned about waste from naval ships]

Coast Guard officer [concerned about enforcement of the new treaty provision]

costal housing developer [concerned about waste reducing property values]

environmental activist [concerned about pollution, damage to wildlife, long-term health of Gulf]

marine biologist [concerned about Gulf's productivity, monitoring existing contaminants]

owner/operator of a boat yard [concerned about inconvenience]

Have each student (or pair) present their points and concerns at the mock public hearing. Other students may ask questions but should not interrupt a presentation. Encourage students to listen and consider the points brought up.

Close the meeting with a debate and then have a secret ballot vote for or against the proposed treaty. The purpose of the vote is only to sample public opinion: tally and report the outcome of the vote to the class.

**Discussion:**

1. What insights did you gain from the role-play?

2. How do you think equitable and sound decisions can be made concerning the Gulf's future—taking into account all these different perspectives? How much agreement was there among the various participants in the hearing? Were there any overriding concerns that all the participants shared?

**Extension:**

Use a coastal issue currently being discussed in your community as the basis for this role-play. Students may then interview the person whose role they will assume in the mock public hearing. Invite community members to attend the mock hearing and encourage students to track the issue in the news.
ACTIVITY

What's It Worth To You?

➤ Discussion:
In an October 1988 speech, Maine Mari­time Academy President Kenneth Curtis observed: “I think we have to admit to ourselves that—to date—we are failing in the preservation of the Gulf of Maine. But I don’t think we understand the ecosystem well enough to provide the type of action we need to absolutely ensure that there’s no further degradation of the Gulf.”

Discuss this statement with students. If Curtis is right, how could we better understand the Gulf’s ecosystem and take action to ensure its survival? [monitor level of contamination; better understand its species composition; reduce sources of pollution] What values of the Gulf do students feel are important? How would they like to see people use the Gulf of Maine? What can they do to influence how the Gulf is used? [write representatives; consider marine careers; take action to reduce pollution in their homes] Could they make an exhibit to teach others about the Gulf of Maine? If so, what should it include? How should the Gulf of Maine’s resources be shared with other countries?

ACTIVITY

The Gulf of Maine Reporter—Creating A Newspaper

➤ Materials:
Existing newspapers; typewriters; paste-up materials.

➤ Procedure:
Students will investigate, write, and produce a newspaper that features Gulf of Maine information and issues. Have students use an actual newspaper as a model to look at the variety of news articles, as well as the special-interest departments. Ask each student (or team of students) to choose one newspaper section to plan and write.

Have students research topics and gather information for their chosen sections. Tell them whatever information they compile has to relate to the Gulf’s future. Topics may include water-quality issues; mineral and oil drilling; the life cycle or survival of a particular species; or a report on a local shore cleanup. Each section should include a combination of information and students’ opinions (based on other activities from this guide and what students learn through research. Encourage students to share their ideas with each other and work as part of a news production team. Have students type or write neatly in a specified column width, and create graphics to illustrate their stories. A small group of students can volunteer to lay out and design the newspaper. Investigate the possibility of having copies made for each student (consider copying when you determine paper size).

Finish the activity with a discussion of each article or feature, emphasizing different perceptions of the Gulf’s future.

[adapted with permission from Aquatic Project Wild]
Appendix A: GLOSSARY:

anti-fouling boat paints: boat paints containing a toxic chemical tributyltin (TBT) which inhibits the growth of barnacles and other marine organisms.

assimilative capacity: the amount of materials (or contaminants) that a water body can absorb before becoming overburdened.

biodegradable: capable of being decomposed by biological means (e.g., bacteria)

biocide: a chemical designed to kill life

biomass: living matter

carcinogens: cancer-causing agents

cumulative impact: an increased effect from successive additions (e.g., of development or pollution)

detritus: decaying organic matter

ecosystem: an interactive community of animals, plants, and micro-organisms and the physical and chemical environments in which they live

effluent: wastewater entering the environment from an industry or sewage treatment facility

estuarine: estuary systems occurring where rivers meet the sea

estuary: any confined coastal water body that forms a transition zone between freshwater and saltwater

eutrophication: the process by which dissolved nutrients fertilize a water body, increasing its productivity (sometimes to undesirable levels where the oxygen level is depleted).

food chain: a sequence of organisms in which each creature is sustained by eating the preceding one

food web: the network of feeding relationships in a biological community

groundwater: water beneath the earth’s surface in the zones of soil and bedrock

household hazardous wastes (toxins): any chemicals discarded from the home that, if handled improperly, could threaten human or environmental health

hydrologic cycle: the processes of evaporation, precipitation, transpiration, and runoff by which water cycles through the environment.

lacustrine system: lake systems

marine debris: any lost or discarded human-made objects that accumulate in the ocean or along its shores

runoff: water from rain or melted snow that drains or flows off the surface of the land

nonpoint source pollution: contaminated runoff from many diffuse and/or small-scale sources
nonrenewable resource: a natural resource that is considered finite due to its scarcity, rapid depletion rate, or excessively slow rate of formation

overboard discharge systems: residential sewage treatment systems that partially treat wastes with chlorination and a sand filter

palustrine system: freshwater wetlands that are small in size, shallow, and have no significant wave action and no bedrock shoreline

pathogen: disease-causing agent

PCBs: (polychlorinated biphenyls) synthetic industrial chemicals that are carcinogenic

photodegradable: capable of degrading in sunlight and warm temperatures within a given time period.

phytoplankton: microscopic floating plants

point source pollution: contaminants emitted from a central, identifiable source

protozoans: minute acellular or unicellular animals

detention basins: large basins that retain runoff, allowing contaminants to settle out before water is released

recyclable: capable of being reprocessed for reuse

recycling: the collection and reprocessing of manufactured materials for reuse either in the same form or as part of a different product

renewable resources: natural resources derived from an infinite or cyclical source (e.g., sun, wind, wood, fish, water)

riverine: river systems

salt marsh: a protected intertidal wetland characterized by salt marsh cordgrass, salt hay, and black rush

secondary sewage treatment: a wastewater treatment process that uses micro-organisms and settling to remove 90 percent of the biological oxygen demand (this is the standard for treatment set by the Federal Clean Water Act)

seepage: ability of solubles to infiltrate solids

sewage: solid or liquid domestic waste material from homes, businesses, or industries

transpiration: a plant's ability to dispose of excess water through leaves

wastewater: water filled with sewage (i.e., human pollutants) or industrial wastes

watershed: the land area that drains into a given body of water

wetlands: low-lying lands in which the soil is saturated with water throughout the year (e.g., swamps, marshes, bogs)

zooplankton: free-floating microscopic animals
Appendix B: BIBLIOGRAPHY

The Maine Coastal Program gratefully acknowledges the following authors and publishers whose works served as reference materials for compilation of *Charting Our Course*.


Minnesota Pollution Control Agency. *Protecting Minnesota's Waters ... The Land-Use Connection.* 1986. (Minnesota Pollution Control Agency, 520 Lafayette Road, St. Paul, MN 55155).


Appendix C: FOR FURTHER READING


Bennet, Dean B.; Peter Corcoran; and Gail Shelton. Science and Natural History: A Maine Studies Sourcebook—Ecological Science Topics (Volumes 1-4). Camden, ME: Down East Books, 1986. An excellent, comprehensive (350-page) curriculum guide with units on the Gulf of Maine; rivers and streams; lakes and ponds; salt marshes; coastal shorelands and estuaries; and other habitats. Available on loan from the Teacher's Resource Center at Maine Audubon (see Appendix D) or for sale from Down East Books.


Miller Christina and Louise A. Berry. Coastal Rescue: Preserving Our Seashores. NY: MacMillan Publishing Co., 1989. This book written for young (intermediate) readers, outlines some of the problems facing coastal areas; action being undertaken to protect our shores; and actions that young people can take.

Miller, Dorcas S. The Maine Coast—A Nature Lover's Guide. Charlotte, NC: East Woods Press, 1979. Section I introduces the reader to coastal ecosystems and their plant/animal communities. Section II describes over 80 areas of interest open to the public.


O'Hara, Kathy et al. Citizen's Guide to Plastics in the Ocean: More than a Litter Problem. (Center for Marine Conservation, 1725 DeSales Street, NW, Washington, DC 20036). This 130-page booklet discusses the types and sources of plastic debris; its impact on wildlife and coastal economies; and the citizen's role in addressing the issue. Available for $2 from the Center.
PART 3: RESOURCES


Teal, John and Mildred Teal. The Life and Death of A Salt Marsh. NY: Random House, Inc., 1969. An account of how salt marshes develop, sustain species, and contribute to (or are exploited by) human communities.


Appendix D: EDUCATIONAL RESOURCES

Codes:
A—Audio-visual materials
C—Curriculum materials
E—Annual Coastal/Marine Events
I—In-school programs
O—On-site/field programs
R—Resource Listings
T—Teacher Workshops

I, O  Chewonki Foundation, RR 2, Box 1200, Wiscasset, ME 04578. 882-7323. contact: Michael Heath, Don Hudson. Five-day residential environmental education programs on the coast; outreach programs for schools on marine mammals and other topics; and a Maine Coast Semester for gifted eleventh graders.

E  Coastweek: Maine Coastal Program, Station 38, Augusta, ME 04333. 289-3261. contact: Coastweek Coordinator. A week of educational and recreational events held each fall to celebrate Maine's coastal resources.

I, O  College of the Atlantic Natural History Museum, Bar Harbor, ME 04609. 288-5015. contact: Fielding Norton. "‘Whales on Wheels’,”“Naugehyde Whale,” and other educational outreach programs.

A  Fishermen’s Library, Department of Marine Resources Laboratory, West Boothbay Harbor, ME 04575. 633-5572. contact: Pamela Shephard-Lupo. Videos on coastal marine topics available for 2-week loan.


R, T  Gulf of Maine Marine Educator’s Association, PO Box 2652, South Portland, ME 04106. 799-6234. contact: Jeff Sandler/Deb Hall-Sandler. A network of individuals and organizations committed to education on the Gulf of Maine. Annual conference, newsletter.


O  Ira C. Darling Marine Research Center, Walpole, ME 04573. 563-3146. contact: Dr. Les Watling.

E  Lake Week, Maine Department of Environmental Protection, Station 17, Augusta, ME 04333. 289-7783. contact: Barbara Welch. An annual week held in July celebrating our lake resources with educational and recreational events.
C, I, O Maine Aquarium, Route One, Box 859, Saco, ME 04072. 284-4512. Educational programs at aquarium; outreach to nursing homes and hospitals.

C, O, T Maine Audubon Environmental Education Department, 118 US Route One, Falmouth, ME 04015. contact: Maureen Oates, Carey Hotaling. Natural History Programs at Scarborough Marsh, Mast Landing Sanctuary (Freeport); Gilsland Farm (Falmouth) and Orono; a Teacher’s Resource Library where materials can be borrowed in person or by mail; School Science and Natural History Enrichment Project (workshops for teachers to focus science curriculum on Maine’s environment).

C Maine Coast Heritage Trust, 167 Park Row, Brunswick, ME 04011. 729-7366. Land-use planning curriculum.


A Maine Coastal Program/Maine State Library—Special Services Division, Station 64, Augusta, ME 04333. 289-5650. Eleven videos on coastal/marine topics available for 2-week loan.

C, I, T Maine Department of Marine Resources, Marine Education Division, Station 21, Augusta, ME 04333. 289-2291. contact: Lorraine Stubbs. Free in-school programs; teacher workshops at numerous locations; Saltwater News marine education newsletter.

R, T Maine Environmental Education Association, PO Box 9, Wiscasset, ME 04578. 781-2330. contact: Carey Hotaling. A network of people and organizations involved in environmental education; spring conference; newsletter.

R, T Maine Island Schools Project, Island Institute, 60 Ocean Street, Rockland, ME 04841. 594-9209. contact: Julie Ann Canniff. Conferences and resources available for year-round island schools.

I, T Maine Maritime Academy, Operation Sea Specimen, Castine, ME 04421. 326-4311. contact: Dr. John Barlow.

A, R Maine State Library/Information Exchange, Station 64, Augusta, ME 04333. 289-5620 or 1-800-322-8899 (in Maine). Data base with resource information about educational programs, projects, services, and instructional materials—provided by subject matter as requested.

I, T Mr/Mrs Fish Marine Education Programs, Southern Maine Vocational Technical Institute, South Portland, ME 04106. 799-6234.

O, T Nature Walks Unlimited, PO Box 17731 CCP, Portland, ME 04101. 774-2441. contact: Cynthia Krum.
Northeast Marine Education Project (formerly the Northern New England-Marine Education Project), College of Education, Shibbles Hall, University of Maine, Orono, ME 04469. 581-2434. contact: Michael Brody.

Office of Waste Reduction and Recycling, Department of Economic and Community Development, Station 130, Augusta, ME 04333. 289-6800. contact: B.J. Jones.

Project Wild, Maine Department of Inland Fisheries and Wildlife, Station 41, Augusta, ME 04333. 289-3303. contact: Lisa Kane. Teacher-training workshops using Project Wild scheduled to begin in the Fall of 1989.


Univeristy of Maine Sea Grant Office, 30 Coburn Hall, Orono, ME 04469. 581-1440. contact: Kathleen Lignell or Susan White. Coastal/marine videos for sale and assorted free publications available.

University of New Hamphsire Sea Grant Advisory Program, NEC Administration Building, University of New Hampshire, Durham, NH 03824. 603/862-3460. contact: Sharon Meeker or Julia Steed Mawson. Marine Docent Program; instructional materials; and teacher workshops at Odiome State Park.

Wells National Estuarine Research Reserve, PO Box 1559, Wells, ME 04090. 646-1555.

West Quoddy Biological Research Station, PO Box 9, Lubec, ME 04652. 733-8895. contact: Robin Moloff-Gautier.
Appendix E: STATE AGENCIES INVOLVED IN WORK RELATED TO THE GULF OF MAINE

Maine Coastal Program
Maine State Planning Office
State House Station 38
Augusta, ME 04333
207/289-3261
contact: Flis Schauffler, communications coordinator

Responsibilities:
• participates in a multilateral Gulf of Maine policy initiative developing a Canadian-American Action Plan for resource management in the Gulf;
• provides technical and land-use planning for coastal towns;
• provides public education resources on coastal issues (including a travelling display on the Gulf of Maine); and
• coordinates Maine’s annual Coastweek celebration and the Gulf of Maine Coastal Cleanup (held in September).

Department of Conservation
State House Station 22
Augusta, ME 04333
207/289-4900
contact: Marshall Wiebe, public information

Responsibilities:
• manages coastal state parks and boat access sites;
• manages state-owned submerged lands and planning/zoning on islands that are unorganized territories;
• maintains the Coastal Island Registry and administers the Island Recreation Program; and
• investigates and maps marine geology.

Department of Environmental Protection
State House Station 17
Augusta, ME 04333
207/289-7688
contact: Sally Fitch, public information
Responsibilities:

- administers regulations affecting coastal wetlands; sand dunes; overboard discharge systems; oil pollution and site location approval for major developments.
- publishes citizen’s guides and pamphlets that are available free to the public.

**Department of Inland Fisheries and Wildlife**

State House Station 41  
Augusta, ME 04333  
207/289-3303  
contact: Lisa Kane, natural science educator

Responsibilities:

- works on species recovery work on threatened and endangered species;
- identifies and manages significant habitats; and
- administers *Project Wild* for Maine (see Appendix C).

**Department of Marine Resources**

State House Station 22  
Augusta, ME 04333  
207/289-2291  
contact: Lorraine Stubbs, marine educator

Responsibilities:

- provides teacher workshops, curriculum materials, and resources in marine education;
- conducts marine monitoring;
- administers regulations governing the fishing industry; and
- conducts basic research on marine organisms and fishing methods.

**University of Maine Center for Marine Studies/Sea Grant Office**

30 Coburn Hall, University of Maine at Orono  
Orono, Maine 04469  
207/581-1440  
contact: Kathleen Lignell or Susan White

Responsibilities:

- Conducts research on fisheries management, changes in the coastal environment, and industrial and commercial development.
Appendix F: SOURCES FOR MAPS OF THE GULF REGION

DeLorme Publications Catalog: Lists maps and field guides, many of which highlight significant natural features and landmarks. Available from DeLorme Publishing Company, PO Box 298 CT, Freeport, ME 04032.

Navigational Maps: appear in Spencer Apollonio's book The Gulf of Maine (available through your local library or for sale from Courier of Maine Books, 1 Park Drive, Rockland, ME 04841).

U.S. Geological Survey Topographical Maps (and maps by other state and federal agencies) are available in most major town or university libraries or by contacting:

National Cartographic Information Center
507 National Center
Reston, VA 22092
1-800-USA-MAPS
Appendix G: Evaluation Form

Maine Coastal Program, State Planning Office, Station 38, Augusta, ME 04333, 207-289-3261

Please complete the following evaluation and return it to the Maine Coastal Program.

1. Subject of class in which curriculum was used:
   _____ social studies _____ science _____ other (please specify: __________________)

2. Grade level(s) of class(es): ____________

3. How did you hear about the Charting Our Course curriculum?
   _____ newsletter (please specify name: _____________________)
   _____ school library
   _____ another teacher
   _____ received a copy unsolicited in mail
   _____ notice in newspaper (please specify name: _________________)
   _____ other (please specify: _______________________________)

Please questions 4–8 by circling the numbers to the right of each question.

To What Extent Did This Curriculum Guide:

4. Accomplish its stated goals (see Introduction)? 1 2 3 4 5 6 7 8

5. Motivate you to discuss the Gulf of Maine in your classroom and try guide activities? 1 2 3 4 5 6 7 8

6. Heighten your understanding of the Gulf and your ability to convey that information? 1 2 3 4 5 6 7 8

7. Interest and involve your students in coastal issues? 1 2 3 4 5 6 7 8

8. Provide you with further ideas and resources for ongoing marine education efforts? 1 2 3 4 5 6 7 8

9. How could the curriculum guide be improved? What did and didn’t you like about its content and format? Were there any factual errors or statements open to misinterpretation?

10. Other comments?

[Optional]
Name:
School Address:
Work phone number:
Would you like to be placed on the Maine Coastal Program’s mailing list for educators? ______