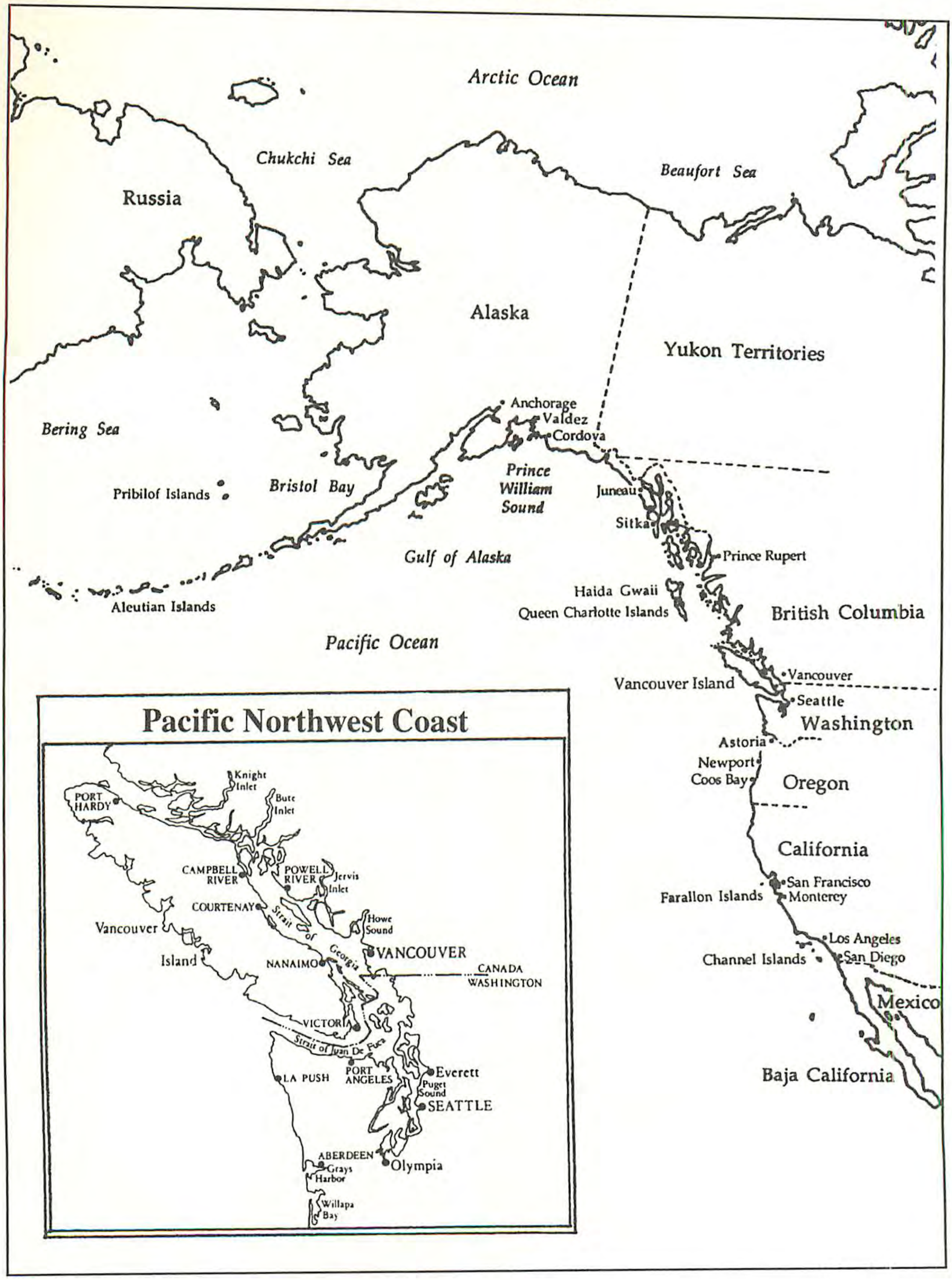
Beach Explorations
A Curriculum for Grades 5–10

by Gloria Snively

West Coast of North America



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Contents continued

Introduction

Seashores are special places where nature touches us and lets us glimpse the diverse life of the sea. Life is everywhere—on rocks, under rocks, in tidal pools, in the sand or mud, among the massive curtains of seaweeds, in eelgrass beds, and in sea caves.

In nature, interesting things often occur at the edge. An edge is like a line separating two places, a thin zone sharing qualities of two places, but unique in itself. It is well known to biologists that the number of species of plants and animals present is often greater at an environmental boundary. At these environmental boundaries, where the land meets the sea, where fresh water meets salt water, where air meets a water-filled environment, we can find species that occur on either side of the boundary plus some species that are found only in the transition zone. Biologists call this phenomenon the "edge effect."

The ocean's edge is an exciting place—a place of life and death, full of drama. Never before has our awareness of the oceans and its seashores been so widespread, and never before has there been the knowledge that much of this life is threatened or has been lost.

Through my experiences teaching elementary and junior high school students; teaching science and environmental education studies at universities; working with park naturalists; camping or talking with divers, fishermen, and families enjoying the beach at low tide, I have become aware of the tremendous interest and desire of teachers, students, and students to know about what they are seeing and how they can help preserve the seashore and all its living creatures.

Rocky shores, sandy beaches, mud flats, and estuaries are places to experience the sights, smells, textures, and sounds of the sea. They are places where classes can conduct scientific observations and investigations, and where artists, poets, musicians, and mathematicians can bring yet other dimensions to our experiences.

But seashores are fragile, and many shores are too small for the numbers of people who wish to visit them. To preserve them we must learn rules—etiquette, if you will—for our visits to the sea's edge. We must learn how to walk carefully, how to properly handle marine organisms, when not to touch them, and how to best investigate a beach without destroying it.

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Marine plants and animals are magnificently adapted to survive the harsh conditions of the intertidal, the rise and fall of the tides, the rainfall that dilutes the salinity, and at times the hot sun that dries away the moisture. But seashore organisms are not adapted to feet encased in gumboots, shovels or chisels that pry them from the rocks, or probing fingers that overturn or otherwise destroy their homes. So it's up to us to be careful and protect the plants and animals on the beaches.

This curriculum is written to help teachers and students to understand the world at the edge of the sea. What is often most remembered in life is the experiences that one has at the edge.

Preface

In thinking back over our school years, doesn't each of us remember with pleasure the discoveries we made in natural environments; the seashore, forest, woodlot, pond, and stream? Aren't these memories, in fact, often the brightest of our recollections?

Most young students come to school curious and alert, easily stimulated, eager to learn about the plants and animals and the world in which they live. One of the principal purposes of the elementary school is to keep this curiosity and interest alive by providing ample opportunities to investigate living organisms firsthand.

This resource book was written to help the elementary teacher plan and organize field trips to the seashore. The guide assumes that the teacher may not have a background in biology, and therefore provides background information about the natural history of organisms and habitats. It also assumes that the teacher has had little or no previous experience conducting field trips to the seashore. The book attempts to help the teacher plan and organize field trips, read tide tables, conduct inquiries with living organisms both at the seashore and in the classroom, and if desired, use microscopes, collect microscopic plankton, and set up a saltwater aquarium.

This book includes lessons on topics ranging from the tidal cycle that influence seashore communities, to the pattern of distribution of plants and animals on the shore, to the ways they got there. It includes sections on plankton and how organisms are adapted to survive in particular habitats. It includes studies of rocky shores, sandy beaches, cobble beaches, mud flats, and estuaries.

In writing the book, I have referred to Pacific Coast organisms as examples. This may seem obvious, for how can one write a book with the hope that it has local appeal without emphasizing local organisms? It became evident early in the writing, however, that most of the key concepts and methods of data collection could be applied generally; for example, protected rocky shores on the Pacific Coast as well as protected rocky shores on the Atlantic Coast.

This curriculum uses the seashore as a source of inspiration and a catalyst for exploration and discovery. It assumes that the integration of subjects provides a more relevant learning experience. I decided to emphasize marine science concepts and science process skills because many elementary teachers are "language arts experts," perhaps lacking knowledge of marine science concepts and inquiry skills. Hence, the subject areas provide a variety of ways to enrich the students' understanding of marine science concepts and skills; for example, the use of drawing, counting, estimating, and graphing populations of organisms on a shore; and the use of speaking, listening, and writing to interview a fisherman or fisheries officer and write a newspaper article on how people use the sea.

Beach Explorations does not pretend to be a definitive work on marine science or a 5–10 curriculum, with clearly defined concepts relating to each grade level. It was written as a resource book for teachers, park naturalists, scout leaders...anyone who has marveled at a tidepool teeming with life and wanted to share their love of nature with students.

Design and Use of the Materials

The lessons and activities in *Beach Explorations* are designed for use by teachers located in close proximity to the seashore, as well as by those hard-working and dedicated inland teachers able to organize long-distance field trips and overnight camp experiences to coastal areas. The materials have been specially designed to accommodate teachers with a range of background knowledge and experiences with seashore field trips.

Design and Organization

Beach Explorations provides teachers with a rational, conceptual framework, and teaching strategies for each activity. Lessons include key concepts, understandings, materials, background information, teaching procedures, questions for discussion, and enrichment activities.

Scope and Sequence: Grades 5–10

Designed for the middle and junior high school program, the curriculum is expected to involve the students for approximately four to six weeks. The materials were field-tested by teachers and students, and are intended as a starting point for learning. You're encouraged to use the chapters and lessons that best fit your type of seashore (rocky, sandy, muddy, estuary); time constraints, the logistics of your field trip opportunities, and personal interests.

Key Concepts

The key concepts serve as the conceptual basis for each lesson. They focus on basic marine ecology concepts such as organism, life cycle, tidal cycle, habitat, predator-prey, food chain, adaptation, zonation, type of seashore, pollution, and stewardship. The activities are designed to correspond to one or more key concepts.

Understandings

This section states the objectives of each lesson. It includes the inquiry skills used to study a given topic. It's expected that you'll guide students in developing their skills of inquiry while developing an understanding of basic ecology concepts.

Teacher Information

Each lesson provides useful information for the teacher: definitions, examples of key concepts, and discussions related to the key concepts and topics of the lesson. Some points are central to the success of the lesson; other points are useful background information for the teacher. Teachers are not prescribed to teach all the information. Instead, they are provided information to consider as informed and responsible instructors. In every case, the teacher is encouraged to adapt the information for different groups, subjects, groups sizes, field trip opportunities, and logistics of classroom situations.

The Science Inquiry Skills

The science process skills are introduced and developed within most lessons. At the primary level, these skills include observing, comparing, questioning, inferring, classifying, and to some extent, measuring and recording. At the intermediate grades, more emphasis is placed on measuring and recording, as well as building models, hypothesizing, controlling variables, and interpreting data.

Field-Based Learning Cycles

It's hoped that teachers will organize at least one field trip to the seashore, and more trips are encouraged. The field trips will enrich the students' appreciation and their understandings of seashore life by allowing firsthand observation of living organisms and the seashore. Teachers are provided detailed information on how to plan and organize a field trip, and how to organize learning cycles complete with advance organizers, on-site activities, and classroom follow-up activities.

Inquiries with Living Organisms

Seashore animals are fun to investigate with kids because they stimulate immediate fascination. Animals are not fully predictable, no matter how long you study them. Seashore animals lend themselves to inquiry. Their small size is convenient for study, yet they're large enough to observe easily. Many activities are designed for use at the seashore, observing animals in tidal pools or in baggies filled with seawater, and observing shorebirds with binoculars. Other activities are designed for use in the classroom with hand lenses or microscopes. Teachers are provided detailed information on the care and handling of microscopes, and how to use microscopes with children. It's hoped that teachers will learn how to take plankton samples, and use microscopes to observe the fascinating behavior of animal plankton.

Black Line Masters/Transparencies

Most chapters come with black-line masters which can be made into transparencies or activity sheets for student use. The transparencies are designed to provide teachers and students with illustrative materials to enhance their understanding of the concepts and organisms under investigation. For example, there are transparencies illustrating both plant and animal plankton, zonation on a shore, and adaptations of surf-swept rocky shore organisms. Teachers can also duplicate class sets of transparencies for students.

Indoors or Outdoors

Although most activities can be conducted outdoors, some activities can be conducted both indoors and outdoors, and others can in conducted indoors only. In many instances, it's hoped that teachers will introduce many of the key concepts and teach specific skills in the classroom, prior to the actual field trip.

Illustrated Glossary

Scientific terms and concepts used in the curriculum are defined in the glossary of the teacher's guide. The definitions pertain only to the use of these terms in the classroom; they aren't intended to be exhaustive. The glossary is included as an aid to teachers. Only selected terms and concepts should to be taught to the children.

Appendix

The Appendix includes the glossary of terms, a complete conceptual structure, information on how to make a plankton net, ordering sources for supplies and field guides, and metric and U.S. measurements.

Evaluation

There are three types of evaluation—before, during, and after study. The first is informal and assesses the students' prior experiences with, attitudes toward, and knowledge about the seashore and seashore organisms. It consists of brainstorming what students know and what they want to know, as well as concept mapping. The second is ongoing and consists of a wide range of simple evaluative instruments for assessing the students' understanding—check lists, writing activities, keeping a field notebook, sketching the details of organisms, group discussions, and activity sheets. The third is more formal and is given after the study is completed to assess the students' understanding of the major concepts and process skills. The black line masters can be used as evaluative instruments during and after instruction. For example, the "Tidal Pool" transparency can be used as an identification sheet; the "Habitat Data Sheet" can be used to count and map organisms in specific habitats; and the "Zonation on a Rocky Shore" transparency can be used to identify organisms in the spray zone, high tide zone, middle tide zone, and low tide zone, and infer how organisms survive in each zone.

Pacific Coast Information Cards

The information cards are designed to provide students with background information about the common—and not-so-common—marine plants and animals that live on our coast. Each of the cards includes an illustration of the organism on the front side and important information on the back side; e.g., the organism's Common Name, Latin Name, Phylum, Range, Type of Shore, Habitat, Food Relationships, Commercial Value, and Population Status.

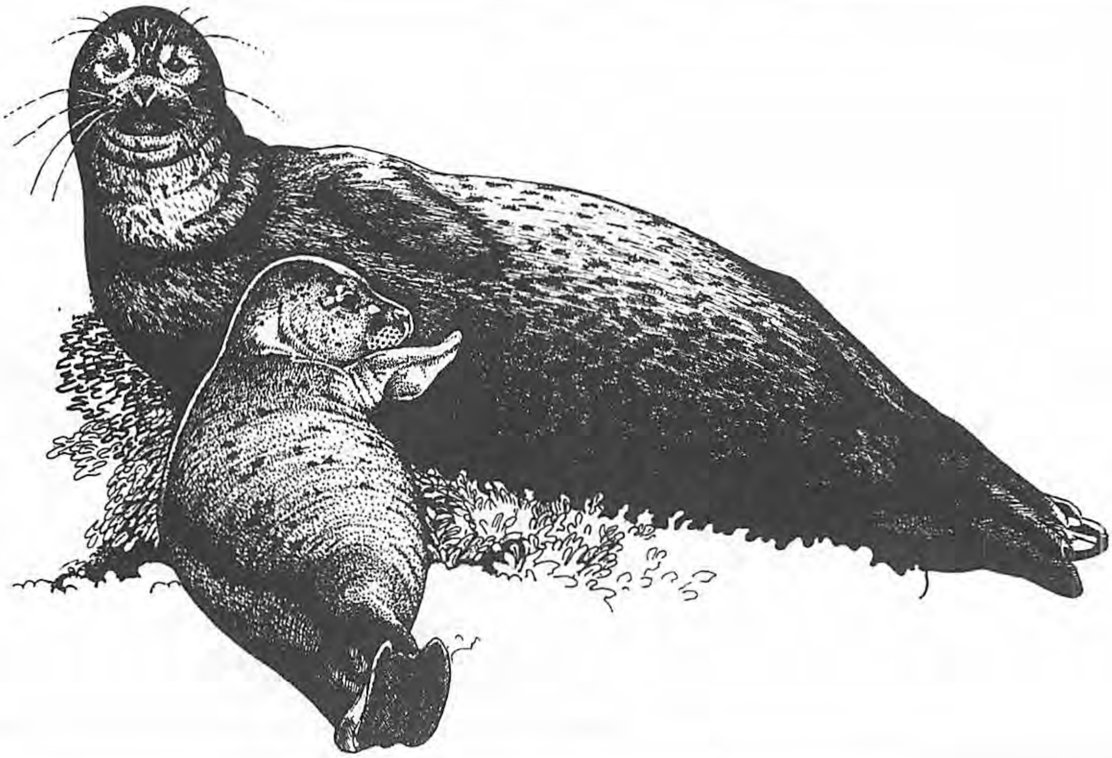
The Teacher's Guide includes activities that employ the Pacific Coast Information Cards to teach process skills and marine science concepts. For example, when teaching classification, the students read the information on the backside of the cards to identify organisms then sort cards into groups according to the appropriate classification. When teaching food relationships, the students can read the information on the back side and then use the cards to construct predator-prey relationships, food chains, and food webs. When teaching protection types, the students can use the information to draw sketches that camouflage specific organisms in a kelp forest, sandy beach, or rocky shore environment. Students can also use the cards to gain knowledge about the commercial value of organisms, harvesting methods, and how indigenous peoples may have utilized the organism for food, shelter, and clothing.

Teacher's Note

Because the Pacific Coast Information Cards can be used in a great variety of ways to enrich learning, and because students may want to work individually and in small groups, many teachers need several sets of cards. Teachers are encouraged to photocopy four or five complete sets—each set a different color. The variously colored sets enable teachers and students to more easily collect, keep track of, and store complete sets.

Sample Pacific Coast Information Card

Harbor Seal



Information

Common Name:	Harbor Seal
Latin Name:	*Phoca vitulina*
Range:	On the West Coast, the range of the Harbor Seal extends from the southern Arctic from Yukon and N. Alaska south to Mexico.
Habitat:	The Harbor Seal lives along all types of coastal waters, including the mouths of rivers. This seal is easily accustomed to human presence and frequently can be seen basking or resting around boat docks and commercial harbors.
Quick Identification:	Harbor Seals vary in color, from black to white with shades of bluish gray. Most have spots or mottled patches on their back. Unlike a sea lion, its front flippers are too short to prop up its body.
Predators:	The Harbor Seal is consumed by sharks and Killer Whales. It continues to be an important part of the diet of many indigenous peoples in Alaska and British Columbia.
Feeding Type:	The Harbor Seal is a predator that feeds almost exclusively on fish. Its diet includes sculpins, herring, salmon, squid, and whatever else is available. It feeds when the tide comes in, and travels great distances up rivers with the tide.
Commercial Value:	The Harbor Seal has little commercial value, except for the seal's coat which is often used in native handicrafts.
Status:	Common. Since they became protected in 1970 by the Canadian Fisheries Act, and in the U.S. by the Marine Mammal Protection Act, their numbers have increased by about 7–12% a year through the early '90s. The growth rate now appears to be slowing.

Overview of Each Chapter

Chapter 1: Planning and Organizing Field Trips

In this first chapter, teachers are given general information on planning and organizing field trips—how to pick a site; plan for clothing, supplies, and equipment; teach safety and conservation; and plan field-based learning cycles.

Chapter 2: Exploring Seashores with Students

This key chapter introduces students to common seashore organisms, tidal pools, the tidal cycle, and how organisms survive the changing tides. Students observe seashore animals firsthand, measure tidal changes, and infer how organisms survive life at the seashore during high tide and low tide.

The major factors that influence the intertidal are stressed: the tides; the type of shore (rocky shore, sandy beach, mud flat, estuary); the type of habitat (on rocks, under rocks, in tidal pools, in sand or mud); and whether a seashore is exposed to beating surf or protected by islands and bays. Students learn how to identify the type of seashore nearest the school, and to map and build models of seashores.

Students come to understand that seashores are fragile and they must learn the careful handling of organisms prior to their trip to the sea's edge.

Chapter 3: Plankton Soup: Microscopic Life of the Ocean

In this chapter students learn about the most abundant organisms in the ocean: the microscopic plankton. Known as "wanderers," they are tiny plants and animals that drift with the ocean currents. Students learn to collect, draw, and identify both plant and animal plankton. Gradually, students come to understand that seashore organisms have their own life cycles, and that certain marine animals such as barnacles and clams actively pass seawater through filtering devices to trap planktonic food.

Chapter 4: Food Relationships

Students learn how our coastal waters produce a rich harvest of food year-round, and how predators, scavengers, grazers, and filter feeders obtain their food. They learn how to construct food chains and food webs.

Chapter 5: Science Inquiries with Seashore Animals

In this chapter, students have several exploratory activities with living organisms. The chapter dwells on developing the science process skills of observing, predicting, inferring, measuring and recording, etc. In the process of discovery, students develop some understanding of living things, how organisms sense their environment, have attachment devices or locomotion, protect themselves from predators, and keep from drying out when the tide goes out.

Chapter 6: Rocky Shores

This chapter provides students with studies that show the great variation of rocky shores, from steep cliffs to almost flat platforms. The chapter examines zonation (spray zone, high tide zone, middle tide zone, low tide zone), and how seashore organisms are adapted to survive the living conditions of the rocky shore at each tide level. Students learn how to map, conduct transect studies, identify populations in each tide zone, and infer the factors that limit the distribution of organisms on a shore.

Chapter 7: The Cobblestone Beach

The cobble beaches protected by inlets and islands have little wave action, and are very different from those of the outer coast. This chapter examines how organisms are adapted to survive beneath the cobbles and boulders, and in the mix of loose sand, mud, and gravel under the cobbles.

Chapter 8: Sandy Beaches

The sandy shore, in contrast to the rocky shore, appears barren of life. But life does exist here. Most of the organisms, however, live beneath the surface. Students learn how sandy beach animals have adapted to the harsh conditions that accompany the changing water levels. This chapter describes some of these organisms and their adaptations.

Chapter 9: Saltwater Wetlands

The estuaries, salt marshes, and mud flats together make up one of the most productive of all ecosystems. They contain an abundant and diverse community of organisms. They also provide a nursery for many other marine and freshwater organisms. Students are introduced to some of the common organisms, and how organisms are adapted to specific environmental conditions. They develop techniques for studying how freshwater flooding and tidal cycles can cause wide changes in salinity, oxygen, and temperature.

How the Understandings are Established

The following examples show how the inquiry skills are used to study each topic. The understandings should be modified to meet the needs of a given group of students, and the field trip possibilities for each teacher.

First-Level Understandings

Recalling

What happened? What do we know? Recall what the beach was like, what organisms we saw, what the scuba diver said, what the weather was like? Was the seashore rocky, sandy, cobble, muddy, or a combination?

Observing

What did we see? Hear? Smell? Touch? Taste? and Find? What did we notice during our field trip to the seashore? What did we notice about tidal pools? Rock crevices? The on-rock and under-rock habitats? What did we notice about the behavior of Purple Shore Crabs, sea stars, barnacles, and gulls? What did we notice about the harbor front?

Defining

What does this mean? Can we define it in our own words? Can we use dictionaries, glossaries, scale and distance, legends, symbols to represent organisms? Can we define "habitat," "food chain," "pollution," the difference between a sandy beach and mud flat? Can we define the natural features of the local seashore that make it an ideal location for field trips? Define a position about how people use the sea (i.e., conservationist, exploitative, preservationist).

Comparing and Contrasting

How are they alike? How are they different? Compare and contrast the behavior of snails, barnacles, and gulls at low tide and at high tide. Compare and contrast photographs of the local seashore today, 50 years ago, 100 years ago.

Classifying

Discuss similarities and differences. In which group should this be placed? Sort photographs of seashores into surf-swept and protected; and into rocky, sandy, cobblestone, or muddy. List seashore organisms observed at the seashore and classify according to plant and animal, vertebrate and invertebrate. Classify ideas that result from brainstorming.

Questioning

Why do shore crabs walk sideways? Do all the crabs that live under this cobblestone belong to one family? Are they related?

Why do sea urchins have long, sharp spines? How did not much sand come to be beach? Where does the sand go in the winter? What happened to the native people who used to live here?

Inferring

Why did it happen? Possible causes? What will happen next? Why? Describe what might happen in this experiment with barnacles. Why was a cannery built on the waterfront? Why did it close? Why was a pulp mill built on the waterfront?

Predicting

What might happen next? What might be the effect of the pulp mill on seashore organisms? How will food chains change as seashore animals go through their life cycle? Why? How big will the harbor get?

Interpreting

What does it mean? How does it make you feel? Interpret feelings and values shown in pictures, maps, graphics, books, art work, dramatizations. How does the fisherman, artist, politician, real estate agent feel about the shoreline? The harbor? Interpret how native people traditionally feel about the forest and the sea.

Higher-Level Understandings

Measuring

How big is it? How many? How many times does a barnacle sweep the seawater each minute? Estimate the number of barnacles on a boulder. How many different ways can we measure the change in tide level at the seashore?

Recording

How shall we record our data? Table of numbers? Bar graphs? Line graphs? Graphing populations of organisms in the spray zone, high tide, middle tide, and low tide level. Graphing tide changes, temperature changes, seasonal changes.

Building Models

Constructing papier-mâché organisms, a bulletin board mural of the rocky shore showing the tide zones. Building a clay or papier-mâché model of the bay and field trip site. Building a model of the shoreline today, 50 years ago, 100 years ago.

Evaluating

Evaluating behavior, change, activities, events, proposals, rights, rules, responsibilities, what it means to be a caretaker of the seashore. Use check lists, self evaluations, and group evaluations. Express your opinion on the pollution and changing seashore. Apply rules of proper care and handling of seashore organisms. Evaluate the effect of exploring the seashore on the habitat qualities of seashore organisms. Evaluate the significance of different viewpoints.

Synthesizing

How shall we organize our role-play, newspaper, or mock press release? Synthesize data and key ideas around such concepts as pollution, habitat loss, community needs, and differing viewpoints. Write a newspaper article expressing concern about beach pollution.

Values

Introduce aesthetic awareness and important principles of conduct. Respect seashore plants and animals. Accept personal responsibility for the welfare of seashore environments, and ultimately for the oceans and planet.

How to Use This Resource Guide

There is no need to do all the activities in *Beach Explorations* in order, nor to do all the activities in a particular chapter, nor to do all the chapters. You can pick and choose from the chapters the activities that suit your own location and field trip possibilities. The following easy steps will help you organize your own journey into the out-of-doors:

Step 1. Familiarize yourself with the resource book by reading the table of contents, chapter overview, list of transparencies, and information in the appendix.

Step 2. Read Chapter 1, "Planning and Organizing Field Trips," page 21, which gives teachers general information on planning their seashore unit and organizing their trip to the seashore; choosing a suitable field trip site; how to plan for clothing, supplies, and equipment; safety and conservation; how to plan a field-based learning cycle.

Step 3. Read Chapter 2, "Exploring Seashores with Students," page 43, a key introductory chapter which introduces basic marine science concepts, e.g., the tides; seashore organisms (crabs, sea stars, gulls); types of habitats (tidal pools, crevices, on rocks, under rocks); types of seashores (rocky, sandy, cobblestone, mud flat, estuary); and how organisms survive high tide and low tide; and how to investigate a beach without destroying it.

Step 4. Identify the type of seashore nearest your school. Chapters 6, 7, and 8 are designed for teachers who want more in-depth studies of a particular type of seashore. For example, if the nearest seashore is:

- A rocky shore, go to page 177
- A sandy beach, go to page 235
- An estuary, go to page 252
- A mud flat, go to page 265

Often, comparative studies of two or three types of seashores develop in-depth understandings of how organisms are equipped for life in specific environments. Many teachers incorporate the lesson on rocky shore zonation (page 190), even when unable to take their students to the rocky shore.

Step 5. Making choices. On the other hand, logistics such as transportation, distance, and available time might necessitate that you include only a few more selected lessons. The following chapters include lessons to consider for any grade level:

- Plankton, turn to page 91
- Food relationships, turn to page 119
- Science inquiries with living organisms, turn to page 145

Throughout, it's hoped that teachers will incorporate as many sensory awareness and appreciation activities as possible into their seashore unit. These experiences will inspire an appreciation of the beauty that is in nature, lead toward a refreshed spirit, and develop a reverence for life that recognizes the importance of all living things.

Grades 5–10 Pacific Coast Information Cards

Marine Mammals

Gray whale
Killer Whale
Humpback Whale
Harbor Porpoise
Harbor Seal
California Sea Lion
Walrus
Elephant Seal
Sea Otter
Beluga Whale
Northern Stellers Sea Lion

Fish

Chinook Salmon
Northern Cling Fish
Pacific Herring
Tidepool Sculpin
High Cockscomb Blenny
White Shark
Sand Sole
Pipefish
Garibaldi

Arthropods

Dungeness Crab
Purple Shore Crab
Hairy Hermit Crab
Decorator Crab
Kelp Crab
Alaska King Crab
Mole Crab
Coon-striped Shrimp
Beach Hopper
Rockweed Isopod
Gooseneck Barnacle
Common Acorn Barnacle
California Spiny Lobster
*Pea Crab/Horse Clam

Echinoderms

Purple or Ochre Sea Star
Sunflower Star
Brittle Star
Sand Dollar
Red Sea Urchin
Purple Sea Urchin
Giant Red Sea Cucumber

Cnidaria

*Giant Green Sea Anemone
Aggregate Anemone
Plumose Anemone
Lion's Mane Jellyfish
Moon Jellyfish

Birds

Bald Eagle
Great Blue Heron
Brown Pelican
Glaucus-winged Gull
Western Sandpiper
Black Brant

Mollusks

California Blue Mussel
Edible Blue Mussel
Heart Cockle
Razor Clam
*Horse Clam/Pea Crab
Geoduck Clam
Butter Clam
Checkered Periwinkle
Brown Turban
Wrinkled Whelk
Moon Snail
Purple Olive Snail
Black Chiton
Speckled Limpet
Sea Lemon
Opalescent Nudibranch
Northern Abalone
Red Abalone
Japanese Oyster
*Swimming Scallop/Sponge
Pacific Octopus
Opalescent Squid
*Keyhole Limpet/Scaleworm

Sponges

Encrusting Sponge

Seaweeds

Sea Lettuce
Rockweed
Bull Kelp
Giant Kelp
Eelgrass
Sea Palm

Worms

Sand Worm
Scaleworm
Calcareous Tube Worm
Hairy Gilled Worm

Plankton

Plant Plankton
Animal Plankton
Krill

Lichens

Black lichens

*Animals living together in symbiotic relationships

List of Transparencies

Planning and Organizing Field Trips

Exploring Seashores with Students

Plankton Soup

Food Relationships

Rocky Shores

The Cobble Beach

Sandy Shores

Saltwater Wetlands

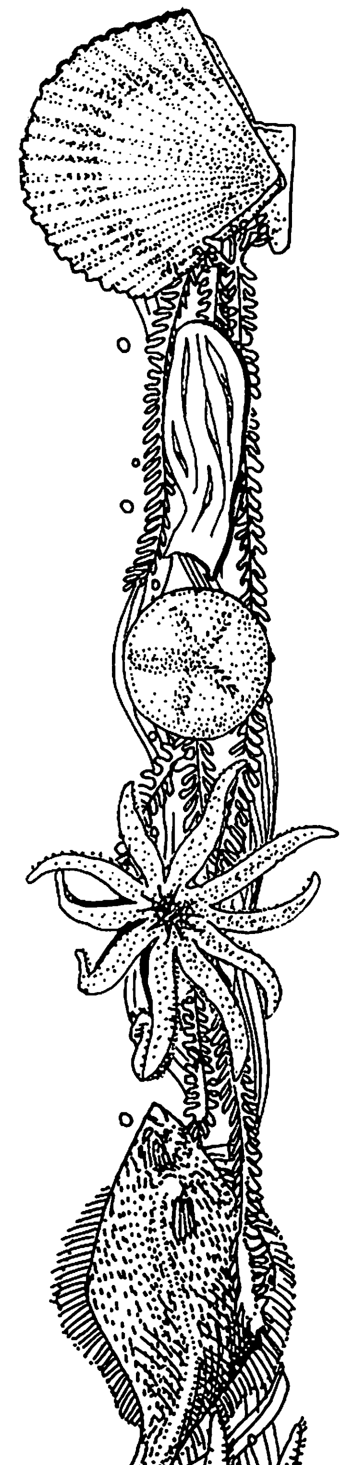
List of Data Collection Sheets

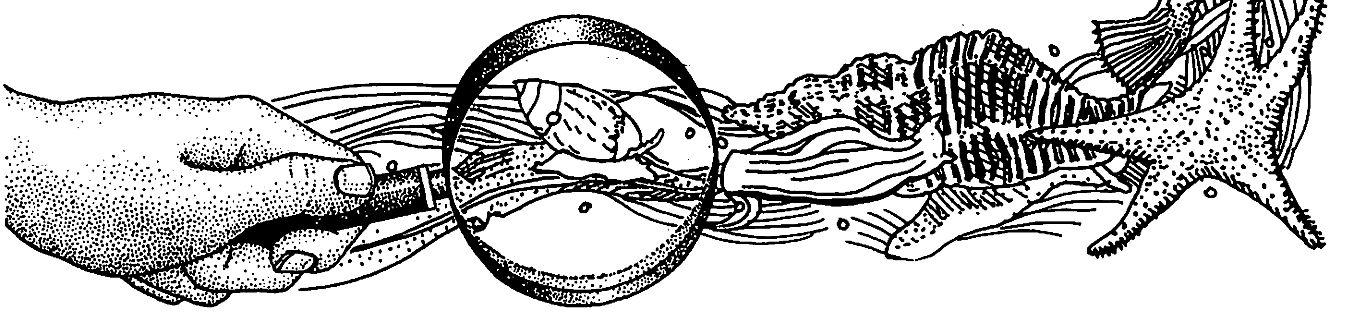
Chapter 1: Planning and Organizing Field Trips

A field trip experience can be the highlight of a student's schooling. At the seashore, students can study those things that are best studied there: water, soil, sunlight, a hermit crab fumbling for a new home, gulls squabbling over food at low tide. Exploring the seashore builds understandings and attitudes that will enrich the whole teaching and learning process. The difference between making your field trip just another fun day outside the classroom and a powerful learning experience in the field rests with how well you prepare yourself and your students. A field trip can be a disaster if logistics, skills, and attitudes aren't properly prepared. You are the biggest factor in determining whether or not an outdoor experience will be successful. Treat the opportunity carefully.

How Many Field trips do I Need to Organize?

To provide firsthand experiences with marine organisms and environments it's assumed that teachers will be able to organize at least one field trip to the seashore. Field trips have been included throughout to encourage those schools located within close proximity to the seashore to include many firsthand experiences with different types of organisms and seashore environments. The irregularity of our coastline creates many different types of seashores: surf-swept sandy beaches, exposed and protected rocky shores, cobblestone beaches, and mud flats, to name but a few. As such, the materials have been designed to accommodate teachers located near specific types of shores. Hence, you will not be able to complete all of the lessons. The chapters and lessons have been organized for use by teachers with a variety of field trip requirements and restrictions. If the type of seashore nearest your school is a protected rocky shore, you'll want to pay special attention to the sections on the protected rocky shore. If there is a mud flat nearest your school, you'll want to consult the sections on mud flats and estuaries.





How Long Should a Field Trip Last?

For your first trip to the seashore, I highly recommend a half-day field trip that includes a 30-minute period of unstructured time and then focuses on two or three activities. Once you gain a little experience with taking students into the out-of-doors, you can take the students on full-day field trips, which allow for more sensory awareness activities that slow the students down and more time to conduct in-depth and time-consuming activities. Even primary students can be perfectly engaged during full-day field trips, provided you plan a variety of hands-on activities, keep the action varied, allow for high-energy snacks, and have fun.

You can take one-day field trips to several different types of beaches—rocky shore, sandy beach, and mud flat—to compare how different organisms live in different marine environments. You can visit the beach at different times of the year to compare the effects of seasonal changes on plants and animals. Or you can visit the same beach several times and explore the area through the eyes of the scientist, poet, artist, or historian. Then, once you're an experienced field-tripper, you can start to plan overnight and week-long adventures.

It is hoped that teachers will learn how to take plankton samples, use microscopes to observe the fascinating behavior of seashore animals, and, if possible, set up a saltwater aquarium. None of these are necessary to creating a successful seashore unit. However, one thing is certain: You must check the tides and plan all field trips well in advance. I am continually surprised to hear of teachers who arrive with their classes at the seashore and find the tide high, and they wonder why. The list below can help you plan your journey:

A Planning Check List

- ☐ Plan and organize your teaching materials
- ☐ Keep a field notebook
- ☐ Choose the site
- ☐ Discuss proper clothing with students and parents
- ☐ Collect and prepare all materials
- ☐ Check the tides
- ☐ Arrange for adult supervision
- ☐ Arrange for transportation
- ☐ Send letters home to parents
- ☐ Discuss safety with students and parents
- ☐ Discuss the care and proper handling of seashore organisms
- ☐ Discuss the care and preservation of seashore habitats
- ☐ Design field-based learning cycles
- ☐ Prepare yourself

On Getting Started

The following list of ideas is meant to help teachers plan and organize their seashore unit. You are the biggest factor in whether or not your seashore unit will be successful. Plan all field trips and activities well ahead.

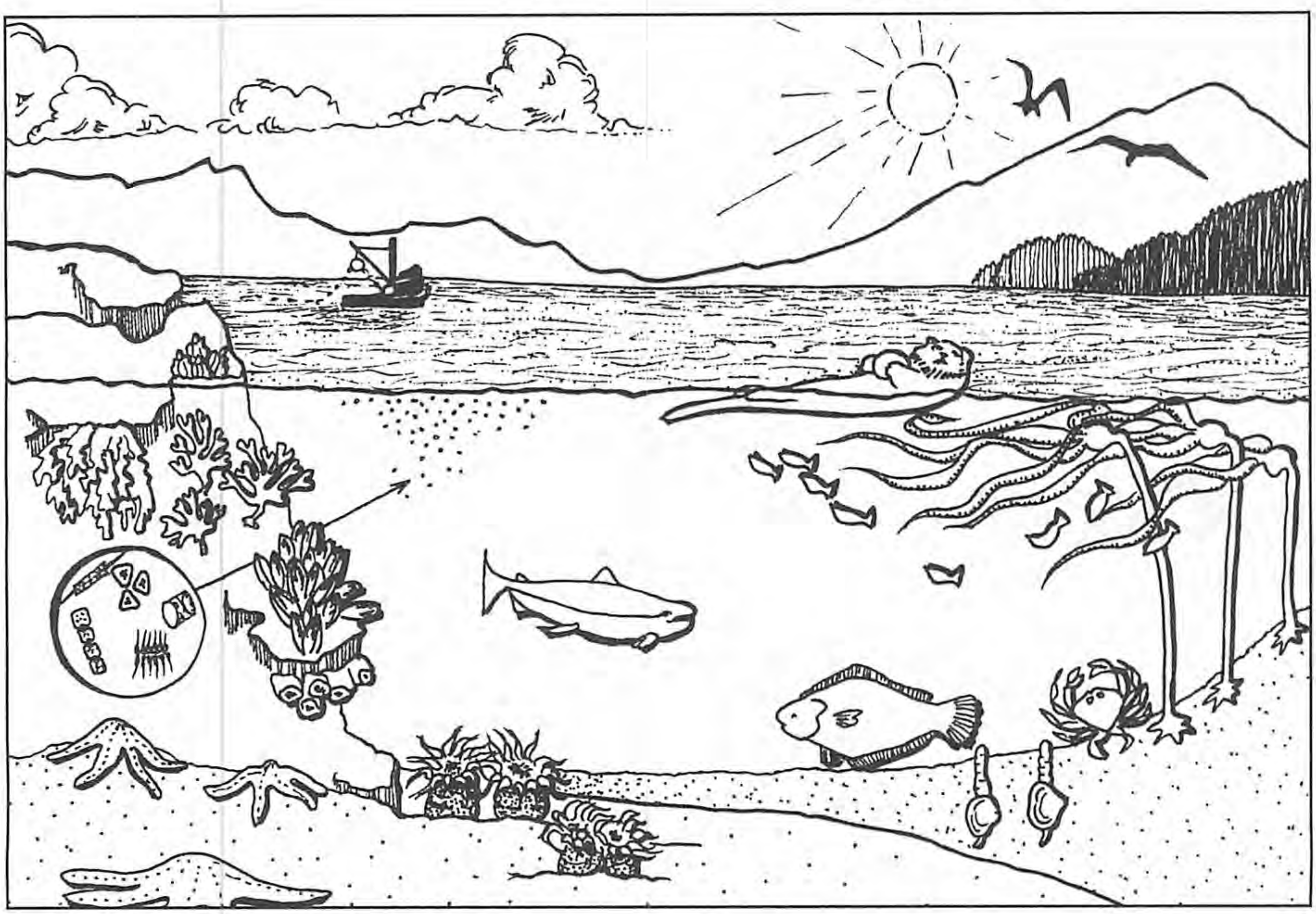
1. Check the tide tables. The months of April, May, and June are best for good low tides and warm weather (see page 30).

2. Ask the school librarian to collect seashore and ocean-related books. Identify local field guides. Set up an Ocean Learning Center. Students can read from the ocean books available in the classroom or in the library.

3. Order marine-related films and resource materials, and local field guides (see page 280).

4. Set up an appropriate bulletin board backing for students to complete and add to as the unit progresses. Cover the bulletin board with blue butcher paper, construction paper, or cellophane. As the students learn about different types of seashores, they can draw, paint, or make paper constructions of marine plants and animals and pin them up in the appropriate environment.

Sample bulletin board



5. Set up a bulletin board for news items related to the ocean and local seashores. Students should look for items on marine animals, marine pollution, marine resources, ocean fisheries, shellfish closures, etc.

6. Ask the students to collect pictures of different types of seashores: exposed and protected shores, rocky shores, sandy beaches, cobblestone beaches, gravel beaches, mud flats, and estuaries. These can be used to stimulate interest, identify types of seashores, and enhance understanding of how organisms survive in different environments.

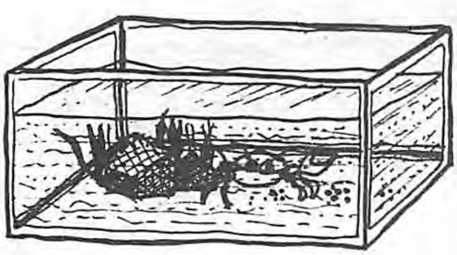
7. Collect pictures of local marine organisms: crabs, sea stars, snails, eagles, kelp. These could be mounted onto construction paper and used in a variety of ways.

8. Collect items from the sea; seashells, crab molts, crab claws, clam shells, mussel shells, oyster shells, dried pieces of seaweed, bird feathers. USE ONLY THE DISCARDED SHELLS OF ANIMALS ALREADY DEAD, AND DO NOT BUY SHELLS AT STORES. Buying shells encourages the killing of local and tropical animals for commercial purposes.

9. Locate, purchase, or make the necessary equipment, e.g., dip nets, plankton nets, collecting jars, etc. (see supplies, page 280).

10. Attempt to locate both compound and stereo microscopes, as well as field microscopes. District resource centers and high schools are frequently good sources of quality microscopes. (See equipment list pages 28-29, and also microscopes on pages 101 and 154.)

11. Purchase steno-pad field notebooks for each student. Use these on all field trips—seashore, forest, pond, city. Students can keep field notes, collect data, draw organisms, keep a log of their travels, write poetry, etc.



12. Identify local resource persons such as fishermen, fish farmers, oyster farmers, marine biologists, fisheries officers, and indigenous people. Many students have an uncle, brother, or father who scuba-dives and might be willing to make a dive during a field trip to collect intertidal and subtidal organisms.

13. Contact public aquariums and local marine and oceanographic research centers. Many have educational programs, field trip opportunities, and resource persons available to schools.

14. If possible, set up a proper saltwater aquarium. (See pages 171–173) Start an Identification Guide to the Seashore. Fold strips of paper in half. Write clues on the outside and answers on the inside, and mount these on a poster beside the aquarium.

Choosing a Site

Be sure you're familiar with the beach you're going to. Never take students to a seashore that you haven't explored carefully. By being familiar with it yourself, you can anticipate what your students will be able to see and do there.

For safety reasons too, it's important that you explore the selected site at high tide and at low tide prior to the field trip day. You'll need to familiarize yourself with the physical layout of the beach, the offshore currents and tidal conditions, and the types of plants and animals that live there.

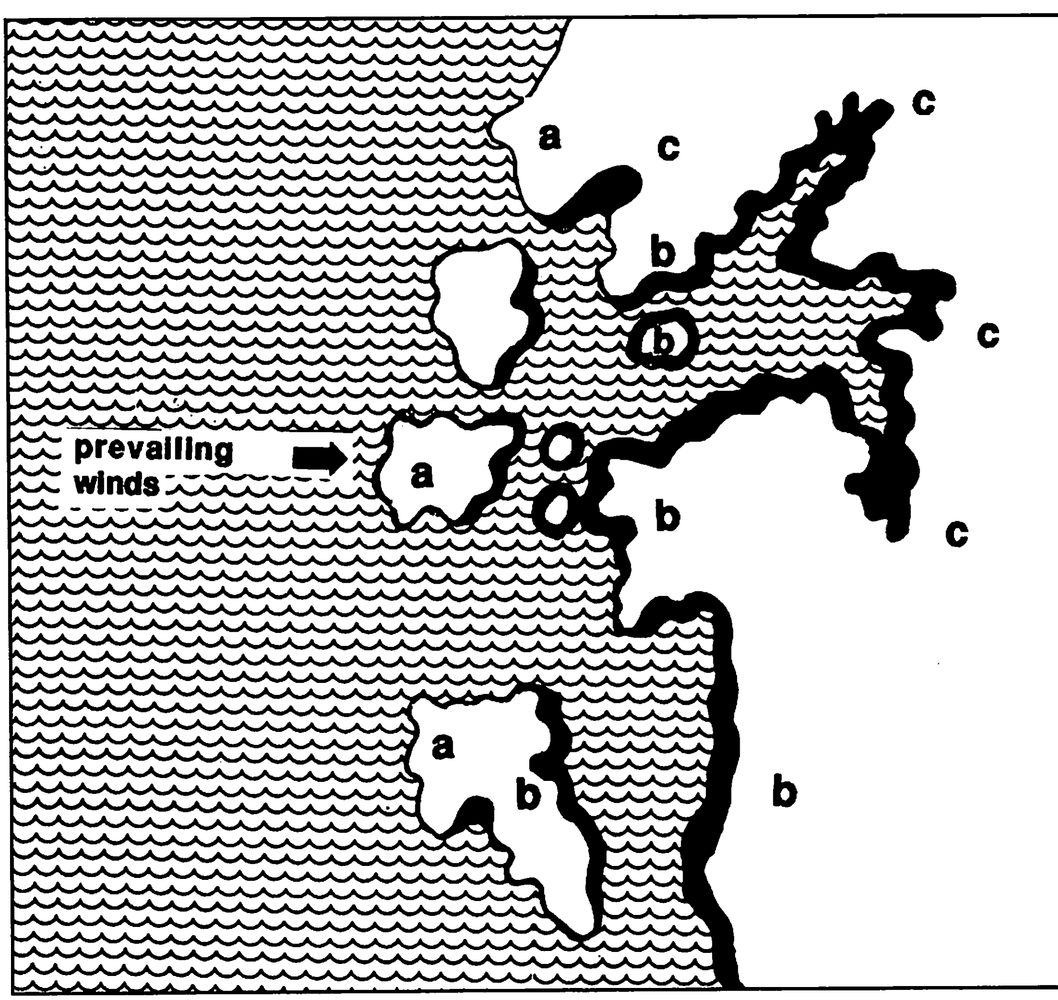
Explore the shoreline to find a site that is protected from high winds and beating waves. Protected shores occur on irregular coastlines where offshore islands shelter coastlines, or where bays and inlets provide shelter from the full force of waves. The shaded areas on the map show where protected shorelines are likely to occur.

Try to find a site that is not overly used. Some beaches have been exploited to the point that they're in serious danger of being destroyed.

Ask yourself the following questions:

- Is there a good spot for conducting tidal pool studies?
- Where is the best place for conducting sensory awareness activities?
- What are the activities that I can best do at this site?
- Are there unsafe areas?

Exposed, transitional, and protected shores:
a. Exposed to full force of beating waves
b. Neither fully protected or exposed
c. Protected by offshore islands, inlets, and bays



Clothing

Proper clothing is an important consideration for the enjoyment and success of seashore activities. Most trips need not be canceled due to poor weather conditions, provided that the participants are properly clothed. At the seashore weather conditions are highly unpredictable; sun, wind, rain, and hail can all occur on the same day. Therefore, it's essential that clothing be both comfortable and functional. Pay attention to the characteristics of different fabrics. Wearing layers of clothes always makes sense—a long-sleeved shirt topped by a sweater or warm jacket and something waterproof. As a general rule, IT'S BETTER TO OVERDRESS THAN TO UNDERDRESS.

The following is provided as a guide to proper clothing:

Rain gear

Emergency rain gear

Rain gear. One of the most important considerations when going to the seashore is how to keep dry. One way to choose the most appropriate gear is to examine what a fisherman wears: good rubber boots with thick soles, woolen socks, a long nylon or rubberized rain coat with a hood or a fisherman's rain hat, and rubberized pants. A variety of synthetic substitutes can be worn, but items such as wind breakers, sweat shirts, and cotton jackets aren't substitutes for waterproof rain gear.

Emergency rain gear. No matter how much you emphasize the importance of proper clothing, there will always be students and assistants who show up poorly dressed. It's a good idea to bring a dozen or so large plastic bags which can be fashioned into makeshift rain coats, hats, and boots. And get clear plastic bags—they also can be used as portable aquariums or as see-through "tents" for individual students to sit under while observing tidal pools or recording in their field notebooks.

Cold weather gear

Hot weather gear

Cold weather gear. Wool retains warmth better than any other material, even when wet. Fishermen often wear woolen sweaters, woolen mittens, woolen hats that cover the ears, woolen pants, and long woolen or thermal underwear. Layer socks for maximum heat retention.

Hot weather gear. On hot, sunny days the reflection off the water can cause severe sunburns and even sun strokes. This is particularly true of students who aren't used to the out-of-doors. On first trips each student should bring a long-sleeved cotton shirt and a cotton hat that can be tucked into a back pocket. Cotton is an excellent material for any trip to the seashore because it can be worn under wool or under rain gear.

Clothing Check List

1-Day Trip

- ☐ Rain coat
- ☐ Rain hat
- ☐ Rubber boots
- ☐ Woolen sweater
- ☐ Long-sleeved cotton shirt
- ☐ Woolen socks
- ☐ Day backpack

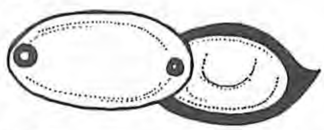
2–3-Day Trip

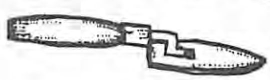
- ☐ Rain coat
- ☐ Rain hat
- ☐ Rubber boots
- ☐ Woolen sweater
- ☐ Long-sleeved cotton shirt
- ☐ Woolen socks
- ☐ 2–3 pairs jeans
- ☐ 2–3 shirts
- ☐ 2–3 pairs socks
- ☐ Long woolen underwear
- ☐ Runners
- ☐ Woolen mittens
- ☐ Swimming suit
- ☐ Day backpack

Make a study of exposure and hypothermia part of your preparation. Help your students learn how to take responsibility for their physical well-being by teaching them what their bodies require.

Supplies and Equipment

In addition to the supplies that each individual student is required to bring, you'll need some extra equipment and supplies for class activities. The equipment list depends on the length and the specific purpose of your trip. As a general rule, travel as lightly as possible. Carrying a backpack is a good idea for students and teachers alike. It leaves your hands free, lets you store away clothes you want to shed or don't need, and is a good place to keep a favorite field guide, a hand lens, plastic baggies, and any snacks you or the students might bring along.





Equipment for Observing Plants and Animals

2 dozen quart-size zip-lock plastic bags

12 plastic pails (ice cream buckets)

Kitchen sieves

6 gallon-size zip-lock plastic bags

6 gallon-size plastic aquariums

1 student's wading pool (new, not used)

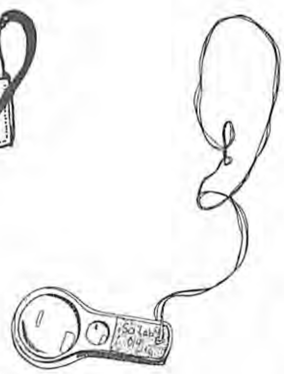
Magnifying lenses with string attached

Magnifying glasses

Field scopes

Binoculars

Face masks



Equipment for Measuring and Recording Data

Compasses

Thermometers

String

Stop watch

Metric ruler or tape

Marker ribbons

Spiral field notebooks (22.5 x 15 cm)
with pencil attached

Tape recorders

Cameras

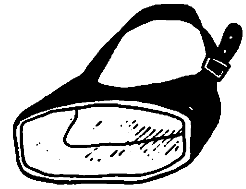
Clipboards with pencils attached

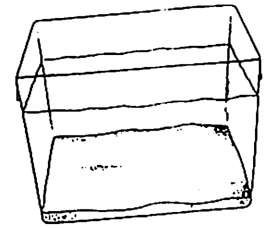
Additional Equipment

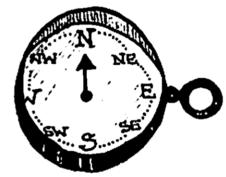
Local field guides
Extra notebooks and pencils
Toilet paper
First aid kit
Sun screen
Water color sets
Pastels
Large sketch pad
Rope or sturdy string
Snack food
Water
Backpack
Large garbage bag
Flashlights for evening beach walks
Life jackets when exploring near deep water, or when transporting students in boats

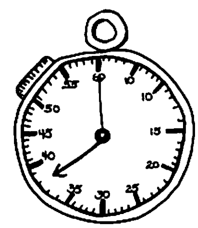
Refuel the Bodies

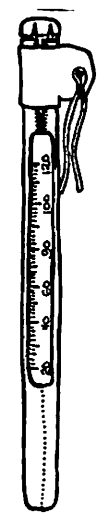
Snack foods such as nuts, sunflower seeds, fruit, water, and hot chocolate

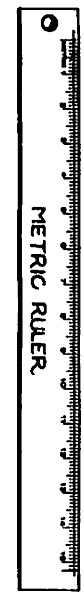


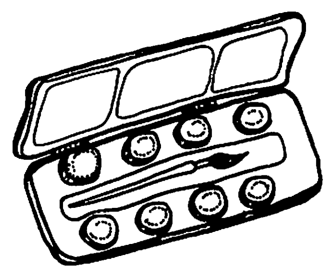


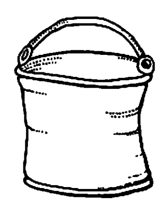


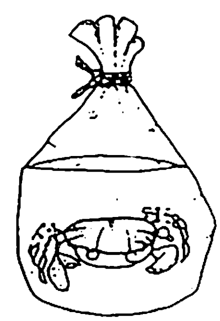












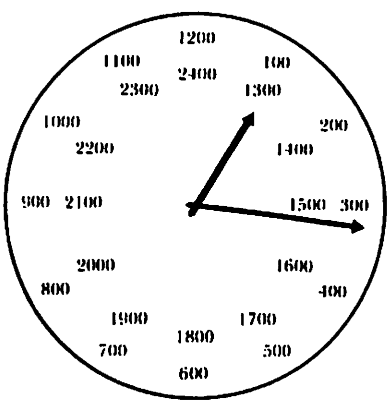
Check the Tides

When scheduling your field trip, be aware of the time of low tide. Plan to arrive at least an hour prior to low tide. The time of very lowest tide should be kept open for observing the zone nearest the water. If possible, activities such as taking a break for lunch or gathering around buckets to discuss and examine particular organisms should occur when the tide is at its highest level. Discuss tide levels and changes with the students. Talk about the need to be aware of the tide level—for example, don't set a pack or bucket next to the water's edge and expect to find it there later.

How to Read a Tide Table

May

Day	Time	Ht./ft.	Ht./m.
25	0120	**10.3**	3.1
	0610	**13.7**	4.2
SA	1315	**1.3**	.4
	2050	**15.6**	4.8



Each region of the world has its own tide tables, most of them drawn up on a 24-hour clock. Regional tide tables are printed each year by the Department of the Environment in Canada. You may acquire a tide table for the appropriate area of Alaska, British Columbia, Washington, Oregon, or California from most marinas and large book stores.

Pretend for a moment that you want to take a trip to the seashore on Saturday, May 25. On the tide table at left, the highest tide of 4.8 meters (15.6 feet) occurs at 2050 (8:50 p.m.) and the lowest of .4 meters (1.3 feet) at 1315 (1:15 p.m.).

On the West Coast, the best tides for observing seashores occur during the daytime in the spring and summer months. The fall and winter have high tides during the day and low tides at night. The ideal tide level for studying intertidal plants and animals is .9 meters (3 feet) or less on Vancouver, B.C. tide tables, and 2.1 meters (6.8 feet) or less on Puget Sound tide tables. Because Canadian and U.S. tide tables are not based on the same system, you must have a local tide table.

Do not, however, rule out fall and winter. Consider mid-tide or high tide, too. Start the day a little earlier. Visit the beach at night with flashlights—a thrilling adventure because many intertidal animals that are inactive during the day search for food at night.

When to Arrive at the Seashore

In the U.S. and Canada, the best daytime tides for observing seashore life occur in the spring and summer months. The fall and winter months bring high daytime tides and low nighttime tides. The ideal tide level for studying seashore life is three feet (1 m) or less. On one-day trips it's a good idea to arrive at the seashore one or two hours before low tide, then follow the tide out.

What about Trips to the Seashore in the Winter Months?

Don't rule out fall and winter studies. Interesting observations can be made at mid-tide or even high tide. You may just have to start your day a little earlier. At visit to the beach at night with flashlights can be a thrilling adventure. Many intertidal animals come out searching for food at night only.

Teach Safety Rules

Just as in the classroom, when you go outside there is a need for some kind of order. Remembering that most of the time students spend outside is unordered, they're free to do as they please; it's helpful to establish some rules that order their behavior for their adventure. When exploring seashores, it's necessary to establish rules for safety and for minimizing damage to seashore organisms and habitats.

Safety Procedures

Before departing for your trip to the seashore, be sure students and parent chaperones understand all safety rules. Brainstorm safety rules with the students. Write their ideas on the blackboard. At the seashore, schedule a familiarization time when you first arrive. Discussion can include: What kind of coastline is this? What kinds of rocks are present? How steep is the beach, the surf condition, currents? What places are safe and unsafe? What are the boundaries? Who is your buddy? The following guidelines will help you choose a safe site and establish proper safety procedures with your assistants.

- Many cliffs are undercut and unstable. Stay back from the edge.
- Cliff trails are slippery in wet weather; don't trust shallow-rooted shrubs on coastal cliffs for climbing support.
- Be alert at all times for extra high waves. They come unexpectedly and they can be dangerous. Wandering to the rocks near the water is an invitation for a wetting or worse, being swept into the water.
- Never play around or near logs and drift wood that can be rolled or tossed by unexpected waves. A small wave can roll the logs.
- Divide the class into small groups with an adult leader. Constant supervision at the beach is the best insurance of a safe and enjoyable experience.

Know the Area

Before planning a trip to the seashore, gather as much information about it as possible. Go to the safe protected bays, inlets, and estuaries. Avoid cliffs, caves, and sandbars.

Know "Indicator Organisms"

If you have wandered to a part of the beach where Sea Palm (algae that looks like miniature palm trees) grows, you're in a very dangerous spot. The Sea Palm grows only in the most exposed parts of the beach that catch the pounding surf. Return immediately to a safer part of the beach.

Check the Tides

Before going to the beach know how low the tide will fall and at what time the tide will start to rise.

- Plan to arrive one hour before low tide. It's easier to tidepool on an outgoing tide.
- Always keep an eye on the waves. If the tide has turned and is incoming, be especially alert so students aren't stranded on a distant part of the beach.

Set Boundaries

Set boundaries in which the students are allowed to explore: use land marks such as a log boulder or use yellow flag markers to set their boundaries.

Set Up a Buddy System

While in the classroom, assign students to a buddy system. This provides the students with a working partner and helps eliminate the possibility of losing one student.

Wear Life Jackets

If your site will be near deep water, life jackets may be a good idea.

First-Aid Kit

Carry a well-stocked first-aid kit along. Algae on rocks can be slippery; barnacles and mussels are sharp.

Additional Tips

Bright-colored baseball caps or bandannas can be helpful in keeping groups together on crowded beaches. They are also useful to divide students into groups.

Emergency Transportation and Procedures

Never arrange for bus transportation that leaves the class stranded without at least one car for emergency purposes.

Establish Safety Rules with Assistants and Students

Some good activities to help set the mood include telling stories about the site, showing pictures of the site, telling stories about people who got lost, or funny stories about people who left a bucket or camera that got swept out to sea. The following rules should be discussed in the classroom prior to any field trip experience:

Keep your eye on the ocean. Continually check your times and locations. People often become so involved with looking at tidepools that the rising tide cuts them off from the land and they become stranded. Do not turn your back to the sea.

Know your waves. Every seventh wave is not higher and those in between are not safer: sometimes several high waves follow in succession. Never turn your back to the sea until you're familiar with the wave action of the area.

If caught by an unexpected wave, don't run. Lie down, like a barnacle or a sea star, and cling tightly to the rocks. Let the water pour over you.

Take care when a ferry or speed boat comes near. The waves can sweep you away.

Do not climb shoreline rock faces. Do not climb cliffs facing the ocean: the tide will rise and might trap you. In addition, shoreline cliffs are frequently of soft sandstone or clay, and could crumble beneath your weight.

Never walk on floating logs. Do not walk on log booms or on stranded logs in shallow water. Floating logs roll unpredictably. Avoid walking on logs resting on beaches in bays and along estuaries: an incoming tide can turn them over or sweep them away.

Never fool around. Don't play practical jokes. Do not run or push or shove. Algae is slippery; running and rowdy behavior can result in nasty falls.

Explore in groups. Honor the Buddy System. Never explore alone. Always explore with a partner and preferably in threes—if one is hurt the second can stay while the third goes for help.

Stay within the boundaries.

Protect Seashore Plants and Animals

Give students rules only for essential items that tend to disturb the energy of the group or the seashore environment. Students love to run and shout. If they have to, try to arrange a way they can do that as part of the activities of the day. Here are some rules that will help you explore the seashore in a way that will cause as little damage as possible.

Turn the rocks back over. When turning over a rock, do so gently. Try not to crush animals living on, beside, or under the rock. Put the rock back the way it was, or learn it face down against another rocks.

Fill in any holes. When digging for burrowing animals, do not leave piles of sand or mud on the beach; many burrowing animals float away or die when the tide returns. Furthermore, the unnatural holes and piles of sand and mud may kill many small clams or other animals whose burrows can no longer reach the surface.

Handle organisms as little as possible. Observe the organisms in their own habitats or with the animals submerged in cold seawater, in tidal pools, or in clear plastic bags or containers filled with seawater. Even if the organism is submerged in seawater, limit observations to 20–30 minutes.

Cover abandoned animals with seaweed. When investigating animals living on or under seaweed, return the animals and cover them with moist seaweed, to keep them from drying out.

Avoid walking on animals. When walking on rocky shores, try to walk on bare rock or on the patches of sand and mud between them. Try not to crush barnacles and other organisms living on the surface. DO NOT RUN IN AREAS OTHER THAN SANDY BEACHES. Soft-soled shoes cause the least damage to fragile animals.

Do not remove attached organisms. Do not pry limpets, chitons, or sea anemones from rocks.

Leave the specimens in their natural habitat. As much as possible, do your investigating at the seashore. Do not move animals from one tidal zone or one type of beach to another. You may be removing them from their food supply or you may place them in a different zone, where they cannot survive. Do not take animals away unless a proper saltwater aquarium has been set up in the classroom. Always take only a few organisms and return them to their original location on the shore: on rocks, in tidal pools, in sand or mud. Always model appropriate behavior.

Don't climb the rocks. Seabirds use the rocks for nesting and will be frightened from the nest, exposing the eggs and chicks to hungry gulls.

Don't frighten seals from the rocks. Rocky intertidal areas are often their favored resting areas. Baby seals are often left on the beaches by their mothers who go out fishing. Do not approach the seal pups. They're not abandoned, and your curiosity will only cause them stress.

Do not mount, dry, or preserve specimens. Many people boil snails to make jewelry from the beautiful shells, or dry sea stars and sea urchins to decorate basements and bulletin boards. For such purposes use only the discarded shells of animals already dead.

Camp and leave no trace. Put out any fire you might build and scatter the pieces. Pack out all of your garbage. In every way, try to leave the beach and its inhabitants as they were.

Involve Students and Parents

Involve the students, parents, and volunteer helpers in the preparation and planning of the field trip as much as possible. The better prepared they are, the more successful the field trip will be.

Informing Students

During the early stages of planning, you might try having a brainstorming activity in which the students offer their ideas on what to do at the seashore. All of the students' ideas should be listed on the blackboard and then prioritized. If the students have some responsibility in planning the trip, they are much more likely to understand why the trip must be planned in a particular way.

Carefully think through the activities of the day and make sure the students have the skills they will need in order to complete the activities successfully. For example, if they are to map a tidal pool, they need to know mapping skills prior to their arrival on shore. If students are to observe a tidal pool, they should have had experiences in the classroom observing the details of a rock, a seashell, or a living organism.

Informing Parents

If possible, arrange for a parent-teacher evening to inform parents of your field trip plans. A set of slides from previous years is informative and can be a big help in enlisting parental support. Letters, including permission slips, should be sent home to parents so that they know about the activities of the day.

Supervision

Arrange for proper supervision. Usually there is no problem in finding parents willing to go along. One adult for every five students is a good rule of thumb. Meet with your volunteers before the field trip to acquaint them with your plans for the outing. Be sure that each of them knows specifically what you would like them to do.

Planning with Your Assistants

It's a good idea to have one or two planning meetings with the assistants that you plan to take on the trip. Stress their role as facilitators and students of natural history. Leading a group of students means involving themselves in observing, exploring, and asking questions together. Excite them with the prospect of learning with the children. Give them copies of lesson plans. Each assistant should have a specific job rather than just busy work. Draw upon their resourcefulness at the seashore; e.g., crafts, art, recreation, photography, cooking. If an assistant is or has been a fisher, draw from his or her knowledge. Young students are mesmerized by fisher tales. Such variety adds spice to the day.

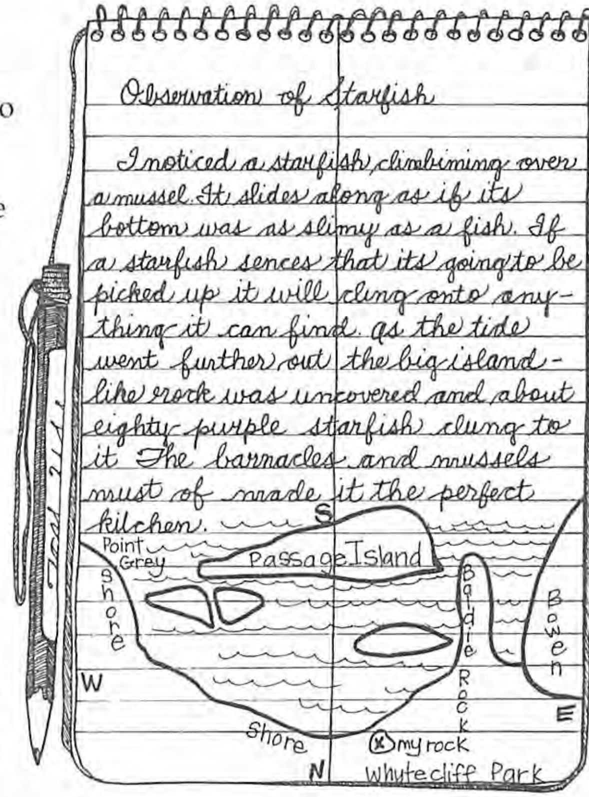
What Every Participant Should Know

- Safety rules
- What to do in case of an emergency
- Conservation rules
- Guidelines for behavior
- The time of low tide
- What to do in case of weather changes
- The itinerary of the day
- Toilet arrangements

Keeping a Field Notebook

A field notebook or log is a scientific diary where you record information and observations that you may wish to use later. A spiral steno pad with a pencil attached by a string makes an excellent field notebook.

When making observations, students should record the date, time, weather conditions, tide level, and tide direction. This information may prove valuable in interpreting data and answering questions that arise when they return to the classroom. For instance, the behavior of plants and animals is often a direct response to stimuli from the sun, rain, tides, etc. When recording information, students should describe in detail what the organism looks like and how it behaves.



Sample page from a sixth-grader's field notebook.

Evaluating Field Notebooks

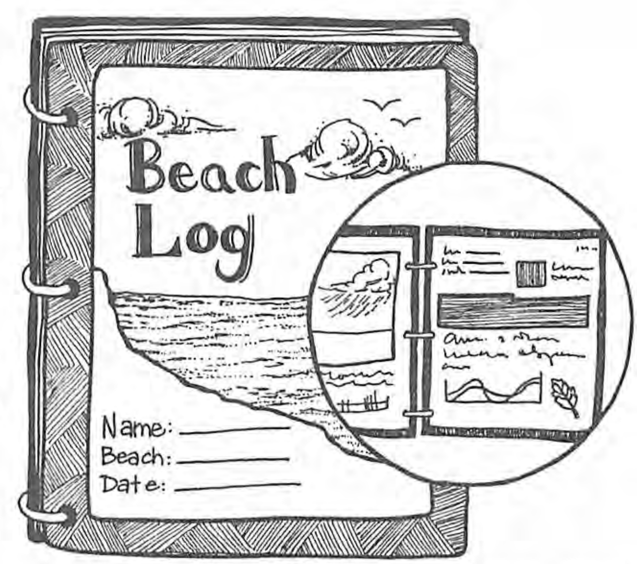
One of the best ways to teach students how to record information is to have them draw quick sketches of the plants and animals and the investigations that they set up. Encourage them to make large drawings so that they can include the details when necessary. Before going to the seashore, they should practice drawing the details of various natural objects such as rocks, wood, leaves, seashells, and insects. Taking photographs is also a good way to record information, especially when conducting investigations over time.

Because conditions at the seashore are often adverse (rain, wind, water, etc.), it's unrealistic to mark students' notebooks for neatness, penmanship, or spelling. Depending on the grade level, it's best to mark field notebooks on such criteria as the amount of descriptive observation, the accuracy of measured data, the quality and detail of maps and sketches, the appropriate use of photographs, the organization of data into graphs and tables, and creative use of the notebook.

Field notebooks can also be used at the seashore for writing first draft poems, haikus, or a personal journal. Use your imagination; the possibilities are endless.

Making a Seashore Binder

Because observations in the field are often taken in adverse conditions, and because the information obtained can be used in a variety of ways, the students will need to transfer some information from their field notebooks to a proper notebook. To make notebooks, attach a colorful photograph or drawing to the notebook cover. When transferring notes, maps, and poems, the students should edit the information for specific purposes and practice their best handwriting. Use colored pencils or water colors to add interest and authenticity to sketches, maps, and creative writing exercises. Add assignments on an ongoing basis. The students should take pride in the content and visual appeal of their seashore notebook.



Creating the Journey

Now that you know your site and have a sense of what's possible to do, it's time to plan the kind of experience you want to create. Although it's important to be clear about the concepts you plan to teach, you'll also need to consider the ways in which the activities involve the children. In creating the journey, consider the following guidelines:

1. **Keep groups small.** With all the exciting discoveries that happen at the seashore, it's hard to keep everybody involved in groups of more than 7 to 10. Larger groups have a negative impact on local beaches. Use your assistants to teach small groups.

2. **Use all your senses.** There is much more to the seashore than meets the eye. Smell the sea, taste the seawater, feel the sun and the textures of seaweeds, walk in squishy mud. We long remember things that our senses teach us.

3. **Manage the noise level.** The seashore is full of adventure, and is a favorite place for students to shout, run, and "fool around." Sometimes you'll want to insist on absolute quiet and listening, but be careful not to overdo it.

4. **Plan a variety of hands-on activities.** The seashore is a very hands-on place. The opportunities for involving students in hands-on activities are endless. As you plan your day, try to have an itinerary that includes sensory, scientific, artistic, dramatic, exploratory, and just-for-fun activities.

5. **Allow for flexibility.** Be prepared to stop and take advantage of special moments that so often occur in the out-of-doors, such as an eagle flying low over the shore while you're teaching.

6. **Use tools to aid in discovery.** Magnifying lenses, binoculars, nets and other tools are very valuable things to have on field trips. They are, however, not essential, and can even detract from the experience. Always travel light.

7. **Vary the movement.** Hike, run, walk, sit, close your eyes and listen, observe a tidal pool, map a cobblestone, hide like a predator. All sorts of motor styles are appropriate here.

8. **Keep writing to a minimum.** Writing and other activities that can just as easily take place in the classroom should be kept to a minimum. Naturalist notes, sketches, the occasional map, yes; reams of data sheets, no!

9. **Refuel the bodies.** Protein snacks such as nuts, sunflower seeds, fruit, or a hot dog go a long way toward sparking a group's energy. Water also must be available on field trips.

10. **Have fun.** Above all, remember that students need to enjoy the beach just for the pleasure in being there.

Prepare Yourself

Many of us avoid going to the seashore with our students because we know so few of the names of plants and animals. The first time I took a group of students to the seashore, many of the sixth-graders knew more organisms than I did, and one boy even knew all the Latin names! But it didn't keep us from having fun and learning new things. The key is organizing learning situations that are fun for students and leaders alike.

1. **Learn with the students.** Don't feel like you need to be a walking encyclopedia of facts to lead a good field trip. The way you react to the questions students ask, or to the organisms they bring for you to see, speaks louder than words. Don't be afraid to say, "I don't know, but let's find out."

2. **Reinforce discovery.** When a student brings you a shore crab or sea slug, this is the most important thing in the world to him or her. Respond with enthusiasm to this discovery; call a small group of students together and share what has been found. Try to adjust your teaching so that you capitalize on these special times instead of being annoyed by them. Be spontaneous.

3. **Use questioning skills.** Open-ended, stimulating questions encourage thinking: "Why is this animal living here?" "What would you need to live in the under rock habitat?" "How might we measure changes in the tide level?" Questions such as these promote thinking and group interaction.

4. **Set a mood of inquiry.** The flow of the whole field trip rests in part upon how you set the mood for the excursion, how you help the students feel about their journey beforehand. Help them know the purpose of their journey, so they can see that the outing is really an extension of their classroom learning. We don't go outside to get away from the classroom. We go outside because there are exciting and important things to learn that we can learn best outside, or cannot learn inside the classroom.

5. **Enjoy the experience.** A sense of joy should permeate the experience, whether in the form of an adventure, surprise, or quiet attentiveness. Students are naturally drawn to learning if you can keep the spirit of the occasion happy and enthusiastic. Remember that your own enthusiasm and interest in learning is contagious, and is perhaps your greatest asset as a teacher.

Field-Based Learning Cycles

For students exploring the seashore for the first time, the seashore is indeed an exciting place. Filled with curiosity, they will naturally run along the tideline to see what is there for the finding. A teacher can plan activities that take into account the enthusiasm and curiosity of the children, or create situations that result in frustration and conflict. Attempt to create learning sequences that flow naturally from one activity to the next. If your class has been working hard on sea-related studies and they know what they want to do with their time at the seashore, then perhaps they will set right to work with whatever task is at hand. If the students have seldom experienced the joys of the seashore, allow them time to explore on their own without structured guidance soon after your arrival. But, if a more structured approach seems to be in order, skip the "free exploration" phase altogether and begin with a more focused activity. The seashore is an exciting place to explore, but careful thought should be given to the sequencing of activities. Following is a general guideline for planning a field-based learning sequence:

Phase 1. Classroom Advance Organizer

Before the students arrive at the seashore, they need to have as much information about the day as possible. Sensory awareness activities in the classroom, such as drawing a rock or pine cone, help students focus their attention on the sensory aspects of a living organism or a tidal pool during their field trip experience. If they're expected to map a tidal pool, for example, you should teach mapping skills in the classroom. The more the students know about the place they're going to and the kinds of activities they will be doing, the less wild excitement you'll have to deal with. The better prepared they are, the easier it will be to connect their experience with the concepts and attitudes you're trying to develop.

Phase 2. Free Exploration

Shortly after your arrival at the seashore, set boundaries for safety purposes and repeat rules for conservation. Then allow the students time to explore the beach, dig in the sand, probe, investigate, and ask questions without structured guidance. This is especially necessary for students from urban or rural areas who have seldom, if ever, experienced the thrill of the seashore. If you have been studying shells in the classroom, you might give them the first part of their time at the beach to see how many different kinds of empty shells they can find, or give them some other kind of task that they can carry out and at the same time still be free to explore other aspects of the seashore. Allow 30 to 60 minutes.

Phase 3. Focused Exploration

After the students have explored the beach on their own, they need to slow down and learn to observe in a more systematic way. Sensory-awareness activities help students to observe better—to see, hear, smell, touch, and taste. In this way, the students are better able to take in the visual knowledge of an object or event, inquire about those things they're curious about, and interpret the world around them. A blind walk, sound map, or observation of a tidal pool, are ways to provide some structure while focusing attention on a particular task.

Phase 4. Guided Inquiries

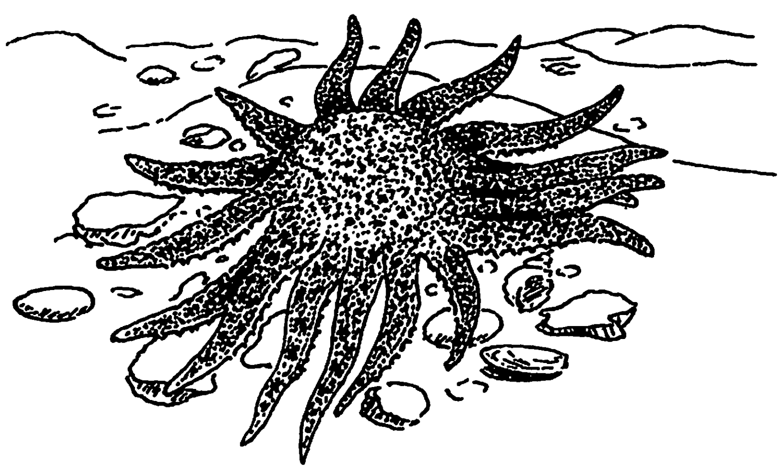
Plan activities that provide for the intake of information that will allow the students to see the big ideas, develop concepts, and practice the skills of inquiry. As an example, groups of four or five students might collect and observe organisms in buckets filled with seawater. They might be looking for a particular group of organisms—for example, crabs or snails, or animals with shell houses. Or they might be assigned the task to follow certain crows, gulls, or sandpipers and observe their behavior. They might map the population of organisms in a tidal pool; compare the temperature of the air, tidal pools at various locations on the shore, and the ocean water; or measure and record tidal changes during the course of the field trip. Depending on available time and logistics; students might paint a seascape, write a poem, or dramatize animals at the seashore.

Phase 5. On-Site Debriefing

After the students have completed an activity (for example, inquiries with living organisms), gather them together. Have the students sit down quietly and talk about what they have seen. If possible, have adult helpers work in small groups with students to share further discoveries or knowledge about observations, questions, or potential investigations.

Phase 6. Classroom Follow-up

After the students have explored the seashore, they will be ready to share their experiences and understandings back in the classroom. Begin by asking open-ended questions, sharing experiences, listing organisms, creating concept maps, and developing graphs and tables from the data obtained. Lead the students to summarize and synthesize information, develop an understanding of vocabulary and marine science concepts, and speculate. Creative theorizing requires the content of experience and the logic of sensory intake and experimentation to support it. Out of the learning cycle comes new questions and new problems to solve.



The Sunflower Star is a feared predator. Put one into a populated tidepool, and watch the violent action as hermit crabs, limpets, abalones, and even snails practically run to get away.

Chapter 2: Exploring Seashores with Students

The oceans and seas of the world are marine ecosystems. Rocky and sandy shores, cobble beaches, mud flats, and estuaries are all marine ecosystems. Even the tidal pools, mussel beds, crevices, and beds of seaweeds on a rocky shore are miniature marine systems. Each type of marine ecosystem is an interacting system that consists of marine plants and animals and their nonliving environment.

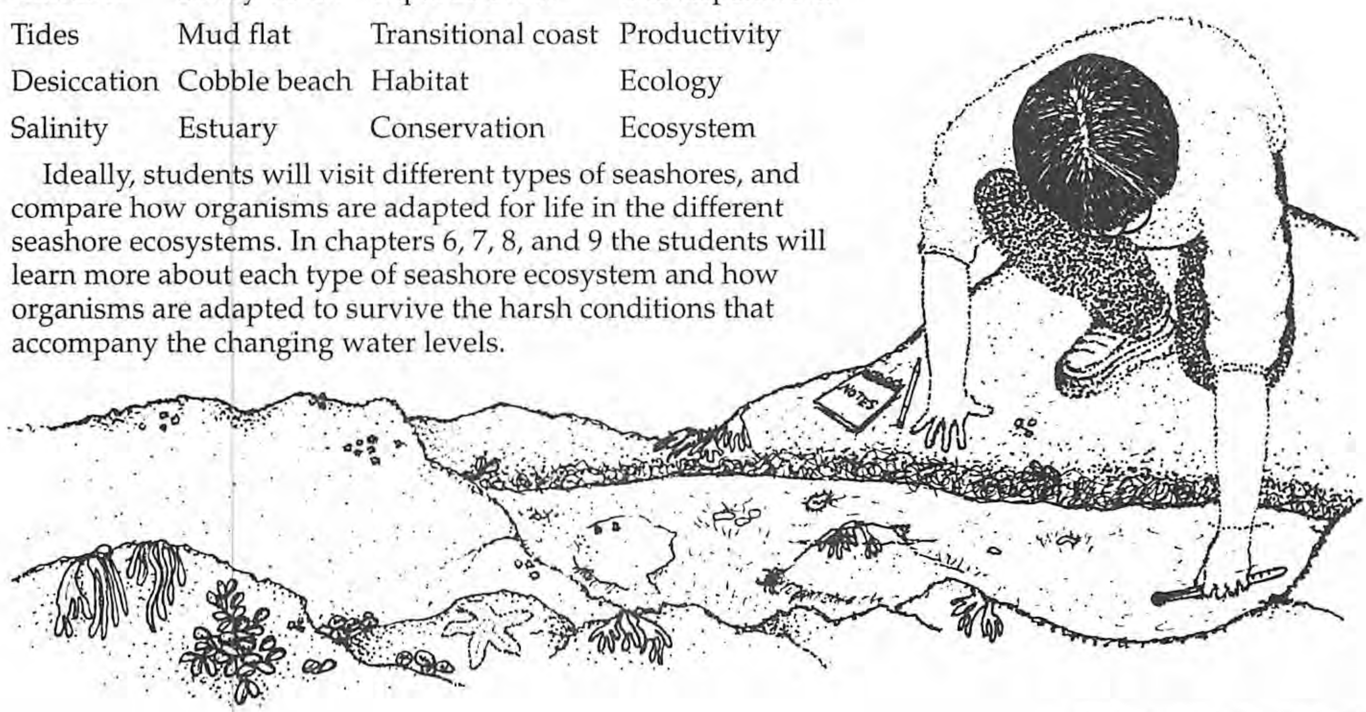
All shores—rocky, cobbly, sandy, muddy, and estuaries—have one thing in common. They are exposed daily to tides. Therefore, organisms that live here must be adapted to survive the harsh conditions that accompany the changing water levels.

The activities described in this chapter help students identify some of the common intertidal plants and animals of the Pacific Northwest, and they emphasize how plants and animals are equipped to survive regular changing of the tides. The activities encourage students to explore tidal pools and conduct simple investigations with seashore animals, and they invite further discussion and reading. The main purpose of the chapter is introducing students to the concept of marine ecosystems, and to the basic ecological principles that govern them. At the same time, students should develop a deep appreciation of the need for conservation while exploring seashore organisms and habitats.

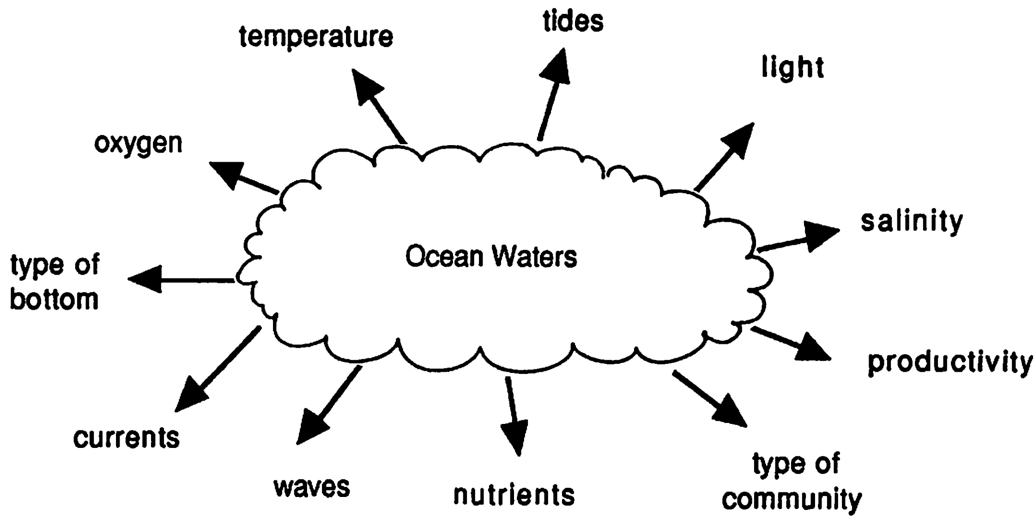
Students should gain an understanding of the following concepts:

Ocean	Rocky shore	Protected coast	Community
Currents	Sandy beach	Exposed coast	Interdependence
Tides	Mud flat	Transitional coast	Productivity
Desiccation	Cobble beach	Habitat	Ecology
Salinity	Estuary	Conservation	Ecosystem

Ideally, students will visit different types of seashores, and compare how organisms are adapted for life in the different seashore ecosystems. In chapters 6, 7, 8, and 9 the students will learn more about each type of seashore ecosystem and how organisms are adapted to survive the harsh conditions that accompany the changing water levels.



The Ocean



Concepts

1. The oceans and seas of the world are marine (saltwater) ecosystems.

2. Many of the living and nonliving factors that interact in the various types of marine ecosystems are unique to marine ecosystems.

3. Productivity is the ability to support life.

4. A marine ecosystem is the collection of plants and animals living in a common area, dependent on one another for survival.

Understandings

The students will be able to 1) identify the five oceans on a map, 2) compare a freshwater pond to a tidal pool, and 3) infer why productivity is greater along the coastal shelf.

Materials

Transparency: "The Oceans of the World"

Teacher Information

If you look at a map of the world, you can find the five great oceans: the Pacific, Atlantic, Indian, Arctic, and Antarctic. Because they're all interconnected by currents, only one world ocean actually extends over the earth's surface. The seven continents are islands in this huge body of water.

Big or small, marine ecosystems differ from freshwater ecosystems in several ways. The most significant differences are:

- Size
- Depth
- Salinity
- Currents
- Waves
- Tides
- Productivity
- Type of community

Size

The ocean ecosystem is very large. It occupies about 71% of the earth's surface. In fact, 97% of the world's water is saltwater.

Depth

The ocean ecosystem is also deep. The deepest parts are over 10 km deep. The average depth is about 3.8 km. If our earth had a smooth surface, the waters of the sea would cover it to a uniform depth of about 2.5 km.

Salinity

The salinity or concentration of dissolved minerals in seawater is very high. In the open sea it averages about 3.5% or 35 parts per thousand. In fact, most seawater is about 2.7% common salt. For this reason, seawater is also called saltwater (NaCl).

Currents

The oceans and seas are interconnected by currents. These mighty rivers of moving water flow on both the surface and the ocean bottom. Ocean currents transport nutrients and oxygen to marine organisms and influence the climate. They also move waste products away from the organisms.

Waves

The surface of the oceans and seas is dominated by waves. These vary in size and speed. Waves are due to wind movement across the surface. When waves enter shallow water, they can become large and powerful.

Tides

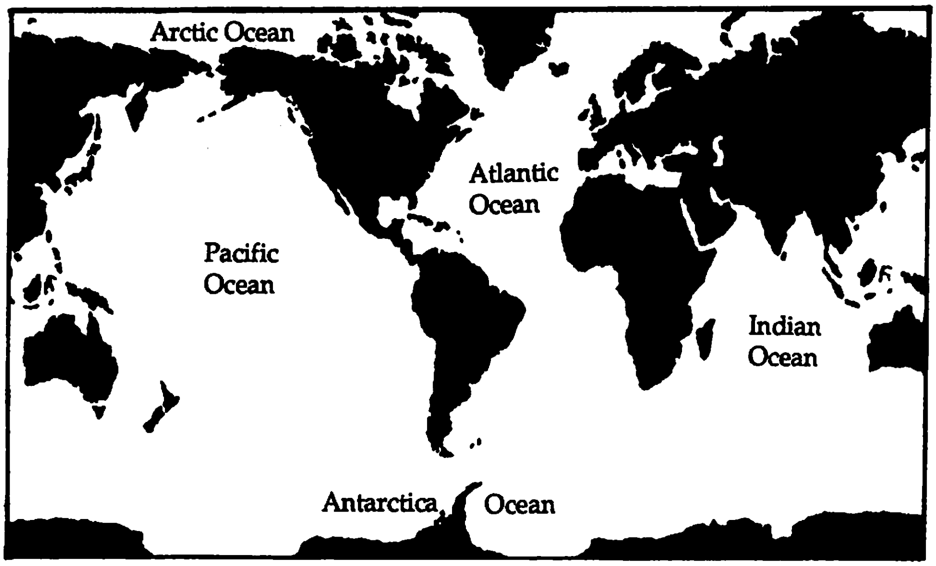
All shores—rocky, muddy, and sandy—are exposed to the rise and fall of the tides. This regular change in sea level has resulted in distinct zones along these shores. Depending on the type and location of the shore, the organisms making up the zones differ. Zonation is discussed in more detail in chapters 6, 7, and 8.

Productivity

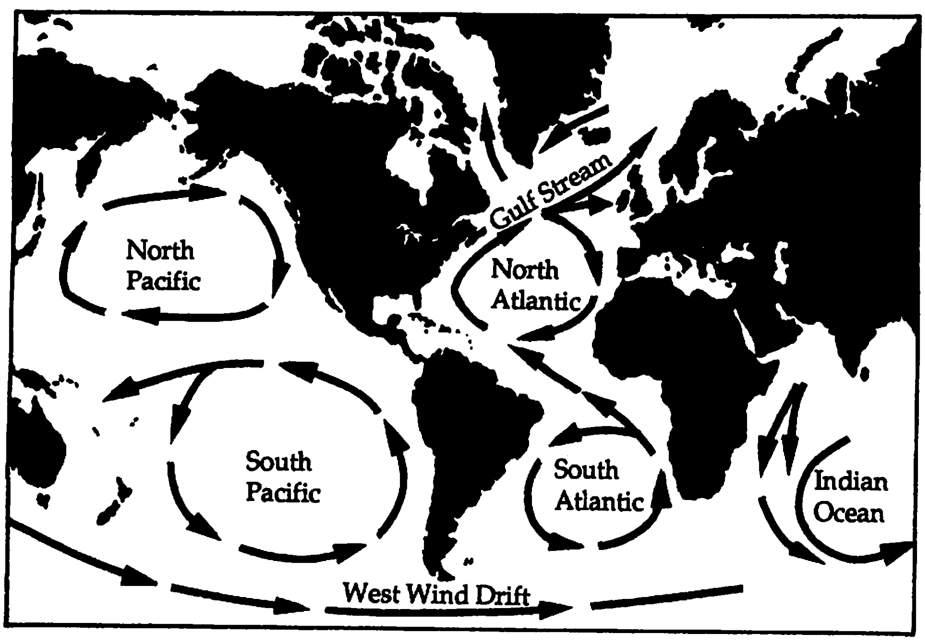
Productivity refers to the amount of life (organic matter) produced in an area. Within an ecosystem productivity is controlled by several factors. These include temperature and the availability of light, water, and nutrients. In the open ocean, productivity is low because of the small amount of nutrients in the surface area where the sunlight is also available. However, productivity is higher along the continental shelf where nutrients are brought up to the surface by ocean currents called upswellings. This enhances the productivity of these areas. For this reason, salt marshes are among the most productive ecosystems on earth.

Plant and Animal Communities

Each marine ecosystem has its own characteristic collection of plants and animals. This is determined by the type of coastline (protected or exposed), the type of shore (rocky, sandy, or muddy), and other physical properties in an area.



The major oceans of the world are interconnected to form one world ocean.



Major surface currents of the ocean

Procedures

1. Write the words "fresh-water pond" and "tidal pool" on the blackboard. For each, brainstorm a set of characteristics.

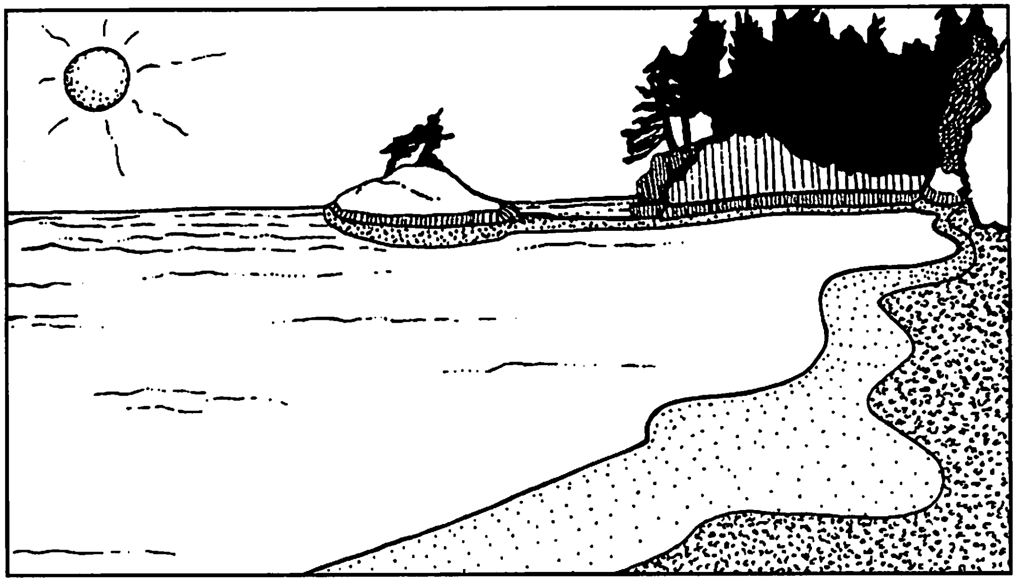
2. What are similarities and differences between a freshwater pond and a tidal pool?

3. Define the terms *currents, waves,* and *tides.*

4. Use the overhead transparency, "The Oceans of the World." What percentage of the earth's surface in covered by oceans? Name the five oceans. Why are the seven continents considered "islands" in one huge body of water?

5. Define the term *productivity.* Why is productivity limited in the open ocean? Why is productivity greater along the continental shelf?

The Tides



Concepts

1. Twice each day the seashore is covered with seawater or exposed to air.

2. Tides are caused by gravitational pull of the sun and moon on the earth's ocean, and the spinning motion of the earth's rotation.

3. Tides are predictable.

Understandings

The students will be able to: 1) sort pictures of the seashore into high tide and low tide; 2) brainstorm causes of the tides; 3) infer why knowing about the tides is important; 4) predict, observe, and describe tidal changes; and 5) measure and record changes in tide levels.

Materials

Make transparencies of the following illustrations:

High Tide

Spring Tide and Neap Tide

Teacher Information

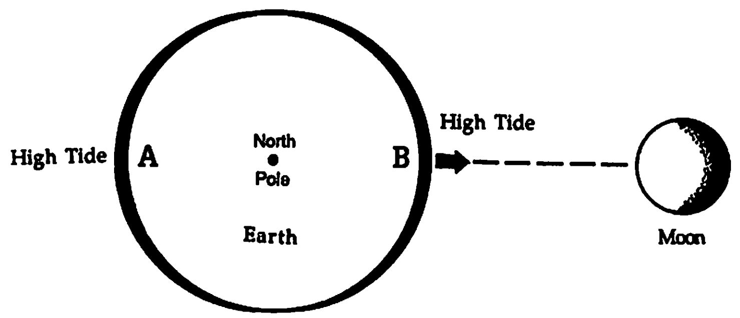
Twice each day the tides rise and fall along the coast of North America. Twice each day the seashore is covered with seawater or exposed to air. Students are surprised to learn how far the tide goes in and out, and how life at the seashore changes for shoreline organisms. They are also surprised to learn that the tides are predictable.

If you have ever been to a beach, you have probably seen the tide water come up high on the shore and then at other times come much lower. This alternate rising and falling of the ocean's water is called the tide. The incoming tide at its crest is known as the high tide: the outgoing is known as the low tide. Incoming water is called the flow and outgoing water is called the ebb.

What Causes the Tides?

About 1700, Sir Isaac Newton gave us the theory that would eventually explain the tides. The theory, called the Law of Gravitation, stated that everything large or small in the universe exerts a pull on everything else. How does this theory explain the tides?

The heavier and closer the objects, the greater the force of attraction. The moon's gravitational pull creates a bulge in the ocean under the moon. This bulge in shown in the illustration below at point A. An important key to understanding tides is to remember that the earth is spinning on its axis daily, as well as the moon is orbiting the earth. This rotation tries to throw the waters in the oceans away from their basins. The centrifugal force of rotation creates a second bulge in the ocean on the opposite side of the world from the bulge caused by the moon's attraction. This bulge is shown at point B, below.



The tides are caused by a combination of the gravity of the sun and moon and the centrifugal force that results from the rotation of the earth, moon and sun.

The moon rises later each day. It takes a point on the earth about 52 additional minutes each day to catch up with and pass through the moon's two tidal bulges. As a result, every 24 hours and 52 minutes there are two high and two low tides. The tides are about 52 minutes later each day. Keep in mind that in the real world, there are no simple tidal bulges.

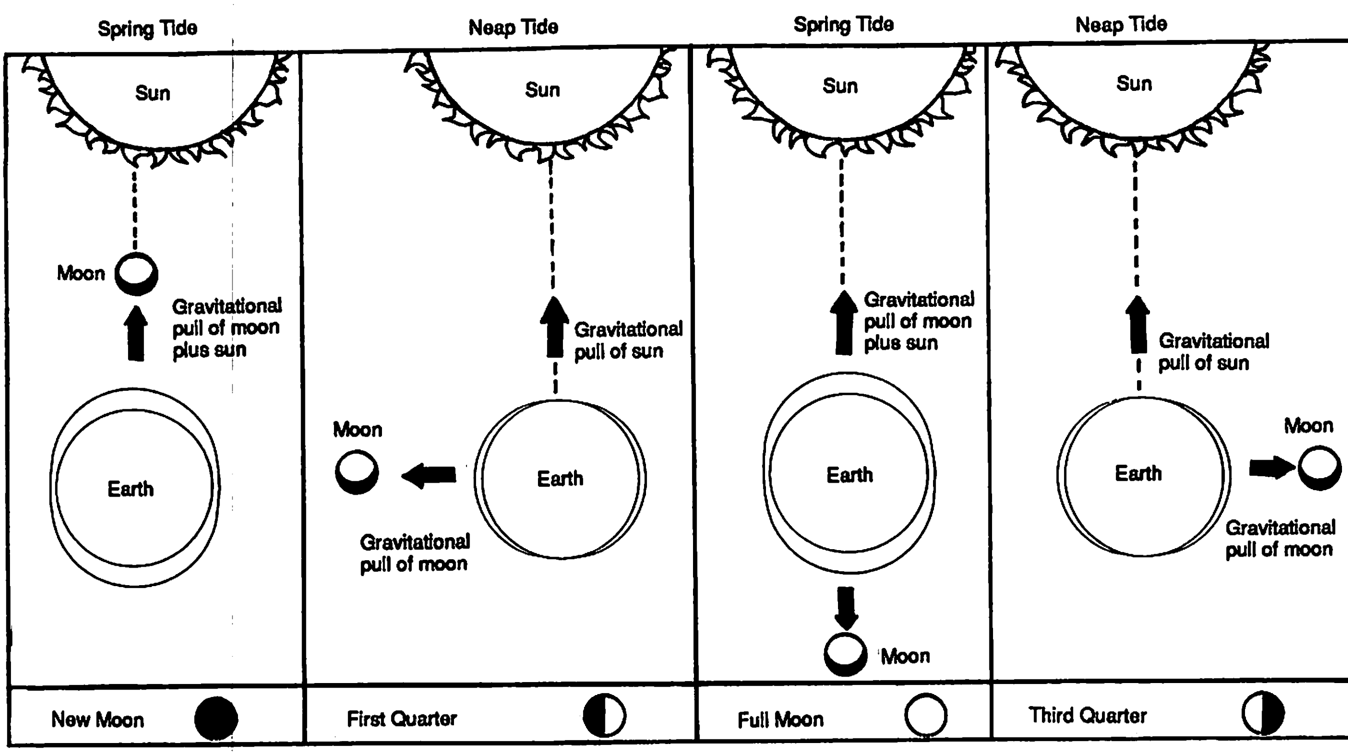
The Sun Also Has an Effect on Tides

The sun, although it is many times larger than the moon, has less effect on the tides due to its greater distance from the earth. The sun's gravitational pull also tends to create two tidal bulges: one under the sun and the other one on the opposite side of the world. These bulges are smaller than those caused by the moon and ordinarily do not have a separate effect. Instead, they increase or decrease the moon's effect on the tide.

The difference between successive high and low tides is called the tidal range. The tidal range changes as a result of the changing positions of the sun and the moon with respect to the earth. As the moon rotates around the earth about once a month, it's in line with the sun twice a month and it's at right angles at two other times during the month. The highest tides occur when the sun and moon are in direct line with the earth; combining their gravitational pull in the same direction; these are called spring tides. (Spring tides have nothing to do with the seasons.) The opposite condition takes place when the moon and the sun are at right angles with respect to the earth, and the attractive forces of the sun and the moon work against each other. At this time the tidal range is decreased. The tide rises and falls less than the average. We call these tides neap tides.

The tidal range varies in different parts of the world. Along the Pacific Coast of North America, mixed tides occur. These tides occur twice daily.

Where does the water go when the tide goes out to sea? The water does not really go anywhere. The sea level rises and falls as the tidal wave passes through it, but the water itself does not move horizontally except where the sea is contained in narrow inlets or passages. The sea ebbs and flows on the shore simply because its own level goes up or down, like the water in a bathtub when you get in or out.



The tidal bulges are largest, and therefore the tidal range is greatest, when the moon and sun are in line and acting together. This happens at new and full moon. When the moon and sun are pulling in different directions, which occurs when the moon is in quarter, the bulges and tidal range are smallest.

Procedures

1. If appropriate, make a transparency of the sketch of low tide, the sand bar, and the rocky island on page 47. Read the following story to the class:

> Sally and Ben had only recently moved to the little community of Windy Bay. They were eager to explore the nearby sandy beach, and especially to adventure to the small rocky island a short distance offshore. They could scarcely wait until Saturday morning when they could explore the tide pools and rocky crevices of the island to look for neat critters. They arose early and walked to the sand bar that jutted onto the rocky island. Only a few small cedar trees rose from the center of the island. At first they walked along the lower beach looking into glassy blue tide pools, then

searched the high tide line for beach pebbles, empty snail shells, and glass balls. After about three hours, Ben and Sally decided to return home. Much to their surprise, the connecting sand bar to the mainland was now covered with seawater to a depth of well over a meter (3–4 feet). They were stuck. They were afraid to swim the distance because of the surprisingly strong current, and it was too far for their yells to be heard. Will Sally and Ben have to spend the rest of the day and the night on the island?

2. Engage the students in a discussion about what happened. To begin, allow the students to brainstorm without discussing right or wrong responses. This is a time to listen to the students' thinking about the tides.

- Can you explain what happened?
- Will the water go out again? If so, how long might they have to walk back across the sandbar?
- What should Ben and Sally do?
- How might Ben and Sally have avoided this situation? Could they have predicted that the water was going to rise? (Review the above questions after completing procedures 3–9.)

Sally and Ben's problem stems from the fact that when they walked across the sand bar to the rocky island, the water level was at its low point or low ebb. When they started to walk back, the water was rising or flooding. We call this rise and fall of ocean water the tide.

3. Write the words "What we know about tides" on the blackboard. Ask the students to brainstorm what they know about the tides. Write their ideas on the blackboard.

4. Write the words "What we want to know about tides" on the blackboard. Write the students' questions on the blackboard.

5. Ask the students to describe the seashore at high tide and low tide. What is the difference between high tide and low tide? Has anyone been on a wharf or boat dock at low tide? What happens to the angle of the walk ramp? Has anyone been at the seashore and lost something valuable because the tide came in and carried it away? How do they know the tide changes?

6. Has anyone been stranded by the tides? Can the changing tide be dangerous to humans? When is it important to know about the tides? Brainstorm why a knowledge of the tides is important; e.g.,

- When boating, sailing, or fishing
- When hiking along coastal trails
- When collecting shellfish
- When swimming, snorkeling, or beach combing
- When observing intertidal plants and animals and studying animal ecology

Teacher's Note

What causes the tides is extremely complicated to understand. Depending on the grade level, it may not be necessary that students understand the causes of the tides. What may be more important is that they observe and describe the tidal cycle, and infer how organisms survive the changing tide levels.

7. Show the students pictures of high tide and low tide at different seashores and have them determine which is which.

8. Ask the students to brainstorm what they think causes the tides. Accept all of the students' responses. Listen to the students' own thinking.

9. Show the transparency, "High Tide." Discuss the following questions:

- What creates a bulge in the ocean at point A? (The gravitational pull of the moon and to a lesser extent the sun.)
- What causes the second bulge to occur at point B? (The centrifugal force of rotation causes a second bulge on the opposite side of the world from point A.)
- What causes the tide to rise and fall? (The rotation of the earth and moon.)
- Where does the water go at low tide? (Pulled away from shoreline by the gravitational pull of the moon.)

10. Show the transparency, "Spring Tide and Neap Tide." Discuss the following:

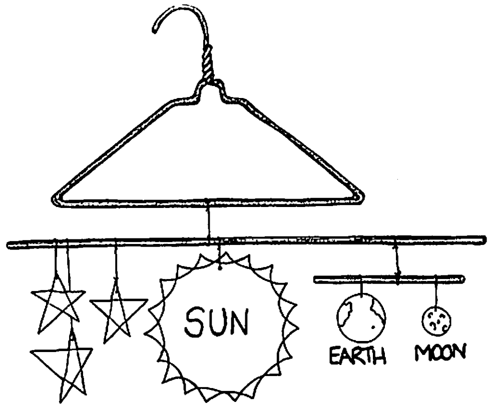
- Which has a greater pull on the ocean: the moon or sun? (The moon.) Why? (It's closer to the earth.)
- What causes spring tides, or the highest tides of the year? (The attractive forces of the sun and moon are working together)
- What causes neap tides, or less than average tides? (The attractive forces of the moon and sun work against each other because they are at right angles.)

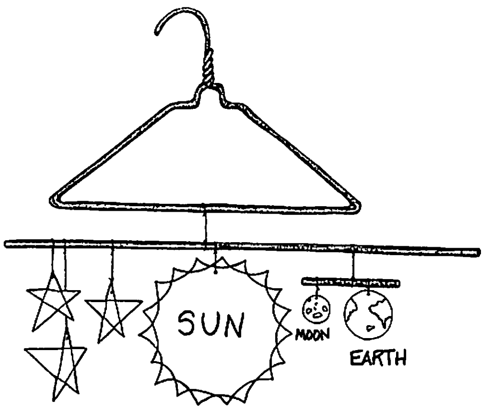
11. How often does the tide rise and fall during a day on our coastline? (Two high tides and two low tides.)

Enrichment Activities

1. Obtain a local tide table from a book store or marina. Graph the tides each day over a period of one month.

2. Each night, make observations of the moon. Is it a full moon, half moon, quarter moon, or crescent moon. Compare the students' observations of the moon with their graphs. What have we learned about the tides?





A Tides Mobile

Materials

Clothes hanger
String
Tag board
Paper clips or small weight
Pencil or markers
One-hole punch
Tag board strips, straws or dowels
Colored construction paper
Scissors
Tape
Glue

Directions

- With pencil or marker draw a moon, sun, earth, and two stars on the construction paper. (Remember to keep them proportional—refer to the diagrams for a guide.)
- Glue the drawings to tag board and cut out.
- With the hole punch make a hole at the top of each piece; put string through each hole and tie securely.
- Attach the ends of the string to the clothes hanger and tag board strips, straws, or dowels as shown in the diagrams.
- Weight the stars with paper clips or the weight so that the mobile is balanced.

Use the model mobile to demonstrate the position of the moon, earth, and sun during a full moon (as shown). Explain that all three bodies are in line and looks full because light from the sun is reflecting back to earth.

Use the model mobile to demonstrate to students the position of the moon, earth, and sun during a new moon (as shown). Explain that during a new moon, the three bodies are in a line just like the full moon but we cannot see the moon because we are in its shadow.

Have students use their own models to explain to a partner the position of the moon, sun, and earth during a full and new moon.

Research Questions

1. What is the tidal variation at the equator? (Little variation, or equal tides.)

2. How might tidal variations change from San Diego, California to Vancouver, BC, to Sitka, Alaska? How could you find out? (The tidal range increases with distance from the equator.)

3. Research what causes the tides. Label the sun, moon, and earth on each drawing. Tell which drawing illustrates the spring tide (or lowest low tide) and neap tide (highest high tide).

Observing the Tides

Materials

Meter sticks or tape
Field notebooks
Watches
Markers and ribbons
Pencils

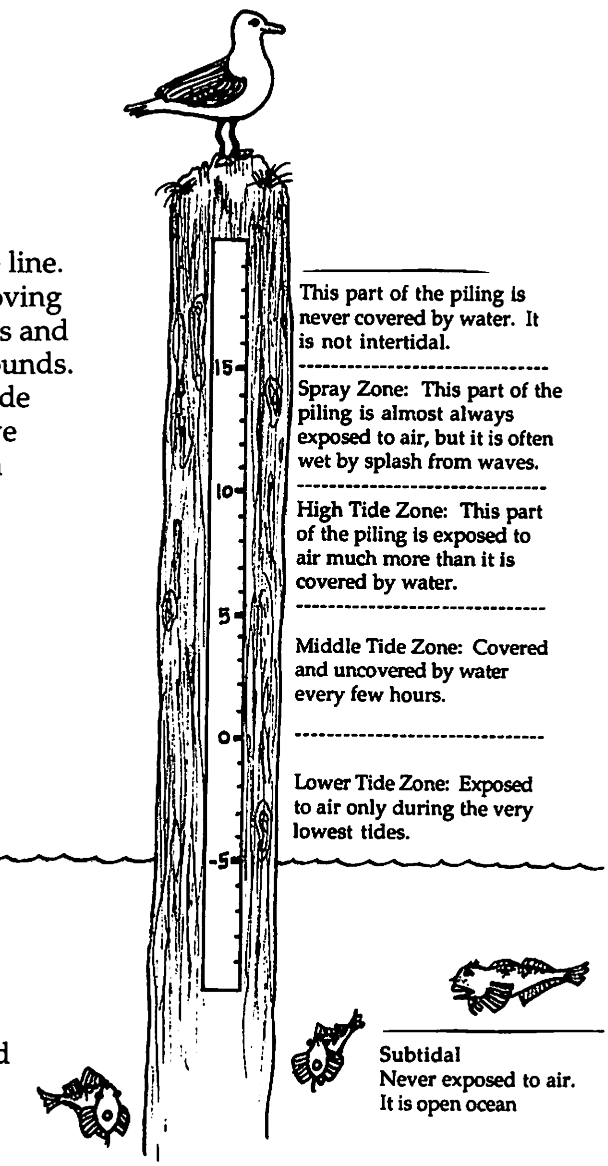
At the seashore, have the students sit a while at the tide line. What observations can they make? Can they see water moving in or out? What sounds do they hear? Listen for far sounds and near sounds. Listen for water sounds. Listen for animal sounds. Listen for sounds at high tide and at low tide. When the tide changes, how do the sounds change? What animals behave differently at high tide, at low tide, and at ebb tide? Watch closely. Find five signs of the effects of tidal changes.

Predicting the Tides

- Predict how far the tide will go out.
- Predict how high the tide will rise.
- Infer how you know when the tide turns.

Measuring Horizontal Tidal Changes

Find an area near the shore that is just exposed as the tide begins to go out. Split the class into groups and record the measurement of the tide over the day from high to low or vice versa. Place a marker where the sand and water meet. Record the time. For the next four half-hour blocks of time, mark where the sand and water meet. Measure the distance between markers. Record what you find. Draw pictures of the beach at high tide and at low tide. Make comparisons. Try this activity in different areas along the seashore.



Measuring Vertical Tidal Changes

Find a vertical rock face or dock piling. Measure both the vertical drop and the horizontal variation of the tides.

Challenge the students to invent a different way to measure and record tidal changes.

From the students' observations at the seashore, discuss the following:

- How fast did the tide go out? Were you surprised?
- How far did the tide go out? Were you surprised?
- What was the vertical drop? Compare this information with the tide tables.
- What have we learned about the tides?

Teacher's Note

American and Canadian tide table charts differ in their interpretation of "lower low water." Canadians define the level of water at the lowest normal tides, west coast Americans define it as "mean low water." Because averaged values are used, stated U.S. tide levels are slightly higher than Canadian tides and tend to show negative tides more often than Canadian. No difficulty should arise if the appropriate set of tide tables is used.

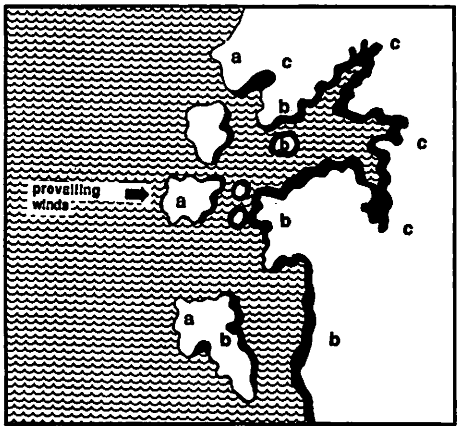
Exposed, Protected, and Transitional Shores

Concepts

1. Exposed shores have no offshore reefs or islands to provide protection from strong currents or violent wave action.

2. Protected shores have offshore islands to shelter them, or bays and inlets to provide shelter from the full force of waves.

3. Transitional shores are neither fully protected nor fully exposed to violent wave action.



Exposed, transitional, and protected shores:
a. Exposed to full force of beating waves
b. Neither fully protected or exposed
c. Protected by offshore islands, inlets, and bays

> **Teacher's Note**
> Prepare a transparency of the above map. See page 25.

Understandings

The students will be able to 1) describe and identify the characteristics of exposed, protected, and transitional coastlines; 2) draw a map showing different types of coastlines, 3) classify pictures of seashores into exposed, protected, and transitional; and 4) infer which type of seashore would have the greatest variety of plants and animals.

Materials

Overhead transparency: "Exposed, Protected, and Transitional Shores"

Background

The irregularity of the Pacific coastline creates a variety of shores: exposed shores that take the full force of the beating waves of the open ocean, protected shores that receive little wave action, and transitional shores that are neither completely protected nor completely exposed. Transitional shores can be calm, but suddenly become violent and change shores that at first seemed "protected" into shores that are dangerously "exposed."

Exposed Shores

An outer coast completely exposed to the full force of beating surf has no offshore reefs, islands, or even kelp beds to provide protection from strong currents or violent wave action. Beaches here support a highly specialized but limited assortment of species because the plants and animals on the exposed shore must have special equipment with which to withstand the pounding surf and to prevent their being dislodged and carried away by strong currents. Exposed beaches are predominantly unprotected, and have sandy, gravely, and rocky shores, or bold headlands. Exposed gravely beaches are typically sterile places, considered "graveyards" because of the scouring action of sand and gravel.

Protected Shores

Shores are considered "protected" if they have offshore islands to shelter them, or bays and inlets to provide shelter from the full force of waves. These sheltered bays and muddy estuaries are comparatively rich in plants and animals, which are out of danger from the waves and strong currents.

Transitional Shores

Transitional shores are frequently dangerous, although people seem to think that danger lurks only on the outer coast. The terms "exposed" and "protected" are relative; in certain places the calm sea can suddenly become violent and change shores that seem "protected" into shores that are dangerously "exposed." Some organisms that live on exposed shores cannot live here because the transitional shore is often too calm. Others that live on the protected shores cannot live here because of the frequent violence. Transitional sand and gravel beaches typically have few organisms because of the scouring action of moving sand and gravel, but the cracks, crevices, and tidal pools house a wide assortment of rocky shore animals.

Procedures

1. Find a large picture of a surf-swept seashore and a picture of a calm, protected seashore. Ask the students to describe the characteristics of each type of shoreline. Who has visited a surf-swept seashore? What was it like? Has anyone visited a calm seashore? What was it like? Locate these beaches on a wall map. Is there a pattern?

2. Show the students the transparency "Exposed, Protected, and Transitional Shores," page 25. Ask the following questions: Do surf-swept beaches occur on the outer coast, or along coastlines that have islands and reefs? (The outer coast.) Explain why protected shores are protected. (Protected shores have offshore islands to shelter them, or bays and inlets to provide shelter from the full force of waves.)

3. Would a mud flat occur at point a or point c? Why? (A mudflat would not occur at point a because the waves and currents would carry mud particles away.)

4. Ask the students to draw their own map showing an exposed, protected, and transitional coastline. Draw islands, inlets, and bays. Include a legend.

5. Ask the students to collect pictures of different types of beaches. Classify the pictures into exposed, protected, and transitional. Make a bulletin board display.

Brain-Buster Questions

1. Why are gravel beaches on exposed coastlines frequently called "graveyards"? (Few organisms can live there because of the constant scouring action of moving sand and gravel.)

2. Are West Coast beaches eroding? (Yes.) What evidence is there that the ocean is eroding away coastal areas? (All the haystack rocks and small islands on the exposed West Coast.)

Enrichment Activity

As a follow-up to the above activity, have the students explore the following metaphorical questions:

If the seashore were a battleground between the land and the sea, what would be the:

- Battleground
- Generals
- Land's weapons
- Cease-fire
- Sea's weapons
- Victors
- Losers

When would the two armies fight?

When would the scene or battleground be calm?

> ### *Teacher's Note*
> This is an introductory lesson. Encourage the students to brainstorm and make inferences about each type of beach. Future lessons describe each type of seashore and explore how organisms are adapted to survive in each environment.

Identifying the Type of Seashore

Concepts

1. Basically, coastlines have five different types of shores: rocky shore, sandy beach, cobblestone beach, mud flat, and estuary.

2. Each type of shore has different physical conditions, such as the type of bottom; stability; abrasiveness; and amounts of moisture, sunlight, and oxygen.

3. Plants and animals are adapted to survive on a particular type of shore.

Understandings

The students will be able to 1) sort pictures into groups according to the type of shores, 2) describe the physical characteristics of each type of shore, and 3) brainstorm the hazards to organisms of living on each type of shore.

Materials

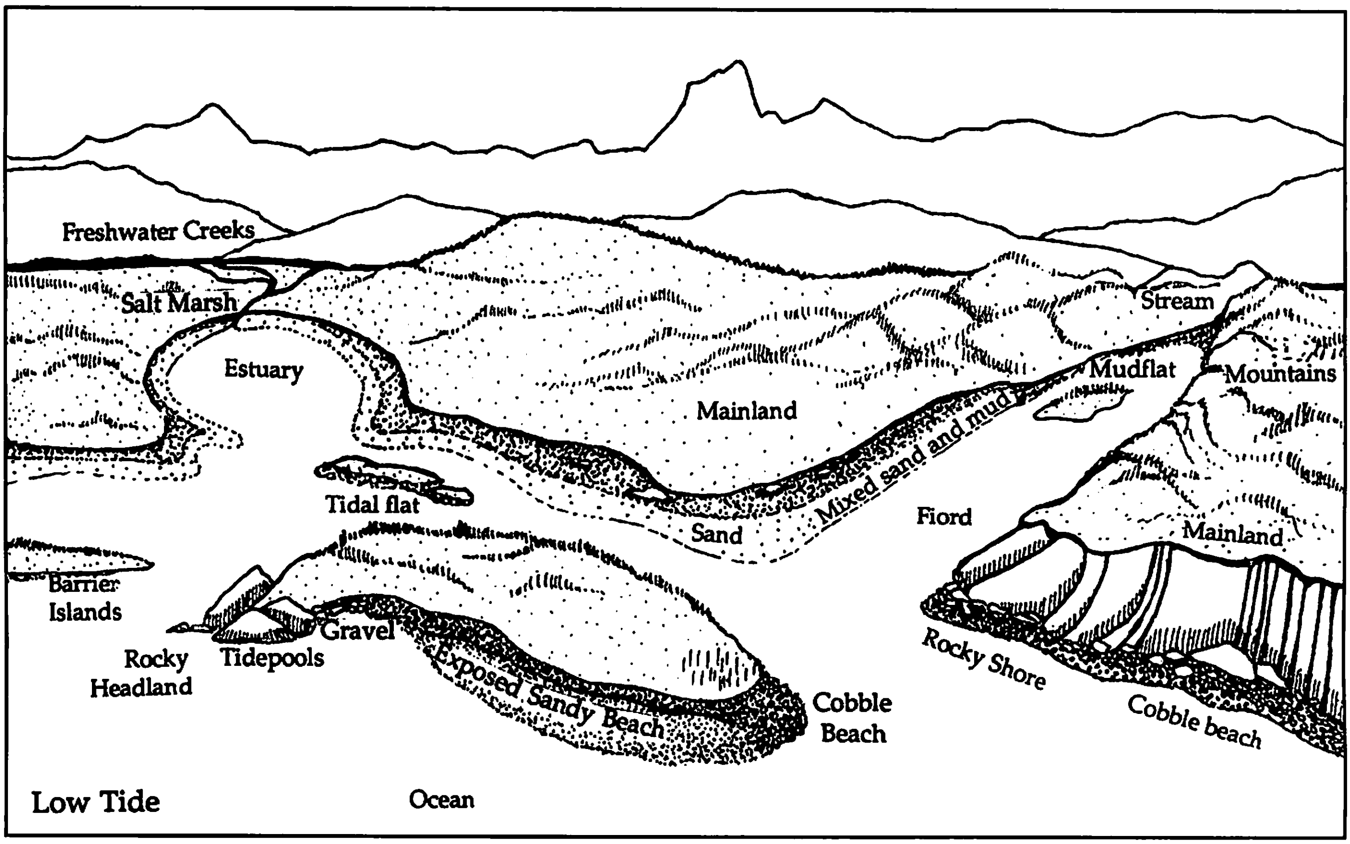
Transparencies:

"Types of Seashores" p. 56 "The Rocky Shore" p. 191

"The Cobble Beach" p. 226 "The Sandy Beach" p. 238

"The Mud Flat" p. 265

Pictures of rocky shores, sandy beaches, cobble beaches, mud flats, estuaries, and salt marshes



Teacher Information

A Rocky Shore

Rocky shores can be basalt, granite, or sandstone. They can be steep or have a gentle slope. Depressions and crevices often hold water after the tide has gone out, leaving interesting tidal pools. Rocky shore plants and animals have special attaching devices to allow for holding onto rocks. Often the thick growths of seaweed protect them from waves and from drying out. Generally speaking, the rocky shore is stable and therefore is home to a great diversity and abundance of species.

A Cobblestone Beach

A cobblestone beach sheltered from strong wave action provides a mixture of cobbles, gravel, sand, and mud. Certain animals here, such as clams and worms, can burrow readily. Many animals living here are associated with the rocky shore; especially animals that live on rocks or under rocks. Generally, animals live "in" the beach rather than on it.

A Sandy Beach

On sandy beaches of the outer coast the constant movement of sand creates an unstable and therefore unfavorable environment for most organisms. Animals on exposed sandy beaches must, therefore, protect themselves: some dig or burrow into the sand, and most, such as shrimp, are free-moving and able to reestablish themselves when the wave action slows. Sandy beaches in protected areas become mixed with fine mud and have a greater variety and number of plants and animals than exposed beaches.

A Mud Flat

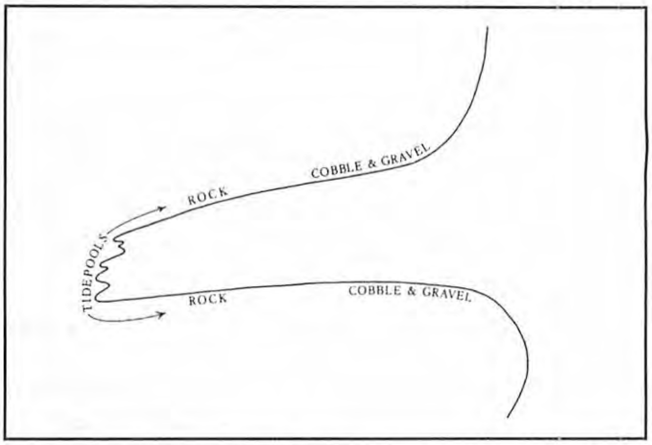
Mud mixes with sands, gravels, and varying amounts of water so that some mud beaches are firm enough to walk on, while others are soupy. Mud flats form only in the most protected bays where fine sediments are able to settle. Mud flats have few hard surfaces for places of attachment, and the problems of moving, food gathering, and breathing are great. Thus, animals live either near the surface or in tubes or shallow burrows open to it.

Salt Marshes and Estuaries

An estuary is an important environment between the land and the sea. It's a place where the waters of all rivers and streams eventually drain into the ocean. Salt marshes are low-lying, nearly flat marine wetlands that form a unique habitat for wildlife. Salt marshes can be huge, with hectares of grasses dominating, resembling a flat pasture. Estuaries and salt marshes serve as nurseries, feeding places, and shelter for a wide variety of wetland animals.

Types of Seashores

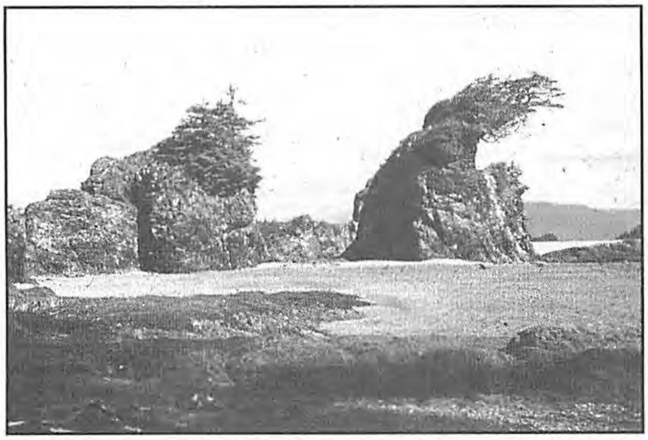
Fog-shrouded Heceta Head in Oregon is a basalt headland exposed to the full fury of violent surf.



Headlands usually consist of rocks more resistant to erosion than the beaches on either side. Tidepools frequently occur at the base of the cliff. Depending on the strength of the offshore current, there will be gravel or boulders on one side and frequently on both sides. Because of the constantly tumbling rocks, these boulder and gravel beaches generally have no large intertidal plants and animals.

Arching white waves advancing against a sandy shore at Long Beach, Vancouver Island, British Columbia.

Pounded by violent storms and currents, this gravel beach near Long Beach, B.C., is too hostile for seashore plants and animals.

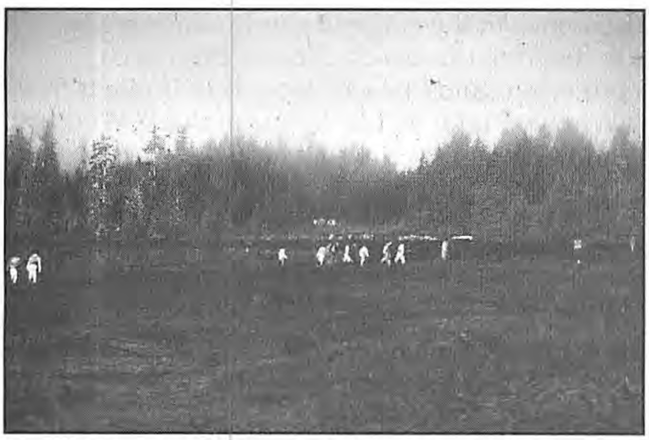


Sculptured trees: a sure sign of a wind and surf-swept shore, on the west end of the Deer Group in Barkley Sound, B.C.

Cobbles alternating with sand, a typical beach in Puget Sound and the Georgia Strait.

Sea Lettuce on a protected cobblestone beach, a rich assortment of clams below the cobbles.

Tall trees at the tideline: a sure sign of a protected shore. Salt Spring Island, B.C.



Junior high students explore mud flat near Bamfield, B.C.

Salt marsh grasses, pickleweed, and eelgrass extend to low tide level in tidal estuary.

Procedures

1. Ask the students to collect pictures of different types of seashores (post cards, magazine pictures, photographs, tourist posters, etc.). Cut these pictures out.

2. Ask the students to share their experiences of the different types of seashores. How many students have been to a rocky shore? Sandy beach? Mud flat? Cobble beach? Estuary? Salt marsh? Where were these shores located? What do people tend to do on each type of seashore?

3. Divide the class into groups of four or five. Ask the students to sort the pictures into groups according to the type of shore.

4. Make a class set of photo copies of the transparency "Types of Seashores," page 56, only white out the names of the physical features. List these on the blackboard. Challenge the students to locate and label as many physical features on their maps as possible.

5. Use the transparency, "Types of Seashores," to help the students label their maps. Use sticky papers to cover the names

of physical features. Remove the sticky papers as the students identify the appropriate features.

6. Show the overhead transparency of the "Rocky Shore" (page 191). Write the word "rocky shore" on the blackboard. Ask the students to list as many words as possible that describe the rocky shore.

7. Brainstorm physical conditions on this type of shore. What are the hazards of living on this type of beach? What are the benefits?

8. Compare pictures of protected rocky shores and exposed rocky shores that receive the full force of beating surf. What evidence is there that one shore is protected and the other is exposed? In which picture are the waves higher? For seashore plants and animals, how might living on these two beaches be different?

9. Show the transparency of the exposed sandy beach (page 238). List words to describe this beach. How is this beach different from a protected sandy beach? How is it different from the rocky shore? What would it be like to live in sand? What do we know about sand? What does it feel like?

10. Show the transparency of the mud flat (page 265). Describe what this seashore looks like. Has anyone been to a mud flat? What was it like? Has anyone walked in a mud flat? What might be the hazards of living in a mud flat?

11. Ask the students to infer which type of seashore supports the most organisms. The least? Why?

12. Which type of seashore is the students' favorite? What kinds of things do they do on rocky shores, sandy beaches, mud flats?

Brain-Buster Questions

Would an organism that lives...
...in a mud flat be able to live on a rocky shore?
...on a sandy beach be able to live on a rocky shore?
...on a rocky shore be able to live on a cobble beach?
...in a salt marsh be able to survive on a rocky shore?

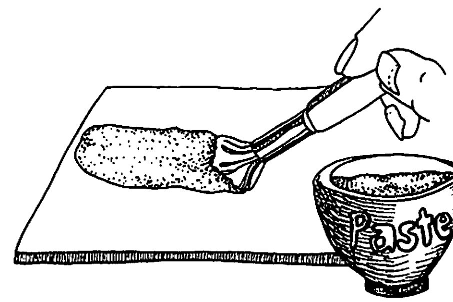
Enrichment Activities

1. Make a bulletin board of types of seashores.

2. Draw a map of the coastline. Locate rocky shores, sandy beaches, cobble beaches, mud flats, estuaries, and salt marshes. Make a key with symbols for the different types of seashores. Locate these types of seashores on the map.

Miniature Model Seashores

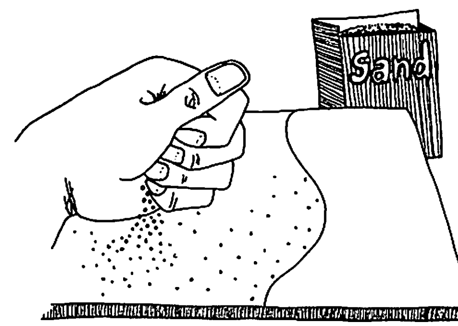
The whole class will have fun working together to make this miniature model seashore.



Materials

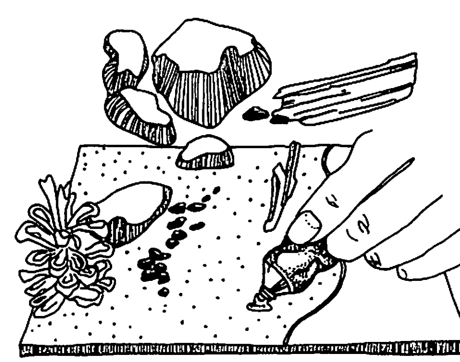
Sand	Table
Hardboard (masonite)	Tiny pine cones
Dried pieces of seaweed	Driftwood
Glue	Beach pebbles
Brushes	Blue tempera paint

1. On a hardboard, draw an outline of the seashore; include the tree line, high tide line, low tide line, boulders, logs, tidal pools, etc. (If possible, refer to the students' field notebooks.)



2. Brush paste evenly over the sandy areas, then cover them with sand. When the paste is dry, shake the loose sand onto newspaper. Place the hardboard on a table.

3. Paint the ocean and the larger tidal pools with blue tempera paint.



4. Arrange and glue on tiny pebbles and driftwood in clusters to look like boulders and logs. Then glue on small pine cones to look like trees, and bunches of dried seaweed to look like seaweed beds.

5. Finish the seascape by adding clay and/or papier-mâché animals.

6. (Optional) Have each team put a flag on its tidal pool (or habitat) study site.

Seashore Bulletin Boards

1. Make a bulletin board of types of coastlines and seashores. Label the pictures.

2. On a separate bulletin board, draw a map of the nearest coastline. Locate rocky shores, sandy beaches, cobble beaches, mud flats. Make a key with symbols for the different types of beaches. Use strings or yarn attached to pins to show where different types of beaches are located.

Creative Writing

1. Pretend you're a beach pebble. Tell about important events and changes time has brought.

2. Write a story about what happens on this beach on a typical day. Or write a story about what happened to you on a particular type of seashore.

3. Pretend you're an artist. What do you like about this seashore? What do you not like? What would you change?

All Living Things Have Needs

Concepts

1. An organism is a plant or an animal.

2. Seashore plants and animals have needs much like those of humans, although these needs are satisfied in different ways.

3. All living things have similar needs for food, water, shelter, and space to survive.

Understandings

The students will be able to 1) brainstorm questions about seashore animals, and 2) identify similarities and differences in basic needs of humans and seashore animals.

Teacher Information

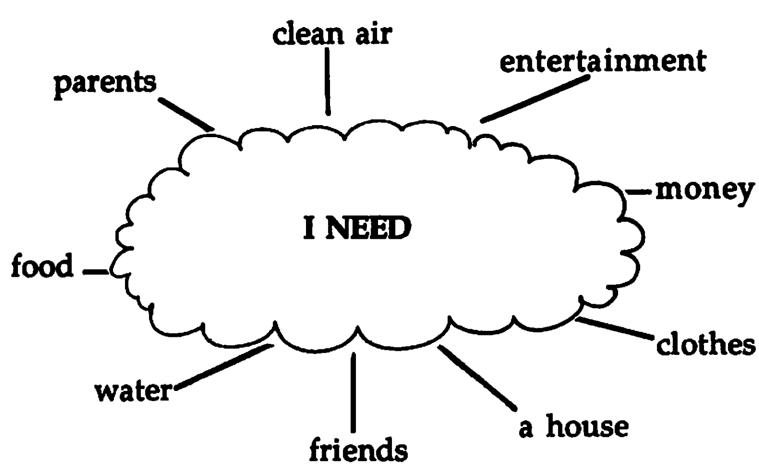
For these first field trip experiences, it's important that students learn that all organisms have basic survival needs. All human babies and whale babies have basic needs. Both are mammals. All organisms need food, water, shelter, and space to survive. Sometimes we forget that all living things have basic needs and depend on one another for survival.

Procedures

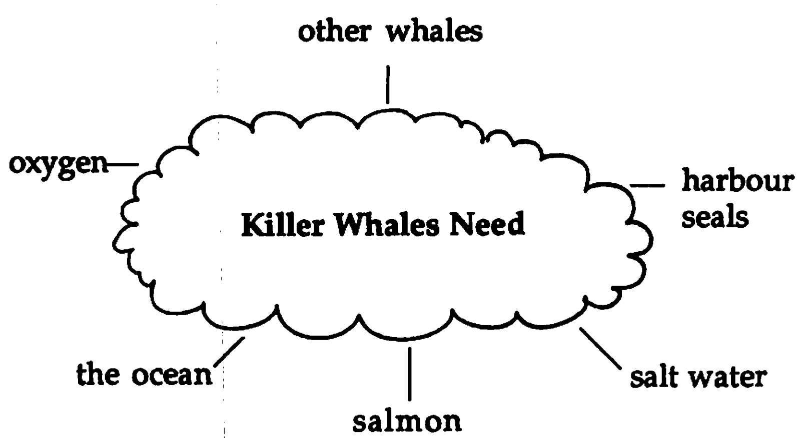
1. Write the words "plants" and "animals" on the blackboard. Ask the students to brainstorm the names of plants and animals. With the student's help, list these under the proper heading. Brainstorm the characteristics of plants and animals. Write the students' ideas on the blackboard.

2. What plants and animals do the students think they will find at the seashore? List these on the blackboard. Or challenge the students to make a list of all the seashore organisms they can think of. Who has the biggest list? The students can add to the list over the course of the unit.

3. How are humans and seashore organisms alike? How are they different? Write the students' ideas on the blackboard. What does it mean to survive? What do humans need in order to survive? Write their ideas on the blackboard.

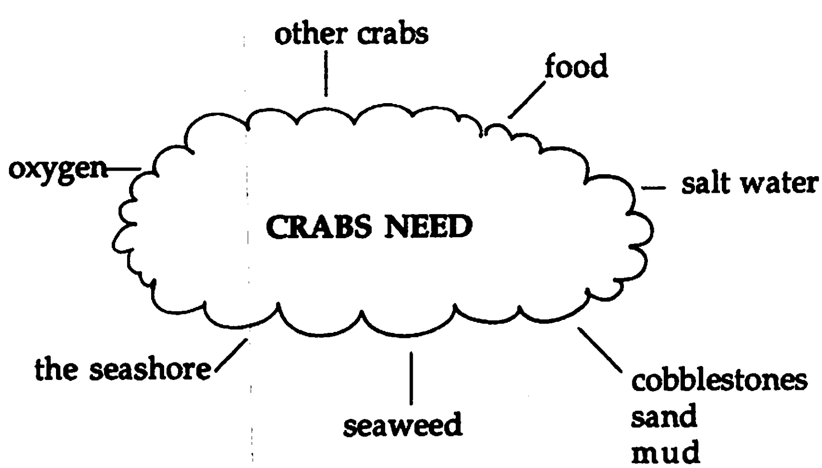


4. What do whales need in order to survive? What do sea stars, barnacles, and Tidepool Sculpins need to survive? Summarize the discussion by reminding the students that although humans and marine animals are obviously different, they all share many basic requirements.



5. What do gulls need to survive...sea stars...crabs? Summarize the discussion by reminding the students that although humans and seashore animals are obviously different, they all share basic requirements for food, water, shelter, and space.

6. Brainstorm what Purple Shore Crabs need to survive.



7. Is there more than one kind (species) of crab? Who can name different species? Remind the students that although all crabs have similar basic needs, each species of crab has particular food, shelter, and space requirements. This is because there are many species of crabs and each species is equipped to survive in its own type of habitat. Purple Shore Crabs, for example, live on rocky or cobblestone beaches, and could not survive long on protected sandy beaches or mud flats. By comparison, the wide-ranging Edible Crab, or Dungeness Crab, prefers to live off-shore or on protected sandy beaches and in eelgrass beds, and the Kelp Crab prefers to live in kelp beds.

Identifying the Type of Habitat

Concepts

1. A habitat is the natural home of a plant or animal.

2. Plants and animals can be grouped according to the type of habitat in which they're most frequently found.

3. Each type of habitat has different physical conditions such as temperature, moisture, sunlight, and available oxygen.

4. A population is a group of organisms of the same kind living and reproducing in the same area.

Understandings

The students will be able to 1) identify types of habitats, 2) identify and count populations of organisms in different habitats, 3) describe the physical characteristics of different habitats, 4) infer the components of habitats that are essential for most seashore animals to survive, and 5) build a model of a habitat.

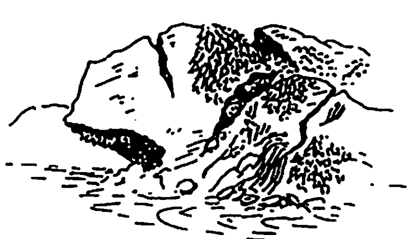
Teacher Information

Generally speaking, there are two types of habitats: large-scale habitats such as rocky shores, sandy beaches, and mud flats; and small-scale habitats such as tidal pools, on rocks, and in crevices. By learning small-scale habitats, students can predict where on a shore a plant or animal is located, simply by locating a particular type of habitat.

On Rocks

Depending on the location on the shore, rock faces and boulders can be exposed for long periods of time to sun, wind, extreme temperature changes, rapid changes in salt content (salinity), currents, and pounding surf. Plants and animals living on rocks must have special methods of attaching themselves to those rocks, otherwise the current would carry them away. They also must have special methods of keeping from drying out when the tide goes out.

In Crevices



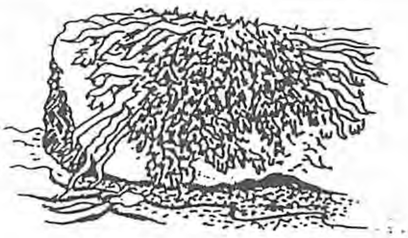
The cracks, crevices, and holes on rocks provide shaded, moist retreats from the sun for some animals, snails, limpets, and small crabs. Some crevices hold water, and thus enable the plants and animals to survive higher on the shore than they would normally. Crevices also provide protection from pounding surf.

Under Rocks

The under-rock habitat is continuously moist, and animals living there cannot survive long in the sun. Crabs, Brittle Stars, blennies, and Northern Cling Fish hide under the rocks at low tide, and tube worms adhere to the undersides of the same rocks.

Among Seaweeds

The holdfasts, stipes, and fronds of seaweeds provide food and shelter for a host of animals, especially those without protective shells. Some seaweeds, such as Rockweeds and Eelgrass, act as a nursery for small snails and limpets, while shrimps, crabs, amphipods, isopods, and worms cling to the stems, fronds, and holdfasts of kelp. When the tide goes out, the massive beds of Rockweeds protect hordes of small animals from the hot sun and from predators.

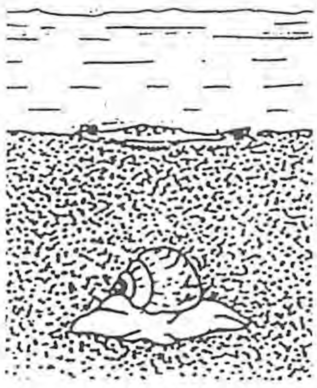


In Tidepools

A tidepool is a small pool of water left on a rocky shore when the tide falls. It provides shelter for plants and animals that cannot stand exposure to air during low tide periods. Every tidepool contains a community of plants and animals: some are bottom dwellers; some attach themselves to the sides; others are free-swimming.

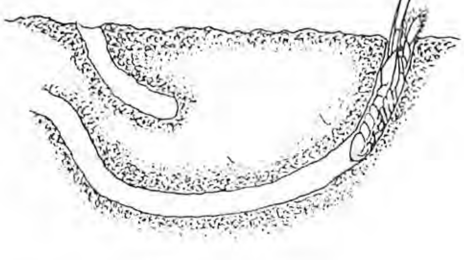
In Sand

Animals living in surface sand must be able to move freely as the sand moves and then reestablish themselves when the sand stops moving. Several species of little amphipods, isopods, worms, shrimp, and fish live at the surface and may become temporarily dislodged when water sloshes over them. The few strictly burrowing forms must be able to dig rapidly (the notoriously fast Razor Clam of the outer coast); or have heavy shells to protect them from the harsh, abrasive action of moving sand (the Horse Clam, Butter Clam, and Cockle Clam).



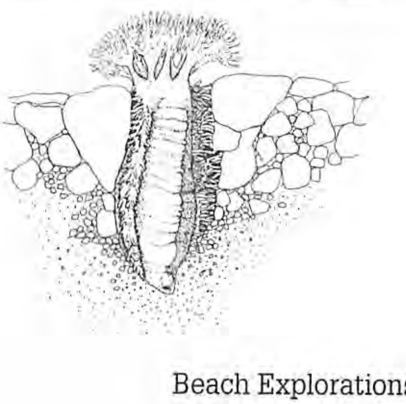
In Mud

Because mud does not allow for the free movement of oxygen, animals live either in tubes or in burrows open to the surface. Mud Clams have soft and fragile shells and siphons open to the surface for food and oxygen. Mud Shrimp live in burrows open to the surface and are able to move oxygen-rich water through the burrow.



Burrowing in Mixed Cobble, Gravel, Sand, and Mud

Few plants and animals can survive the tumbling action of the constantly moving gravel beaches on the open coast, but in protected waters, where there is a little wave action, gravel mixes with sand, broken shell, cobbles, or mud and provides a loose bottom on which burrowing animals can burrow easily. This is the home of clams with their comparatively thick, protective shells, and of an assortment of burrowing worms.



Classroom Advance Organizer

1. Ask each student to draw a quick picture of his or her own house. Then, have them draw a close-up of their own bedroom. They should include windows, doors, the heater, lights, bed, curtains, decorations, etc.

2. Review the basic needs of all organisms (pages 62–63). Once the drawings are finished, have a discussion about whether or not they could get all their needs met for food, water, shelter, and space if they never left their bedrooms. If not, where do they go? They go to the refrigerator to get food. They go to the living room for entertainment. They go to the bathroom, etc. What needs do they get met in the house? Discuss the fact that people go outside their homes to get their needs met. Can people get their needs met in the neighborhood?

3. Write the word "habitat" on the blackboard. What is a habitat? Write the students' ideas on the blackboard.

4. What types of habitats exist in the forest? (Fallen logs, decaying logs, hollow trees, ponds, streams, water lilies, burrows in the ground.)

5. What habitats exist in the marine environment? In different words, what types of "homes" exist at the seashore? Write the students' ideas on the blackboard. Lead the students to conclude that there are many different types of marine habitats: on rocks, under rocks, in tidal pools, etc.

6. How is a house or neighborhood like a habitat at the seashore? How is it not like a habitat at the seashore? (Allow for open-ended responses.)

7. Imagine what it would be like to be a marine animal living on rocks...in mud...in a tidal pool. What would your life be like? How would your needs be met? What would be problems of survival?

8. For each type of habitat, what would happen when the tide goes out to sea? Predict which type of habitat would retain moisture the longest. (Tidal pool.) The next longest? The least? (The on-rock habitat in full sun.)

9. Which type of habitat would have the least amount of oxygen? (Mud.) The most oxygen? (The on-rock habitat.) Why? (It's exposed to air.)

10. Which type of habitat could have the greatest changes in salinity? (A spray pool high on the shore.) Why?

11. Which type of habitat would it be the most difficult to move around in? (Though mud flats can have very different consistencies, problems of moving about can be very difficult.)

12. Reinforce the fact that each species of plant and animal has its own special adaptations to be able to survive in a particular type of habitat.

13. Engage the students in a discussion about loss of habitat. As humans put more and more stresses on the marine environment, more habitats are lost as homes for plants and animals.

Consider the following questions:

- Would an organism that lives in mud be able to live on rocks?
- Would an organism that lives in tidal pools or in deep water be able to survive if it were stranded on rocks at low tides?
- Which type of habitat would retain pollution the longest? (Mud.) Why?

Measuring the Temperature of Habitats

Use thermometers to measure the temperature of different habitats located at various positions on the beach. Determine the temperature of a tidal pool and try checking it again later in the day. What is the temperature of the air? The ocean? What is the temperature on rocks, in crevices, inside mussel beds, among seaweeds, under rocks, in sand, and in mud? What is the temperature of tidepools at different heights on the shore? Are some warmer than others? Why?

Questions for Discussion

- How would air temperatures and tidal pool temperatures change in the winter?
- How would the salt content of the water vary with the weather?
- Would animals lower on the shore be better or worse equipped to survive extreme temperature changes?
- How do tidal pool plants and animals survive under such extreme temperature changes? Discuss barnacles, snails, limpets, sea stars, mussels, shore crabs, sculpins.

Habitat Data Sheet (optional)

This activity is designed to help students identify types of habitats at the seashore, and to begin to identify some of the physical factors that make up a habitats.

1. Some seashores have a variety of types of habitats. If time permits, have the students observe and describe different types of habitats at the seashore. Prior to the field trip day, investigate the field trip site to discover what types of habitats occur. Rocky shores have a variety of habitats; others less so.

2. Divide the students into groups of three or four. Each group should select one type of habitat drawn from a hat. Tell the students that they're to sketch a rough map of their habitat, showing any distinguishing features as well as the position of plants and animals. They should identify, count, and record the numbers of each organism they find in their habitat. Include a sketch and brief description. Consider light, wetness, and type of bottom. Use the Habitat Data Sheet (next page).

3. If possible, each group should present its observations and findings to the class at the seashore, pointing out the distinguishing characteristics of each type of habitat and the organisms that live there.

4. Or, back in the classroom, each groups shares its findings with the class. Compared to other types of habitats, do they consider their habitat densely or sparsely populated? Why? What observations did they make? What inferences did they make?

Habitat Data Sheet

Date ____________________ Group ______________________________________

Habitat Type

- ☐ On rocks
- ☐ Under rocks
- ☐ Rock crevices
- ☐ Tidal pool
- ☐ Spray pool
- ☐ Mixed sand and mud
- ☐ In mud
- ☐ In sand
- ☐ Among seaweeds

Sketch a map of your habitat. Show any distinguishing features, as well as the position of plants and animals.

Organism	Number	Habitat characteristics

How Big is a Habitat?

Concepts

1. An animal's habitat is its location (or the area in which all its needs are met).

2. An animal's range is the area in which members of its population are distributed.

3. An ecosystem is a collection of plants and animals living and interacting in a common area, and dependent on one another for survival.

Understandings

The students will 1) describe an organism's habitat and range, and 2) infer why Pacific Coast organisms occupy different ranges.

Materials

Photocopies of the map, "West Coast of North America ," inside front cover.

The following Pacific Coast Information Cards:

Checkered Periwinkle	Bald Eagle	Moon Jellyfish
Purple Shore Crab	Killer Whale	Sea Otter
Tidepool Sculpin	Rockweed	Spiny Lobster
Purple or Ochre Sea Star	Chinook Salmon	Bull Kelp
Sand Dollar	Beluga Whale	Gray Whale
Alaska King Crab	Brown Pelican	Mole Crab
Garibaldi Fish	Harbor Seal	California Sea Lion

Teacher Information

An animal's habitat must include food and water, the necessary space and shelter to rear young, protection from predators, and protection from the prevailing physical conditions. At the seashore, habitats must provide the necessary protection from weather (sun, wind, rain, snow) when the tide goes out, and protection from shore predators. When the tide is high, or when a habitat is covered with seawater, the habitat must provide food and shelter from intertidal predators as well as big fish that move in from deep water.

Every plant and animal has a range or area in which members of its population are distributed. For example, the habitat of a Purple Shore Crab is a rocky or cobble shore (on rocks, under rocks, and in tidal pools), but its members are distributed along the entire Pacific coastline from Alaska to Baja California. The habitat of a particular Bald Eagle might be the forest and shoreline near its nest situated at the top of the tallest cedar tree at the northern tip of Vancouver Island, B.C. Its species occupies a much greater range, along the entire coastline of North America as well as from coast to coast.

The populations of some organisms are widely distributed. The common Purple or Ochre Sea Star occurs on rocky shores from northern Alaska along the entire Pacific coastline to southern California. By contrast, the Alaska King Crab occurs in deep water from the northern British Columbia coast to northern Alaska, while the Spiny Lobster occurs no further north than southern California.

The most obvious reason that marine organisms occupy different ranges is water temperature. Due to large-scale currents, the water temperature of the southern California coastline is considerably warmer than that of the British Columbia or Alaskan coastline.

Procedures

1. Ask the students to recall the pictures of their own bedrooms. Recall that they needed to go outside their bedrooms to meet their needs. They had to go to the kitchen, bathroom, and living room. People also have to go outside their homes to get their needs met. Summarize the discussion by emphasizing the fact that every organism needs a home: pets, plants, shore crabs, gulls, and Killer Whales. Talk about a neighborhood. Broadly speaking, for plants and animals we call the small-scale "home" where they get their needs met their *habitat*, and the large-scale neighborhood or community where they get their needs met their *ecosystem*.

2. Ask the students to discuss the habitat of a Bald Eagle. How big is its habitat? How far must it travel to meet its needs? Consider a pair of eagles nesting in a tall cedar tree in the local area (or choose a familiar marine animal).

3. Ask the students to discuss the range of Bald Eagles. Where are all the places that Bald Eagles occur? Locate their range on a map. How is an animal's range different from its habitat?

4. How big is an organism's habitat? Of the Pacific Coast Information Cards listed above, which animals would have the biggest habitat? The smallest habitat? Which organisms have the biggest range?

5. Which organisms range the entire coastline from northern Alaska to southern California? Which organisms occupy a more northerly range? A more southerly range?

Brain-Buster Questions

1. Brainstorm reasons why organisms would occupy different ranges. Try to identify the most important factor in determining the distribution of organisms along the Pacific coastline.

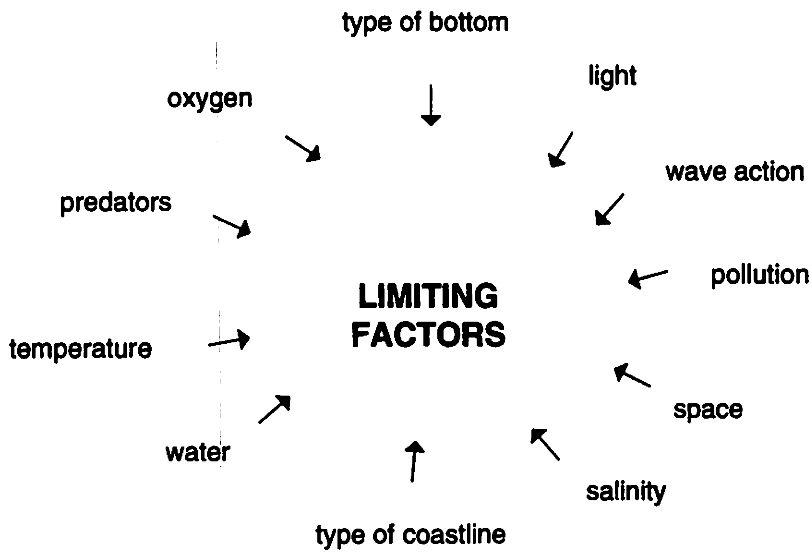
2. Why do some organisms range the entire North Pacific coastline, while other organisms occupy a more restricted range?

3. Discuss the fact that the range of many marine animals has decreased in recent years. Ask the students to brainstorm which marine animals' ranges have decreased. Brainstorm why an organism's range might be decreasing or increasing.

Teacher's Note

To enrich this lesson, duplicate a class set of ,"West Coast of North America" maps, inside front cover. Challenge the students to use the map and the information in the Pacific Coast Information cards to identify the range (and if appropriate, the migration route) of various marine mammals, birds and invertebrates.

Limiting Factors



Concepts

1. Limiting factors (e.g., food, water, shelter, space, and pollution) influence the ability of an organism to survive.

2. Some limiting factors are natural; others are the result of human activity.

Understandings

The students will be able to 1) brainstorm limiting factors for the seashore, and 2) categorize limiting factors as natural or the result of human activity.

Teacher Information

Several factors affect life in the marine environment. Some of these are natural; that is, these physical factors are in the marine environment regardless of human activity. Among these are light, temperature, the salinity or salt content of the water, oxygen, the type of seashore, and the degree of wave shock. Other factors are not natural; they're the result of human activity. Among these are oil spills, pulp mill effluent or sewage, and logging above the beach. Human activity can remove oxygen from water and damage or destroy habitats.

The type of coastline affects life in the marine environment. Whether an organism lives on a surf-swept rocky shore or a protected rocky shore affects the amount of oxygen available in the water. The type of seashore affects life in the marine environment. Whether an organism lives on a rocky shore, sandy beach, or a mud flat affects whether it's exposed to the drying effects of the dropping tide, or can burrow deep into sandy or muddy bottoms to keep moist. In addition, the type of habitat also affects life in the marine environment; some animals can

Teacher's Note

This is an introductory lesson. The concepts will be dealt with again in future lessons related to specific types of seashores.

survive in several habitats, for example, snails and limpets occur on rocks, in crevices, in tidal pools, and among seaweeds. Other animals are more restricted and can survive only in one type of habitat. All these factors put stresses on seashore plants and animals and affect the location, distribution, and diversity of organisms on a shore.

Procedures

1. What do human beings need to survive? Review the need for food, water, shelter, temperature control, clean air, protection from physical abuse, and so on.

2. Write the words "Limiting Factors" on the blackboard. Ask the students to brainstorm factors that might limit the ability of a plant or animal to survive in the intertidal. In different words, what factors might put stress on (or kill) plants and animals in the intertidal? Write their ideas on the blackboard.

3. Classify the list of factors into "natural" factors and "human" factors.

Caretakers of the Seashore

Concepts

1. All living things depend on their habitat for survival.

2. Humans have a responsibility, as caretakers, to minimize stress to seashore organisms and habitats.

Understandings

The students will be able to 1) describe characteristics of the "on-rock" and "under-rock" habitats, 2) infer possible causes of stress to seashore organisms, 3) brainstorm and practice rules for the proper care and handling of seashore organisms, and 4) brainstorm and practice rules for minimizing the destruction of seashore habitats.

Materials

Transparencies:

"Cobblestone Hotel"

"Cobblestone Hotel Turned Over"

Thermometers

Teacher Information

Think what would happen to a small beach if 30 students turned over rocks, dug up the sand and mud, and carted animals away to die in buckets or suffocate in poorly prepared aquariums. Once an area has been visited by one group of unthinking individuals, it would take a long time to recover. Many seashore plants and animals are specially equipped to live in particular places: on rocks, under rocks, in tidal pools, under seaweeds, in sand or mud. Many seashore organisms live extremely long lives and don't move around very much. If several of their kind are destroyed, reproduction may not occur and it may take years for the species to regain a foothold in the area. It's possible to visit the seashore and cause very little damage, but only if we understand that the plants and animals at the seashore are living organisms, just like us.

Because the students will be exploring the seashore firsthand and conducting investigations with living organisms, your major task during this first field trip is to encourage the preservation of the beach and to teach the careful handling of seashore organisms prior to their arrival at the seashore. As well, young students will inevitably want to bring shore crabs, hermit crabs, snails, and even sea stars back to the classroom, or take them home as pets. In this first lesson, students come to understand that all living organisms have special needs, just like us.

Classroom Advance Organizer

For students to understand the concept of preservation at the seashore, they must have an understanding, at least in part, of these related concepts: habitat, tidal cycle, desiccation, predator, protection, and survival. One way of attempting to sensitize students to such complex, abstract concepts prior to their first field trip is to use instructional metaphors. You can lead the students to understand the concept of a habitat by exploring the metaphor "A cobblestone is a hotel" or "A cobblestone is an apartment complex." Lead a discussion to compare the assemblage of plants and animals living on and under a cobblestone to a group of people living together in a hotel. This metaphor helps the students understand survival at the seashore because it allows them to relate their present observations at the seashore to their previous concrete experiences with how hotels protect people from burglars and harsh weather conditions.

Effective use of metaphors requires a classroom atmosphere that allows the students to speculate and test ideas. Focus on the gathering of observations, the verbal explanation of ideas, and the understanding of concepts.

Procedures

1. Show the "Cobblestone is a Hotel" transparency (next page). Encourage the students to identify plants and animals that live on the topside of the cobblestone. Do you think animals live under the rock? If so, what animals? Ask the students to predict what will happen if we turn the rock upside down. (Some students will not know that animals live under the rock, while others know that depending on the location many animals such as shore crabs, blennies and worms will slither to get out of the way.) Allow for an open-ended discussion in which there are no right or wrong answers.

2. Tell the students that we are going to turn the rock upside down, then show the, "Cobblestone Hotel Turned Over," transparency. Goodness! Look at all the animals! Let's identify animals that live under the rock! Again, ask the students to predict what they think will happen to the plants and animals if we leave the cobblestone on the beach upside down. Allow for an open-ended discussion.

3. Engage the students in a more focused discussion. Ask the following questions:

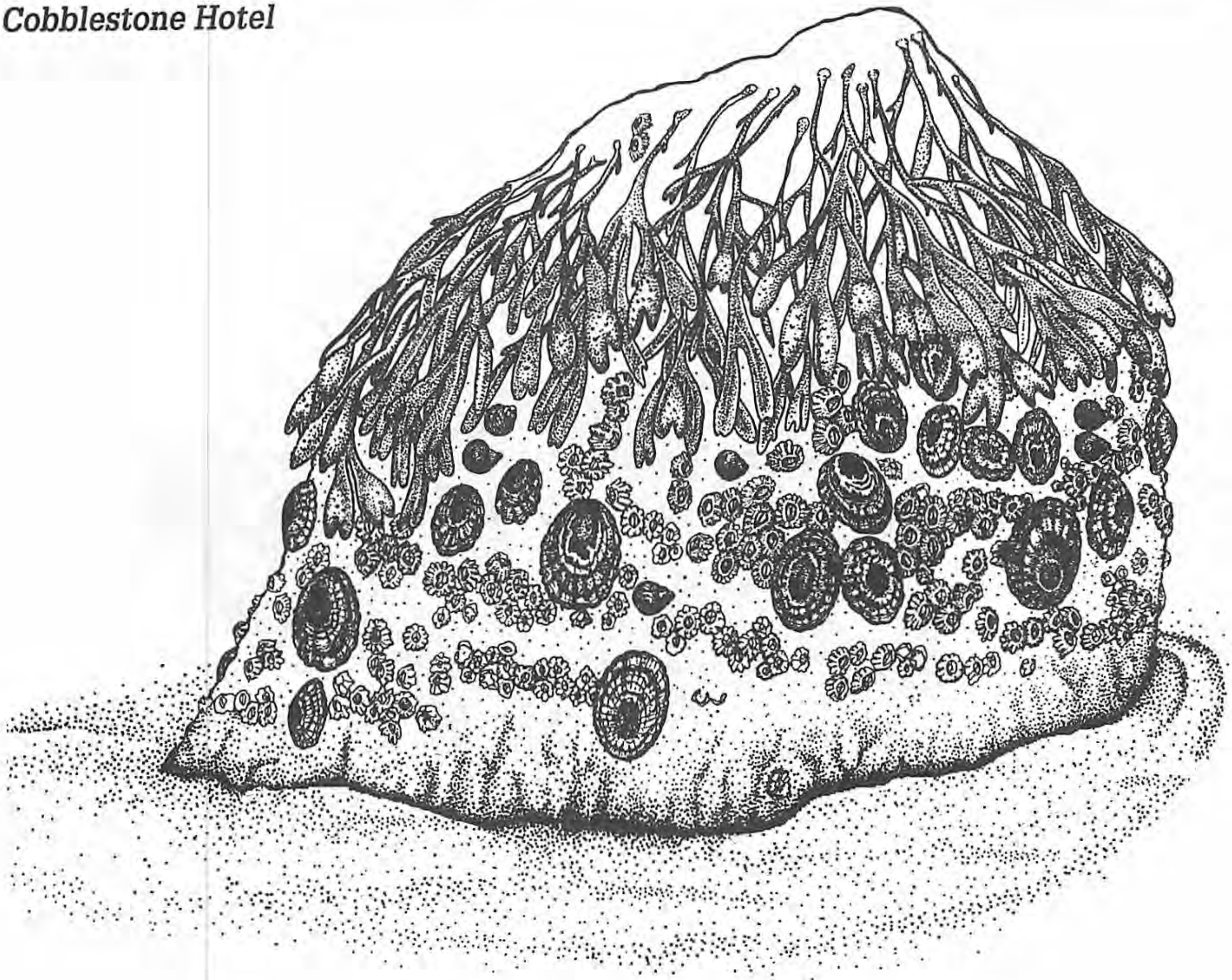
a. Which habitat has the greatest range of temperature? (The on-rock habitat.) Which habitats have a more stable temperature? (Under the rock, in sand and mud, among the moist Rockweeds)
b. Which habitats retain the most moisture when the tide goes out? (Under the rock, in sand and ` mud, among the moist Rockweeds.)
c. What organisms live on the topside? (Limpets, barnacles, snails, Rockweeds.) How are these organisms able to survive exposed to air, wind and sun? (Hard, moisture-filled shells, moisture-laden Rockweeds.)
d. What organisms live attached to the rock's underside? (Flatworms, Tiny Tubeworms.) How are these organisms adapted to survive? (Flattened, elongated shape.)
e. What animals live under the rock? (Purple Shore Crab, Porcelain Crab, Brittle Star, High cock scomb Blennies.) How are these animals adapted to survive? (Wedge-shaped body; elongated body; able to scramble or slither into moist crevices or spaces; if pinned down, able to remove an arm or leg.)
f. What animals live in the sand or mud under the rock? (Sand worms, nemertean worms.) How are these organisms able to survive? (Burrowing; narrow, elongated shape; if pinned down, able to move into moist spaces, able to break in two and regenerate body parts.)

g. What would happen to the animals that live on the topside if the rock were suddenly turned upside-down? (Some would be crushed; some would die of starvation.)

h. What would happen to the animals that live under the rock? (Animals that are not able to quickly relocate their position may be exposed to drying out and are easy prey to shorebirds.)

i. What would happen if one unthinking student left one rock turned upside-down at the seashore? How many rocks might one student turn over in a day? How many organisms might one student condemn to death in one day? (Thousands, perhaps millions.) How many rocks might a class of 30 students turn over in one day? What would happen if several classes visited the same beach during one week? The year?

Cobblestone Hotel

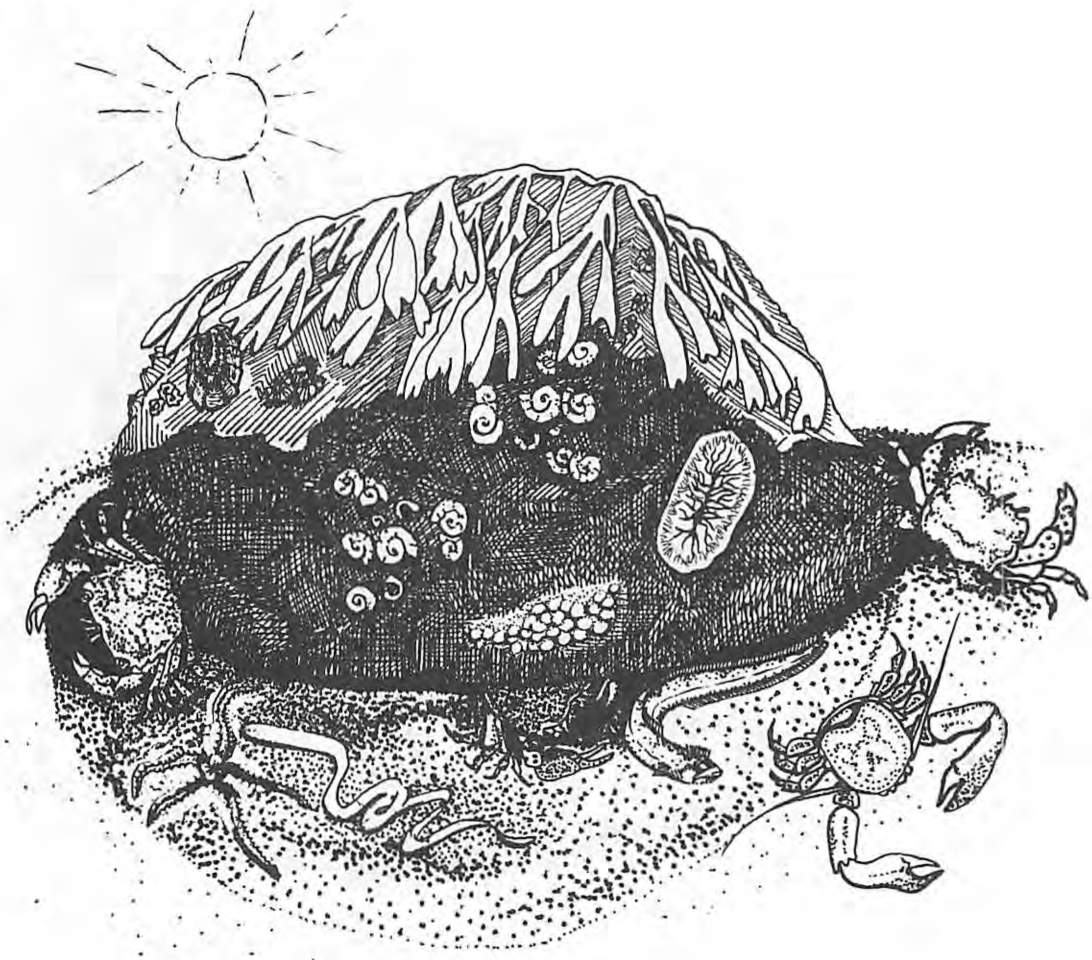


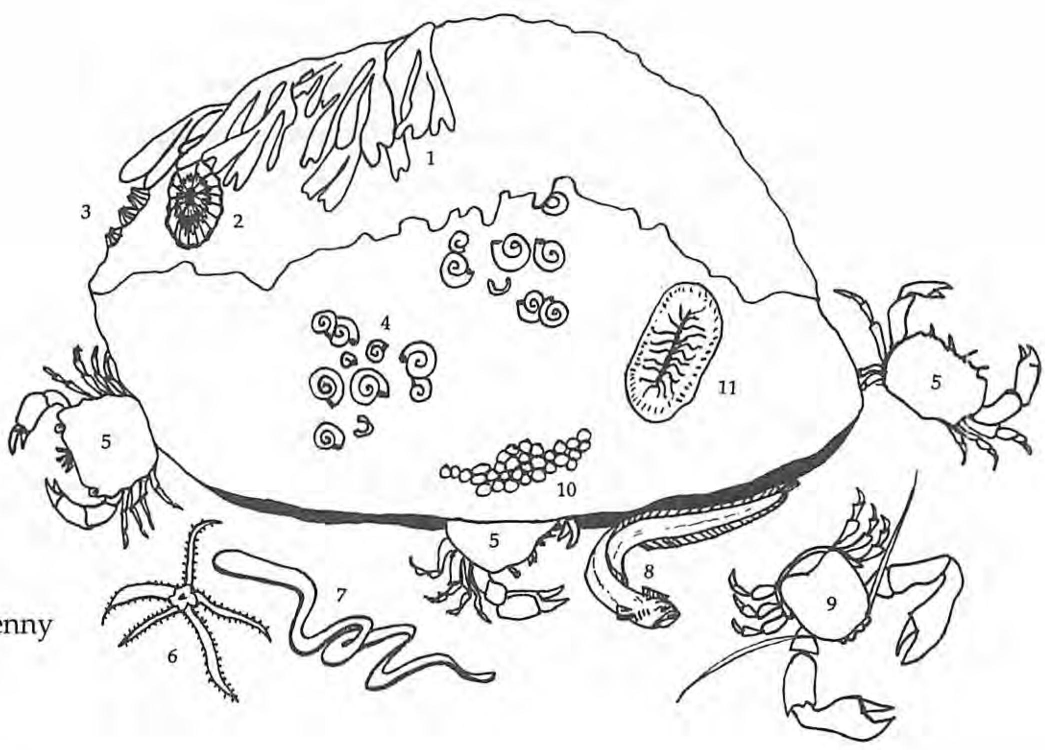
What plants and animals live on the top side of the cobblestone?

Do animals live under the rock? If so, what animals?

Predict what might happen if we turn the rock over.

Cobblestone Hotel Turned Over





Key

1. Rockweed
2. Limpet
3. Acorn Barnacle
4. Tiny Tube Worms
5. Purple Shore Crab
6. Brittle Star
7. Nemertean Worm
8. High Cockscomb Blenny
9. Porcelain Crab
10. Fish eggs
11. Flatworm

Exploring the "Cobblestone is a Hotel" Metaphor

Engage the students in an open-ended discussion designed to explore the cobblestone metaphor. Write the metaphor questions below on the blackboard.

If a cobblestone were a hotel (or apartment complex), what would be its:

- Basement
- Rooms
- Hallways
- Top floor (penthouse)
- Restaurant decorations
- Permanent residents
- Temporary residents
- Top-floor residents
- Ground-floor residents
- Basement residents
- Furnace
- Air conditioner
- Hotel restaurant
- Janitor
- Hotel manager

Why?

Can a resident move from the basement to the top floor? Explain.

Can a resident move from the top floor to the basement? Explain.

How is a cobblestone not like a hotel?

Why is it important to return all of the rocks gently to their original position on the beach?

Brainstorm Ways to Protect Seashore Plants and Animals

The students should set standards for their own behavior before they go to the seashore. In other words, what course of action is needed? What rules need to be followed? Encourage the students to brainstorm rules for their behavior at the seashore. Accept all suggestions. Ask probing questions to get to the reasons for their suggestions. What might be the consequences of an act? Each time the students return from the seashore, brainstorm additional rules for the proper care and handling of seashore plants and animals, and for minimizing destruction of the seashore. Write their ideas on the blackboard or large flip-chart paper, and keep these for future use:

Rules for Handling Seashore Animals

1.
2.
3.

Rules for Protecting the Seashore

1.
2.
3.

Teacher's Note

See pages 85 and 261 for additional metaphorical thinking activities.

Remember:

- If you turn a rock upside down, you may be dooming some barnacles to a slow death by starvation and drying out.
- If you don't return the rocks to their place gently, you may be breaking a crab's shell.
- When you remove a 20 cm square segment of mussel bed, you're destroying more than 6,000 living creatures.

Seashore Observation

Soon after your arrival at the seashore, locate a cobblestone (or small boulder) at about the high tide or middle tide zone. As much as possible, choose a cobblestone with barnacles, Checkered Periwinkles, and limpets inhabiting the topside, tiny tube worms and flatworms adhering to the underside, shore crabs scrambling from underneath the rock, and worms crawling in the mud and sand under the rock. Ask the students to observe the cobblestone closely. What animals live on the top side, adhere to the underside, or live in the sand and mud under the rock? When they turn over the cobblestone, what do the animals do?

- Do the animals move away quickly?
- Do they close up or go into tubes?
- Do they bury themselves in the sand or mud?
- Do they stay quite still so they're difficult to see?
- Do they make themselves look threatening?
- What else do they do?

If possible, take the temperatures of the air above the rock, the shade of the rock, and the watery sand under the rock. Which locations retain moisture the longest? Review how organisms are specially equipped to live on the rock, under the rock, or burrowing in the sand or mud under the rock.

Review the "hotel" metaphor, and the importance of carefully returning all cobblestones to their original position, so that animals don't dry up and die before the tide returns, or get eaten by hungry shorebirds such as gulls and crows.

Handle Seashore Animals with Care

Tell the students that they can have fun observing seashore animals up close, but they should always handle all seashore animals with care. Here are some techniques for minimizing stress to seashore animals.

Materials

Plastic buckets	Zip-lock plastic bags
Dip nets	Clear plastic aquariums
Hand lenses	Field notebooks and pencils (optional)

Gather a group of 7–10 students around a tidal pool (parents or helpers can be trained to do this activity with small groups.) Give the students dip nets to catch sculpins, hermit crabs, etc.

Discuss the importance of using dip nets rather than hands to capture and handle fish (fish have a protective slime covering their bodies.) Why is it important to put an animal in a bucket or freezer bag filled with seawater? What is stress? Do people experience stress? When? Could seashore animals experience stress? When? How might they minimize stress to seashore animals?

Put animals such as Tidepool Sculpins, blennies, or hermit crabs in clear zip-lock freezer bags filled with seawater—one or two per bag. Pass these around. Encourage the students to observe carefully. They should consider the following:

- What can they observe? What colors do they see? What patterns?
- Where in the tidal pool does this animal live?
- How does the animal move?
- If observing a fish, why does it open and close its mouth?
- What might this animal eat? How does this animal get its food?
- What questions do they have?

After all of the students have had a chance to observe their catches, discuss the importance of putting the animals back into the tidal pool (or in shallow water). As much as possible, attempt to put animals back in the same tidepool. Some fish are very site-specific. How long can we observe an animal in a freezer bag or bucket filled with seawater before it will start to experience stress? (5–15 minutes.) What possible problems might seashore animals experience? Why? Discuss the following:

- Temperature changes
- Loss of moisture
- Loss of oxygen
- Fright

Can we remove any animal and put it in an aquarium or plastic bag?

- What about animals cemented to rocks, such as barnacles?
- What about limpets, chitons, and sea anemones that plaster themselves to rocks and can be extremely hard to get off? These animals should be observed in their place of attachment. Remove these animals only if they're attached to a small rock that can be moved and put in a plastic aquarium filled with seawater. Then return the animal, still attached to its rock, to its original location on the shore.
- Put animals back into the same tidepool. Some fish are very site-specific.

Use a dip net to capture Tidepool Sculpins, Sand Soles, and Blennies. Handling fish will remove the slime covering that protects them from infection and disease.

Handle all beach critters as little as possible, or not at all. Observe small animals such as fish, hermit crabs, isopods, shrimps, and nudibranchs briefly in zip-lock freezer bags filled with seawater, then let them go.

Classroom Follow-up

Ask the students to recall their behavior at the seashore. Did they follow all the rules for protecting seashore plants and animals? Now that they have had experiences at the seashore, they may be more fruitful in generating ideas for preserving seashore organisms and habitats. What new rules do they need to add to their list?

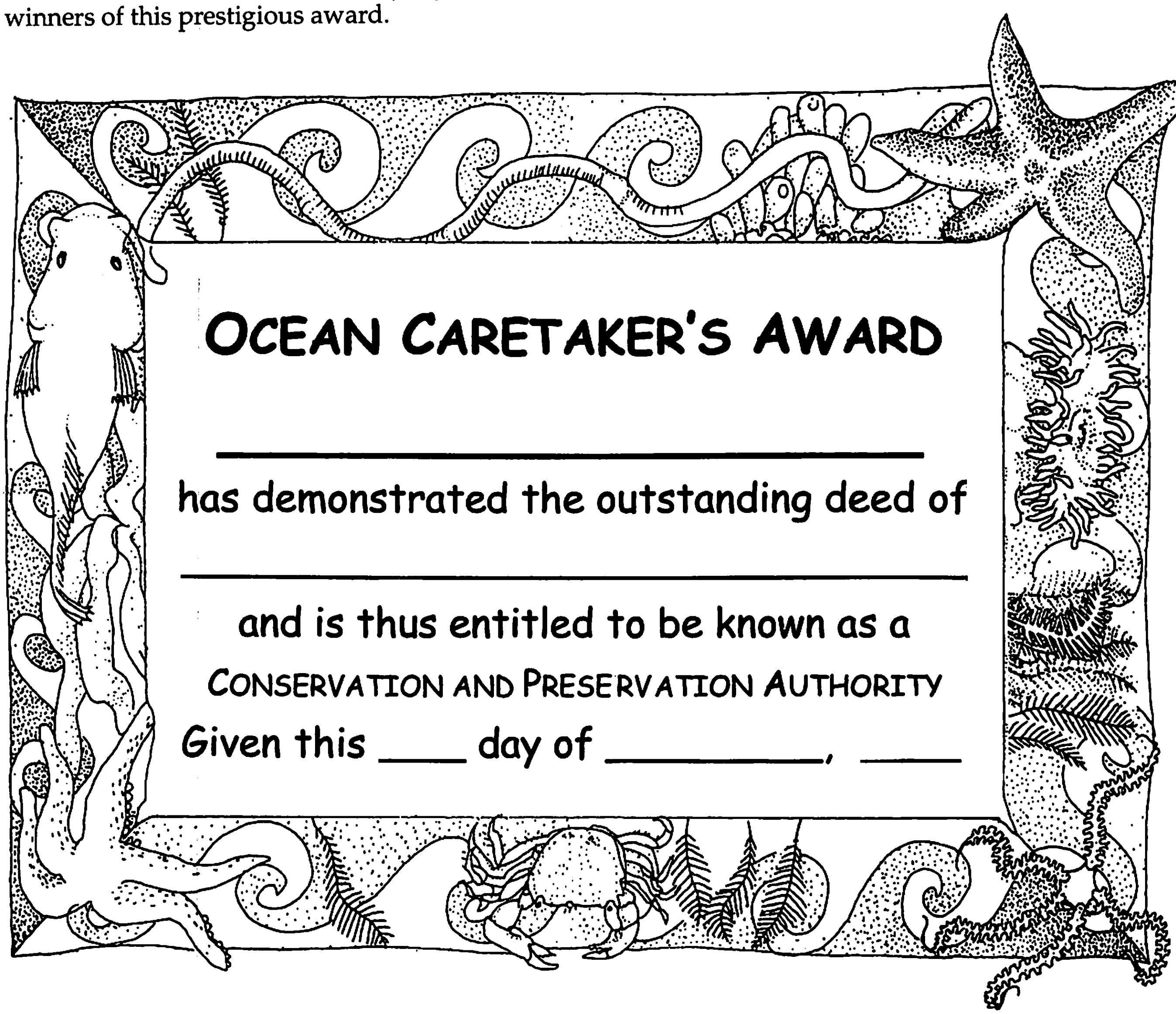
Creative Writing

Draw a "cobblestone hotel," showing the location of various seashore residents. Write a story emphasizing how life changes for the various organisms from high tide to low tide.

Ocean Caretakers Award

The Ocean Caretakers Award is a certificate showing that a student has accomplished outstanding achievement in the field of conservation and preservation of seashore organisms and/or habitats. Awards are granted to individuals who have achieved outstanding deeds, for example: generating the most important rule, diligently following rules for protecting seashore animals, inventing new ways to protect habitat, writing letters to protect habitat, etc. The students will have fun inventing new categories for awards.

The teacher or class can act as a judge to determine the winners of this prestigious award.



OCEAN CARETAKER'S AWARD

____

has demonstrated the outstanding deed of

____

and is thus entitled to be known as a

CONSERVATION AND PRESERVATION AUTHORITY

Given this ____ day of __________, ____

Marine Ecosystems

Concepts

1. Marine ecology is the study of the interactions between the organisms of the sea and between these organisms and their environments.

2. A marine ecosystem is a collection of plants and animals living and interacting in a common area, and dependent on one another for survival.

3. All the plants and animals in a particular ecosystem are connected by food chains and their nonliving environment.

Understandings

The students will be able to 1) draw a map or mural of their own community, 2) compare a seashore ecosystem to a human community, and 3) infer how seashore plants and animals depend on one another for survival.

Teacher Information

The word *ecology* has different meanings to different people. If we were to use the word *ecology* only as it is strictly defined by ecologists, it would refer to the study of how organisms interact with the physical (nonliving) and biological (living) parts of their environment. The word *ecology* is often incorrectly considered synonymous with *environment*. Thus, we read of the need for "proper management of the ecology" or that a pulp mill is ruining the "ecology of the estuary." In this book, ecology is used in the stricter sense.

The oceans of the world are marine ecosystems. The ocean may be divided into a number of ecosystems which occupy very different collections of plants and animals. Rocky shores, sandy beaches, cobblestone beaches, mud flats, and estuaries are all marine ecosystems. Even tidepools are marine ecosystems. Each marine ecosystem is an interacting system that consists of marine organisms and their nonliving environment. All definitions of ecosystems (environments and communities) emphasize the concept of interactions, system, and interdependence.

The very nature of ecology requires that some terms be loosely delineated in scope. For example, the term *community* refers to a collection of plants and animals living in a common habitat and dependent on one another. Communities can vary in size from the organisms living on a seaweed frond to all the living organisms on a rocky shore. Often an organism that far outnumbers other organisms in a particular area may determine the name of the community, so we may speak of the "kelp-bed community," the "mussel community," or the "barnacle community."

As students observe living organisms at the seashore, they become aware of the amazing diversity of organisms and their life cycles. They observe how plants and animals interact with one another and with the type of bottom, nutrients, and sunlight in the vast network of relations that constitute the ecosystem. Thinking about a tidal pool or estuary or rocky shore students think about the ecosystem concept. A tidal pool community is more than a depression filled with seawater. Attached to the rocks are many species of seaweeds. The seaweeds and bottom mud swarm with small crustaceans (amphipods, isopods, shrimp). A variety of snails, limpets, and chitons graze on the seaweeds and line the walls. Tidepool Sculpins dart here and there. Gulls, crows, and other opportunistic shore predators search the tidepools for things to eat. A tidepool is all of these plants and animals living together. The animals depend on the plants for food and living conditions. The plants use sunlight, carbon dioxide, water, and minerals to make food to sustain themselves and other organisms in the tidepool. The interrelated plants, animals, and habitat constitute an ecosystem.

The activities in this lesson can best be understood after the students have explored the seashore and studied a tidepool, a rocky shore, a sandy beach, or an estuary.

Procedures

1. Recall the activity "Animal Homes" on pages 66 and 70 where the students were asked to draw a picture of their own houses. Recall the needs they have that are met in their bedroom, the kitchen, their house. Review the fact that they must go outside their homes to get some of their needs met—for food, water, shelter, and so on. They go to the neighborhood store to buy groceries. They go to a department store to buy clothes and shoes. They go to the doctor if they're ill. Some of their needs are met by persons or services that are delivered to their house: water, gas, electricity.

2. If possible, use a large map of a town or city to locate the business district, the commercial district, the entertainment district, the city center, the industrial area, and a residential district. Why do cities have different districts or zones? What are advantages to living in a community (town or city)? Discuss the concept of interdependence. How do different individuals depend on others for their own welfare?

3. Have the students draw a map or mural of their own community. Include different districts.

4. Discuss seashore communities. How is a tidal pool like a community? How is a rocky shore or sandy beach like a community?

5. Do seashore ecosystems have zones or districts just like human cities? Discuss the spray zone, high tide zone, middle tide zone, and low tide zone. How is each zone like a neighborhood?

6. Discuss the similarities between the communities the students drew and a rocky shore, sandy beach, or mud flat community. In other words, how is zonation at the seashore similar to zonation in a human community? How is a scavenger at the seashore similar to a garbage collector? How are they different?

7. Discuss the differences between the communities the students drew and a rocky shore community. In other words, how are they not alike? (Zonation is caused by physical and biological factors, not social organization, etc.)

Concept Maps

Challenge the students to develop a concept map using the following words: sun, water, plants, plant eaters, meat eaters, death, decomposition.

Pictorial Concept Maps

Challenge the students to invent their own pictorial concept maps to show their understanding of the concept of interdependence. They might illustrate interdependence in their own home, in their own neighborhood, in a tidal pool, a cobblestone, a sandy beach, or rocky shore.

Enrichment Activities

At the seashore, explore a variety of interesting communities:

Snail shell	Boat bottom	Crab's body
Clam shell	Dock piling	Drifting log
Mussel shell	Log on the beach	Floating bottle

How is each of the above a community? What advantages do these organisms share? Are there any disadvantages?

The **Sherlock Holmes Approach**: Measure a one-inch square in different locations. This time use a magnifying glass. Do you notice anything that you're curious about? Can you find any clues to solve The Case of...?

The "Seashore is a Community" Metaphor

The idea of a seashore as a community is an exciting concept. It evokes an image of exploration in our minds. It's a powerful metaphor of our culture—the seashore is houses, factories, neighborhoods, producers, consumers, robbers, recycling depots, treasure houses, and so on. The community metaphor is commonly used by biologists to highlight the ecological aspects of the natural environment, and emphasizes the living together that lies behind the concept of community. The reason that the community metaphor makes our experiences of the seashore coherent is that it makes sense of them—it provides coherent structure by highlighting some things and hiding (or masking) others.

The "seashore is a community" metaphor reflects on our everyday language in different ways. Our past experiences and personal views of communities give rise to at least the following images for this metaphor:

The seashore is families, birth, and growth.

The seashore is houses.

The seashore is zones and neighborhoods.

The seashore is graveyards.

The seashore is factories.

The seashore is balance and harmony.

The seashore is cycles.

The seashore is living together.

The seashore is a system.

The community metaphor highlights very specific aspects of ecology. It's an ecological notion of a community that requires that specific balance of diversity, competition, interdependence, etc. The metaphor highlights the sense of living together that lies behind our cultural notion of community and communality.

In this lesson the students are encouraged to explore the "seashore is a community" metaphor. It's hoped that the students will be able to conceptualize a seashore community in terms of something they understand more readily, namely their own community. This large metaphor includes several smaller metaphors that allow the students to study several concepts. *Habitat* can be explored through the metaphors "a tidal pool is a community," "a mussel bed is a community," and "a cobblestone is a hotel." *Recycle* can be explored through the metaphor "a gull is a recycler." *Energy* can be explored through the metaphor "the sun is a factory," and so on.

This process of comparing a crab to a recycler or a cobblestone to a hotel in order to give it abstract thought by giving it concrete form serves as a key entry point to understanding. The successful instructional metaphor can point to a possible explanation of how the system functions, but it can not give the students an accurate description of what really happens in the system. Usually the metaphor will be simpler than the real system it represents. Such metaphors can provide coherent structure, highlighting some things and hiding other things.

Community Metaphors

This lesson is included to illustrate the use of metaphorical thinking activities to teach seashore relationships. This lesson was taught as a summarizing lesson to a fifth-grade class toward the end of a five-week unit on the seashore. The students had experienced the seashore firsthand, conducted habitat studies, observed plankton with microscopes, and constructed food chains.

Procedures

1. Write some of the following metaphorical comparisons on the blackboard: "The school is a factory," "The teacher is a crab," "The boss is a hard rock," "My grandmother is a gift," "My best friend is a pearl," "Ideas are plants." Engage the students in a discussion about some of the metaphors. For example: Why do we think of schools as factories? What qualities of schools make us think of them as factories? Write their ideas on the blackboard. Students will list such things as: "Schools all look the same," "Everybody is graded," "We march around like in a factory," "We're expected to work," "It's like we're on a conveyer belt."

2. Encourage the students to think of ways that schools are not like factories. "We're not really on a conveyer belt, but it seems like it."

3. Tell the students that every day we make simple comparisons like "The school is a factory." Does anyone know what this kind of comparison is called? Write the word "metaphor" on the blackboard. A metaphor is a comparison between two terms, two things that are not the same, but we treat them as if they were the same. Most of the time we're not aware of the metaphors we use, but every day we use them to help us understand new ideas (or concepts). Can anyone think of other metaphors?

4. Tell the students that today we're going to compare the seashore to a human community, just like the communities that humans live in. Encourage the students to be creative in their thinking, but to think of actual connections.

5. Write the metaphorical comparison below on the blackboard:

If a tidal pool (or seashore) were a community, what would be its:

Residents	Grocery stores	Houses	Delivery truck
Roads	Sanitation department	Factories	Police department
High-rise buildings	Mayor	Underground houses	
When is rush hour?	**Why?**		

Engage the students in a discussion in which there are no right or wrong answers. Attempt to explore the concepts *organisms, habitat, adaptation to habitat, food energy, zonation, tidal cycle, interdependence, balance*, and *community*. Above all, attempt to stress the concepts of *interdependence* and *community.*

The excerpt on the next page is taken from a discussion with fifth-grade students.

Teacher: Today we're going to compare a tidal pool with a human community that people live in. You all live in a community and you have houses and grocery stores, and delivery trucks, and janitors in your community. When we think of a tide pool, we can think of it as having houses, and restaurants, and janitors too, just like a human community. So, if a tidal pool were a community, what would be its residents?

Nathan: Crabs and some small fish like sculpins and sea urchins.

Adam: A sea cucumber, limpets, and barnacles.

Becky: Seaweed and hermit crabs.

Rachel: Sea anemones and periwinkles.

Adam: Plankton.

T: OK good. So all of these different animals and plants and seaweeds would be residents in the tide pool. Can you think of what kinds of things in the tide pool might be houses?

Becky: Shells and rocks.

T: What would live in the shell houses?

Becky: Hermit crabs and limpets.

T: OK, what would be some other houses?

Cynthia: Those little things in the rocks where the limpets put their bodies in. The crevices.

T: OK, good. What would be some other houses?

John: The beer cans and empty bottles.

Arron: Seaweed.

T: Seaweed, OK good. What animals would live in the seaweed?

Arron: Kelp crabs.

T: Would anything else live in the seaweeds?

Jenny: Baby hermit crabs, limpets, and those little juvenile shore crabs.

T: Why would they be in the seaweeds?

Jenny: To protect themselves from drying out.

T: What else might the houses protect the animals from?

Mark: They're hiding from the seagulls and predators?

T: Let's think about this comparison. Would there be grocery stores in a tide pool community?

Cynthia: To the birds, the tide pool would be the grocery store.

T: What would the birds be after?

Cynthia: In the tide pool they'd be after the limpets and mussels. They drop them from the air and break them and then they can eat them.

Nathan: Also, the grocery store is the tide pool itself cause the sculpins and stuff eat the microscopic organisms and stuff.

T: Now think about this comparison. If there are grocery stores in this tide pool community, what would be the delivery trucks? How would the food get delivered to the grocery stores?

Scott: The tide. The high tide would be the delivery truck bringing in the plankton.

T: What kind of seashore animals would be eating the plankton?

Arron: Maybe when it's sunny and things grow fast, like the diatoms in spring, and all the zooplankton are rushing in to eat.

Craig: To me, rush hour would be when the tide comes in the tidepool because the animals are rushing to their homes for safety.

T: What else would be happening when the tide comes in?

Nathan: The biggest sculpins come in and decide to eat all the small ones.

T: OK. Anything else?

Cynthia: It would be rush hour at low tide too when seagulls try to get something to eat.

T: OK. Good. And what is it that the seagulls are after?

Pat: The little crabs and the mussels.

Arron: Maybe when the tide comes in there's some new animals that come in, like big fish that swim in to find something to eat and then swim out again.

T: If you think of a tide pool, would there be janitors or a sanitation system in some way?

Becky: Maybe when a little creature dies and an animal come eats it.

T: OK, and what animals would tend to do that?

Becky: The periwinkles, like the periwinkles in the aquarium.

T: Would a periwinkle be a scavenger? What is it eating?

Nathan: The algae.

T: So what is a scavenger?

Nathan: Animals that are eating dead things, right, like crabs and seagulls.

T: Very good, so what other animals would be garbage collectors, eating dead life, and dying things, dead materials and things?

Nathan: Sculpins.

T: Sculpins certainly would do that.

Nathan: Crabs and that purple starfish we saw eating a dead clam.

Wally: Barnacles.

Alicia: The blue mussels.

T: What else might be delivered by the delivery truck?

Robin: Seaweed, jellyfish might come in, drifting seaweed.

Mark: The kelp like that bull kelp that lands on the beach.

T: What might feed on the kelp?

Scott: Those beach hoppers, those fleas.

Becky: The sculpin would be good for the police department because they can swim very fast without being attacked.

Nathan: Yeah, like that big red crab with the big pinchers.

Jessica: The tide would be the police department too because it controls the traffic.

T: OK. Good. Now if you were to think of a tidal pool, would there be a rush hour? You know how sometimes everything is really busy in a community and other times it's not quite so busy.

T: Would there be other kinds of communities at the seashore?

Becky: Yeah. Where there's animals living in seaweed and then in the rocks and in the sand.

T: So different collections of animals would be in each of those, is that what you're thinking?

Becky: Yeah. There's a community under the rocks and in the mud, and there's a community in the seaweeds, and there's a different community in the tidal pool.

T: Would the community of organisms living in a tide pool high on the shore be the same as a community of organisms living in a tidal pool lower on the shore?

Wally: You could think of the tide zones as creating different communities. The zones could be the police making up the laws about where different animals can live.

T: Would a seashore community be able to survive without homes, or without food, or without a delivery system for food?

Mark: No. All the animals rely on the tide to bring plankton and food.

Jessica: It's just like the barnacles depend on the plankton for food, just like the seagulls depend on low tide for food. It's like the food chain. Everything depends on everything else.

T: So there lots of ways a tidal pool is like a human community. But to be realistic, can you think of ways that a tidal pool is not like a human community?

Tina: Lots of ways. We can get our food at home or in a restaurant, or at the movies.

Scott: Cars in a human community pollute with gasoline and oil and exhaust. But at the seashore, the animals don't really pollute.

T: That's a really good point. Because what happens to their exhaust, if we thought of their waste materials as exhaust?

Scott: Scavengers would eat their waste materials. It's organic. It just decomposes.

T: So what might happens to their waste?

Scott: It just decomposes. It goes back to nature.

T: Great! Are there any other ways a tidal pool is not like a human community?

6. The following metaphorical comparisons highlight the concepts *scavenger, decompose, recycle, tidal cycle,* and *community.*

If a crab were a garbage collector, what would be its:
Garbage
Garbage truck
Garbage crusher
Working hours
Why?
What would be sanitation department?
What would happen if all the janitors and garbage collectors went on strike?

If a seagull were a janitor, what would be its:
Garbage
Garbage bag
Pick-up sticks
Working hours
Why?

7. The following metaphorical comparisons highlight the concepts *habitat, tidal cycle, desiccation, protection.*

If a barnacle (mussel or clam) were a house, what would be its:
Roof
Doors
Walls
Basement (foundation)
Resident(s)
Air conditioning
When would the doors be open? Closed? Why?

If a hermit crab were a motor home, what would be its:
Trailer
Trailer hitch
Driver
Passenger(s)
Headlights
Door
Gasoline
Exhaust
When would the motor home be on the road? When would it be parked? Why?
When would the driver leave the motor home? Why? Would the driver trade the motor home for a new one? Why?

8. The following metaphorical comparisons highlight the concepts *birth, growth, reproduction, life-cycle.*

If rockweeds were a nursery, what would be the:

Babies

Blankets

Cradles

Baby food

Baby sitter

Why?

9. The following metaphorical comparisons highlight the concepts *predator-prey, food chain, interconnections, recycle, system.*

If a tidal pool were a banquet, what would be the:

Guests

Menu

Soup

Meat dishes

Vegetable dishes

Waiter

Leftovers

Dinner table

When is dinner time?

Why?

If the food chain were a necklace, what would be the:

Beads

String

Lock

What would happen if the string broke?

Why?

Chapter 3: Plankton Soup: Microscopic Life of the Ocean

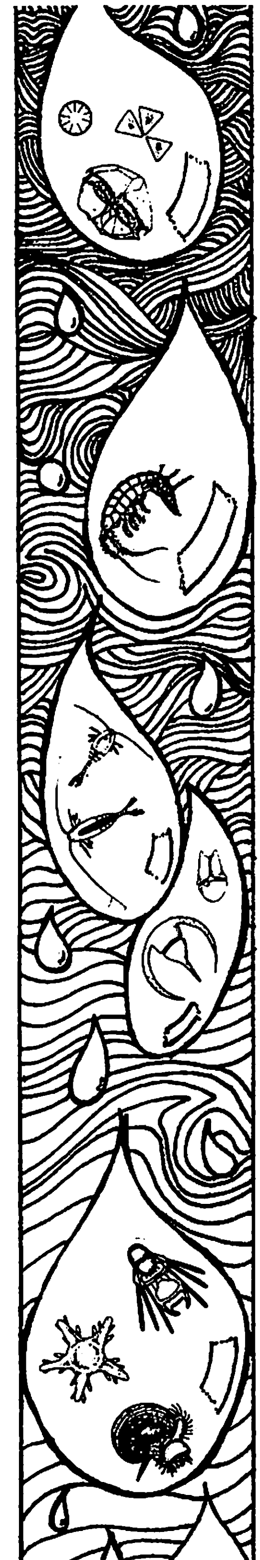
If one takes a bucket of seawater from almost any ocean in the world and strains it through a handkerchief, a brownish sediment will remain on the cloth. If this is examined under a microscope, it will prove to be alive with hundreds or even thousands of individual organisms. Together this large group of individual organisms is known as plankton, meaning "wanderers." They are plants and animals that are able to swim either feebly or not at all, and thus drift in ocean currents.

Each kind of plant and each kind of animal has its own life cycle. By studying the plankton, students come to understand characteristics of living things. Each experience with a living organism should increase the students' awareness of the differences between living and nonliving things and between plants and animals, and of the great diversity of living organisms.

At the seashore, students ask incessant questions about baby animals and reproduction. How does a crab make baby crabs? Is this crab related to that crab? How can I tell the difference between a male and female crab? Upon discovery of egg masses, students ask: Are these eggs? What kind of eggs? How did they get here?

Firsthand experiences at the seashore and with living organisms in aquariums will increase the student's curiosity about how plants and animals reproduce, grow and develop, and care for their young. In this chapter, the students should develop some understanding of a few fundamental concepts:

Male	Adult	Molt
Female	Life cycle	Development
Egg	Fertilize	Diatoms
Sperm	Plant plankton	Dinoflagellates
Birth	Animal plankton	Larva
Growth	Reproduction	Metamorphosis
Nutrient	Photosynthesis	Microscopic



Plant Plankton

Concepts

1. A mixed crowd of tiny plants and animals called plankton drifts near the surface of the sunlit sea.

2. Diatoms and dinoflagellates are tiny, floating plants.

3. Plant plankton need sunlight to grow and reproduce.

Understandings

The students will be able to 1) identify plant plankton, 2) categorize pictures of plants, 3) describe the characteristics of plants, and 4) build models of plant plankton.

Teacher Information

In any collection of plankton, the most abundant organisms are likely to be one-celled plants called diatoms. They are so small that they float easily, supported by water and aided by their spines and oil droplets. When seen under a microscope, many diatoms have a highly decorated shell. Some look like sparkling diamonds or twinkling stars. Diatoms are often joined together in long chains.

Dinoflagellates are another type of plantlike organism found in the plankton. Dinoflagellates are larger than diatoms, and often have one or two whiplike tails which are used for locomotion. Some species are known to produce toxins, and when they "bloom" they create what is called "red tide."

Plant plankton (called *phytoplankton*) remain near the surface of the ocean during the daytime, but tend to sink somewhat at night when the sun's light does not reach them. Plant plankton have a way of producing their own food by using the action of sunlight on the green chlorophyll that colors all green plants. The chlorophyll uses the energy in the light that filters down through the water to form sugars from carbon dioxide and water and give oxygen back to the sea. The organisms use the food they make to live, grow, and reproduce. Because plants need light to grow, the part of the ocean that is lighted by the sun is crowded with plant plankton, but there are no plant plankton where the sea is dark.

Plant plankton are so tiny and so many animals eat them that they must reproduce themselves at a staggering rate so that enough will survive to continue the kind. Most plant plankton reproduce by dividing in two. Diatoms can divide into two new diatoms every 24 hours.

Materials

- Transparency: "Plant Plankton"
- Broom straws
- Tooth picks
- Pipe cleaners
- Colored cellophane
- Paper straws
- Wires
- Clear plastic food containers
- Colored construction paper

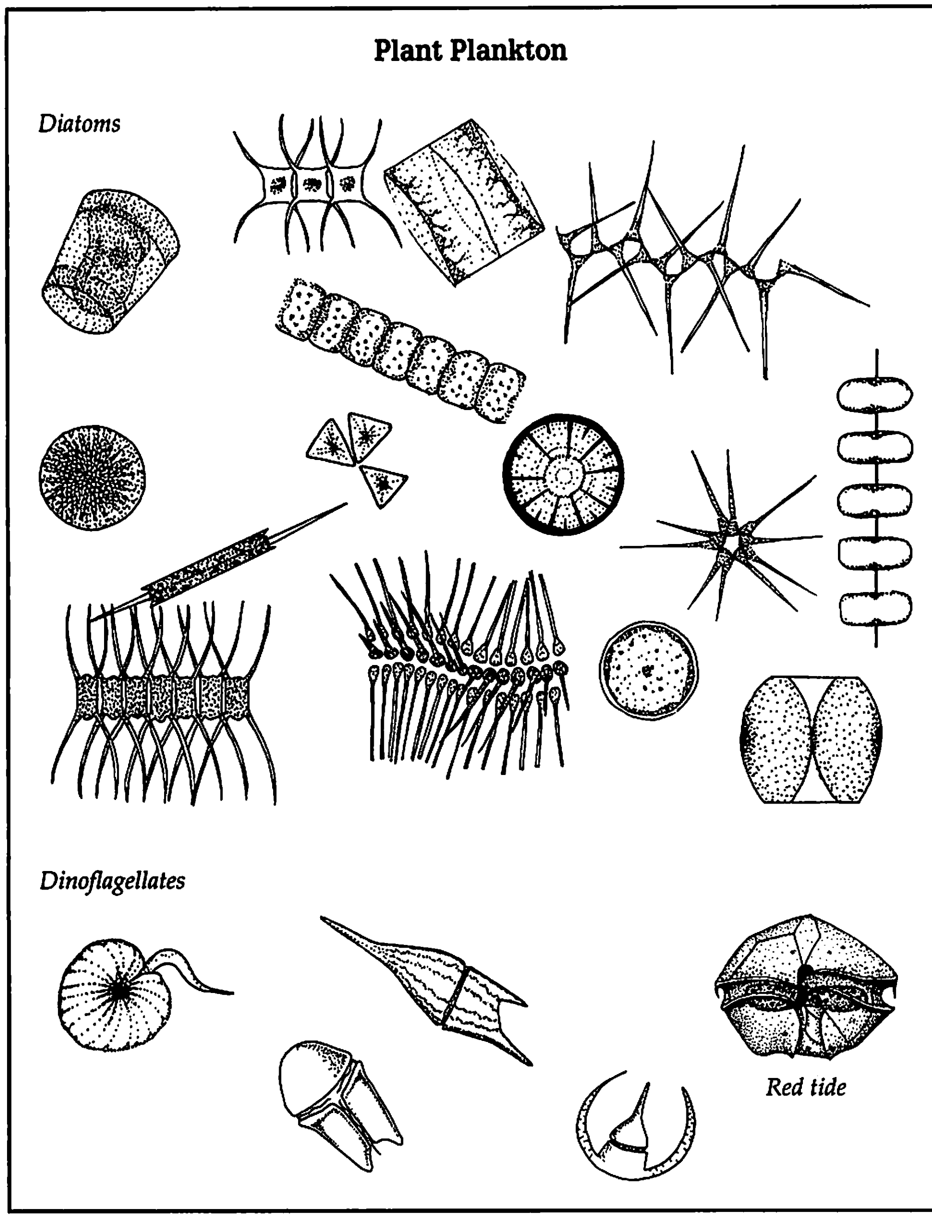
Procedures

1. Collect pictures of plants (trees, flowers, cactus, vegetables, ferns, grasses, seaweeds, etc.).

2. Engage the students in a discussion about plants. What is a plant? What are different kinds of plants? Do all plants live on land? Do plants live in water? (Discuss water lilies and duckweed.) What plants float in water? Observe different living plants. What characteristics do plants have in common? List these on the blackboard.

3. Show the students the "Plant Plankton" overhead. Tell the students that diatoms are one type of microscopic plants that float in water. How are diatoms similar to the plants listed above? How are they different?

4. Tell the students that diatoms and dinoflagellates float near the surface of the sunlit ocean. Why? Discuss the fact that both land plants and water plants need sunlight to grow. What evidence have the students noticed to support this idea? (Plants grow well near a window.)



Diatoms and dinoflagellates

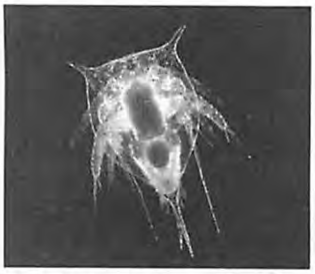
5. How do diatoms float? Brainstorm possible ways that diatoms float in water.

6. Engage the students in a discussion about floating and sinking. What things float? (Metal cubes. Glass cubes. Styrofoam cubes.) Why? How can a piece of aluminum foil be made to sink? If possible, predict what would happen and test out your theories.

Enrichment Activity

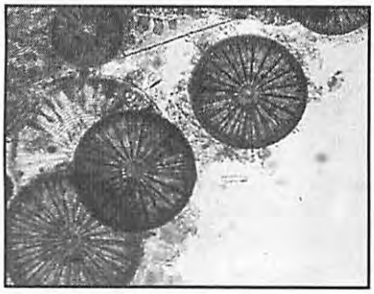
Have fun building models of plant plankton. Ask the students: What is a model airplane? Why do scientists build models? Take the following information into consideration:

- In order to survive, diatoms must float near the surface of the sunlit ocean.



Early barnacle larva, *Naplius*

Sea star larva, *Bipinnaria*



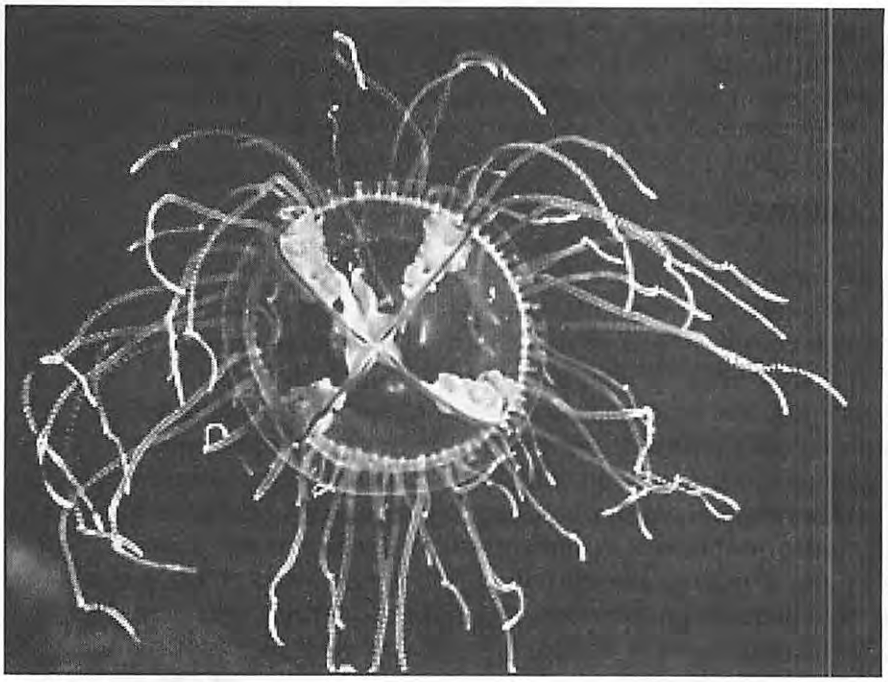
Plant plankton, *Diatoms*

Fish larva

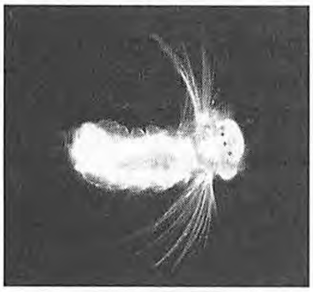
Late crab larva, *Megalops*

- Diatoms are adapted to maximize their time in the surface sunlit areas of the ocean.
- Diatoms can form chains. Is this useful in slowing down the fall of a diatom?
- The tiny size and shape of diatoms gives them a large surface area, which slows their tendency to sink.
- Many species contain oil, and some have long spines which also help keep them near the surface.

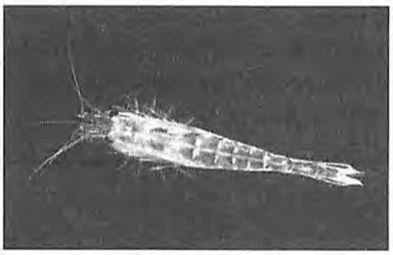
Hang the students' finished models from the ceiling to create an ocean of plankton in the classroom.



Jellyfish, *Gonionemus*



Segemented worm larva, *Polychaete*



Late shrimplike planktonic crustacean, *Mysid*

Early crab larva, *Zoea*

Photos by David Denning, inNature Productions, Salt Spring Island, B.C.

Animal Plankton

Concepts

1. Some animal plankton are temporary, and are the tiny larvae of seashore animals.

2. Some animal plankton are permanent and remain as plankton all their lives.

Understandings

The students will be able to 1) describe characteristics of animals, 2) group pictures of plants and animals, 3) arrange in sequential order pictures of the life cycle of a crab.

Materials

Transparencies:

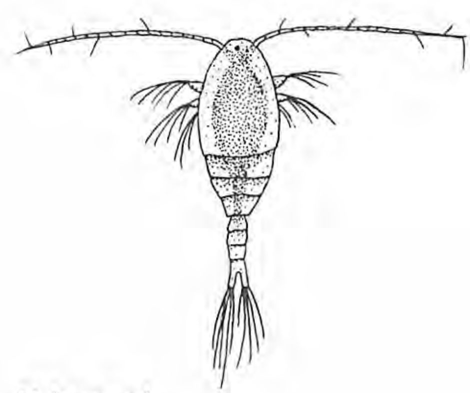
"Permanent Animal Plankton"

"Temporary Animal Plankton"

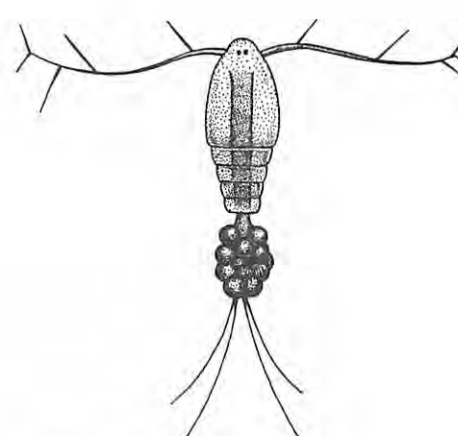
Teacher Information

In contrast to the plant plankton there are the animal plankton, made up of organisms that cannot make their own food like the green plants—they must eat other organisms for food. They usually eat plant plankton, though some of them eat other, smaller animal plankton. Animal plankton (or zooplankton) can be easily distinguished from plant plankton when viewed with a microscope because its members wiggle, swim, or dart about, moving so actively that it's difficult to keep them in the field of the microscope. They're fun to watch under a microscope because they look like dragons with their long bristling legs and long swishing antennae, and because they're so tiny that they continue going about their business of eating and reproducing. In the ocean, however, they're at the mercy of the currents as to where they go.

There are many, many different kinds of animal plankton, but all animal plankton belong to two broad groups. Some animal plankton are "permanent"; that is, they remain plankton all their lives, from egg throughout adulthood. Other animal plankton are "temporary," and are the larvae, or young stages, of such animals as clams, barnacles, crabs, sea stars, and fishes.



Male copepod



Female copepod carrying egg sacs

Permanent Animal Plankton

The most important group of permanent animal plankton are the copepods, tiny animals that swim by means of oar-shaped legs. In fact, the name *copepod* comes from the Greek word *kope*, meaning "an oar." Copepods are easy to identify under a microscope because they're so numerous and because of their odd appearance; pear-shaped bodies and two long antennae that usually point sideways from the head. Most young copepods have a single eye and six legs. Adult copepods still have six legs but may have no eyes, or one eye, or several eyes. Most are less than 5 mm in length, which is about the size of a small grain of rice. Copepods reproduce very rapidly. Some species go through their entire life cycle in 9 to 10 days. After mating, the eggs are laid in two brood pouches, or egg sacs, on either side of the female's tail. In fact, you can watch the eggs hatch into free-swimming larvae under your own microscope. The larvae molt (or shed their skins) several times, but soon reach adult size and begin to reproduce their own kind. Copepods are a very important link in the ocean food chain because they feed on diatoms. A single copepod can have as many as 120,000 diatoms in its stomach at one time.

There are many other different kinds of permanent plankton. Besides copepods, there are amphipods, isopods, comb jellies, arrow worms, krill, and many, many more.

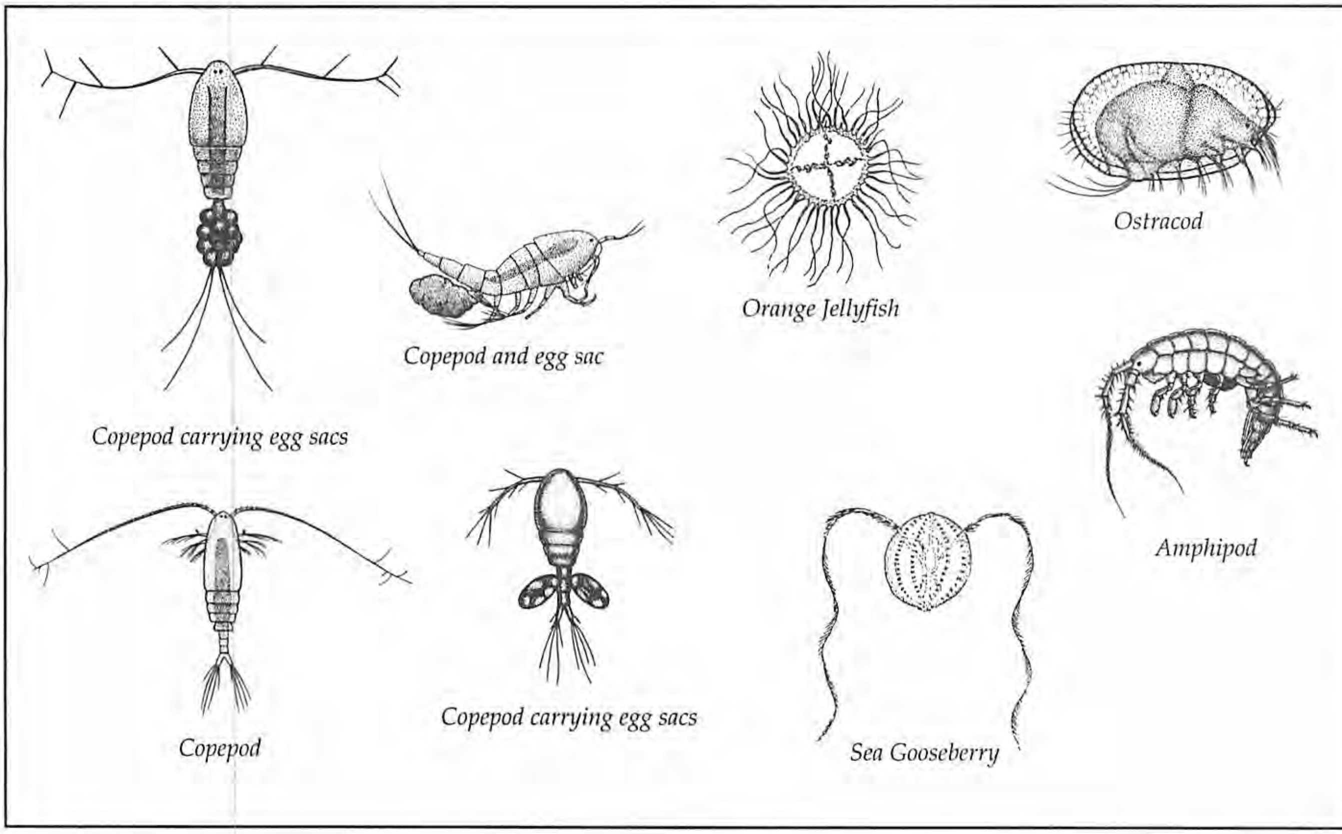
Temporary Animal Plankton

Some animal plankton are called "temporary plankton" because they spend only the first few days, weeks, or months of life as free-floating planktonic larvae, then they settle to the bottom and finish their life cycles as the adult forms we are used to seeing at the seashore. In fact, almost every kind of shoreline and shallow water animal begins its life as a free-swimming larvae. The list includes such seashore animals as shore crabs, hermit crabs, sea stars, sea urchins, snails, clams, mussels, oysters, barnacles, worms, jellyfishes, sponges, and many others.

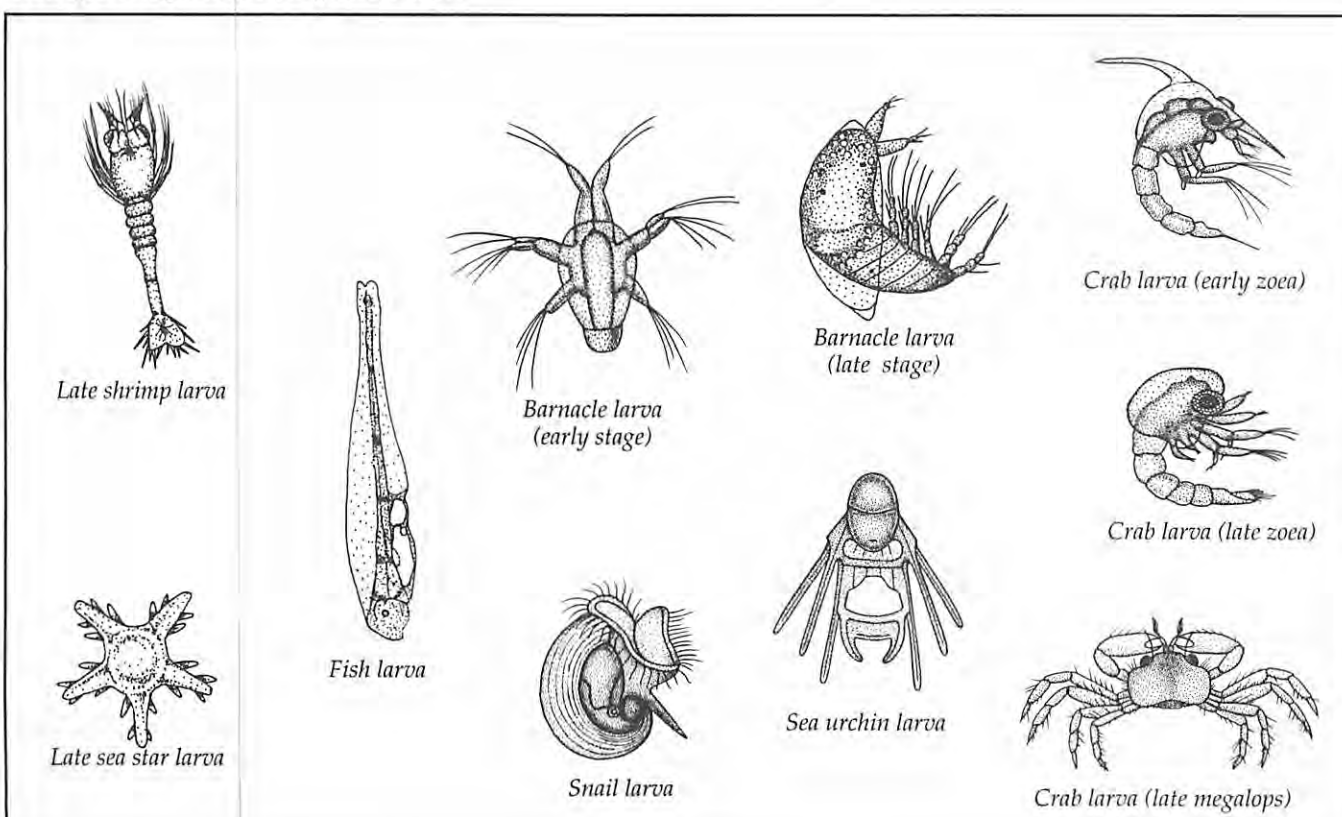
The greatest numbers of plankton occur during the spring because then the sun shines longer and nutrients are abundant, allowing the plant plankton to reproduce rapidly. The plant plankton provide food for the animal plankton as well as other forms of life in the sea. During the spring and summer there can be as many as 300 different species of larvae in a quart of seawater. But in late summer the numbers begin to fall because of a decreased food supply and because many larvae have settled to the bottom and changed into adults. Then, after another period of plant reproduction in the fall, the numbers of planktonic plants and animals drop further until they reach their lowest numbers during the cold winter months.

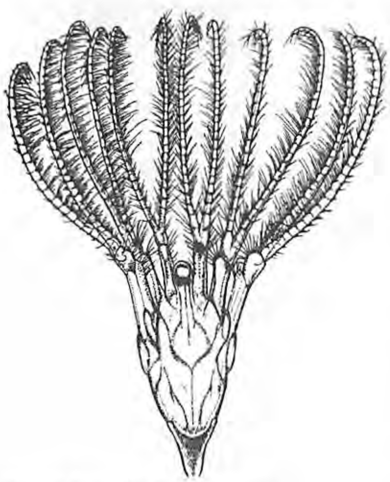
At first it may be difficult to recognize the difference between permanent and temporary plankton. One way to tell the difference is to observe plankton under a microscope. If you see an animal that has a brood pouch or an egg sac, the animal is an adult and as such would be a permanent animal plankton. It would be impossible for beginners to recognize the various larvae, because there are so many different species and because each species goes through several different stages of development. **It's not important that you be able to identify the various species.** Often it's enough to appreciate differences and similarities, to identify plant plankton and animal plankton, and even for students to invent names of their own for the organisms they see. Don't let a lack of detailed knowledge of names discourage study. What is important is that students understand that there are both plant and animal plankton in every jar of seawater. They should also understand that many shoreline animals begin their lives as free-swimming planktonic larvae in the ocean and that plankton is the base of the entire food chain in the ocean. Most important, they can learn to appreciate the rich productivity and diversity of life in the ocean.

Permanent animal plankton

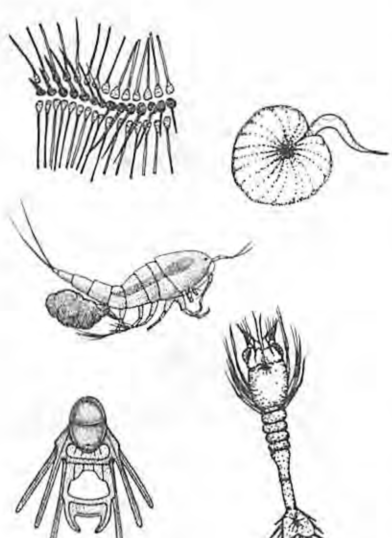


Temporary animal plankton





Barnacle molts are common in the plankton



Procedures

1. What is an animal? Write the word "animal" on the blackboard. Ask the students to brainstorm words and ideas that describe animals. What is the difference between plants and animals? Make a list of characteristics. You can add to this list over the next few lessons.

2. Ask the students to name the three smallest animals they can think of. Discuss these animals. Who thought of the smallest animal? Did anyone think of a zooplankton? Write the word "zooplankton" on the blackboard. The word "zoo" means animal and the word "plankton" means wanderer. What does the word "microscopic" mean? (They must be magnified and viewed with a microscope.)

3. Show the transparency, "Permanent Zooplankton." Tell the students that there is a large group of tiny animals that live their entire lives from birth to adulthood as plankton, and their kind are in seawater all year round. Ask the students to look at the transparency and observe the animals carefully. What characteristics do these animals have in common? (Eyes, eggs, egg sacs; many have jointed legs and antennae.)

4. Ask the students to infer what these animals eat. Tell the students that copepods feed on diatoms, while comb jellies feed on copepods, diatoms, and many other kinds of plankton. Why are these animals grouped together as permanent animal plankton?

5. Tell the students that there is another big group of animal plankton. These are grouped together as "Temporary Zooplankton." Why might these animals be called "temporary"? (They aren't always part of the plankton.) Tell the students that almost all shoreline animals go through a larval stage before they become adults. They live the first few weeks of their lives as tiny animal plankton drifting in the ocean currents, then settle to the bottom where they begin to live our their lives as the adult forms of shoreline animals such as crabs, sea stars, and barnacles.

6. Do all babies look like their parents? Is a baby horse similar in shape to its parents? A baby whale? A child? What other animals are similar in shape to their parents?

7. What baby animals are quite different in shape from their parents? (Butterfly, dragonfly, mosquito, moth, crab.) Ask the students to describe the life cycle of a butterfly: egg, larva, pupa, adult. What is a caterpillar? Would a butterfly caterpillar look the same as an adult? What is another word for caterpillar? (Larva.) Would a baby crab look like an adult crab?

8. Infer why plankton is frequently called "microscopic soup." Why is plankton important?

Enrichment Activities

1. Read to the class the story of Pagoo, the life of a baby hermit crab (by Holing Clancy). (Appropriate for grades 3 to 6.)

2. Write an imaginary story about your life as a baby crab. Tell about your travels in the plankton. What animals do you meet? Tell about your life as you grow, find food, escape enemies, and metamorphose into an adult crab.

Plankton Through the Seasons

Concepts

1. A population is the number of plants or animals of the same kind living and reproducing in a particular area.

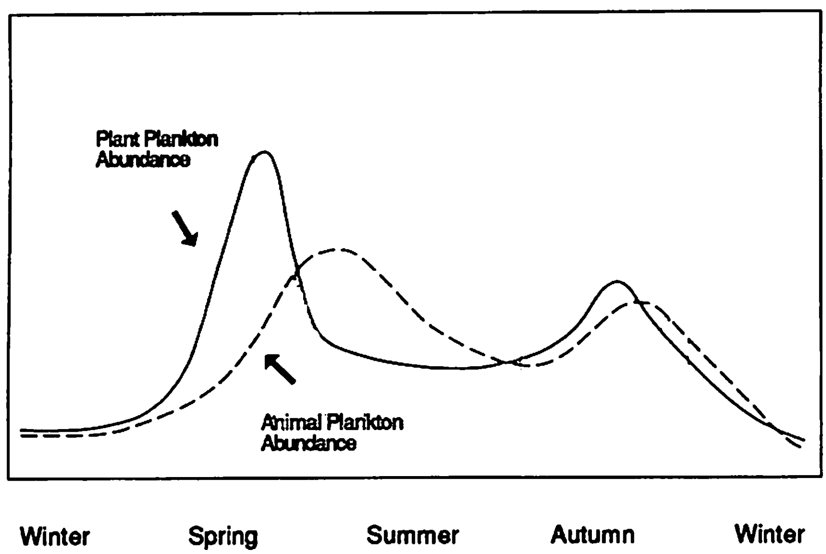
2. The greatest population of plankton occur during the spring because the sun shines longer, nutrients are readily available, and the plant plankton reproduce rapidly.

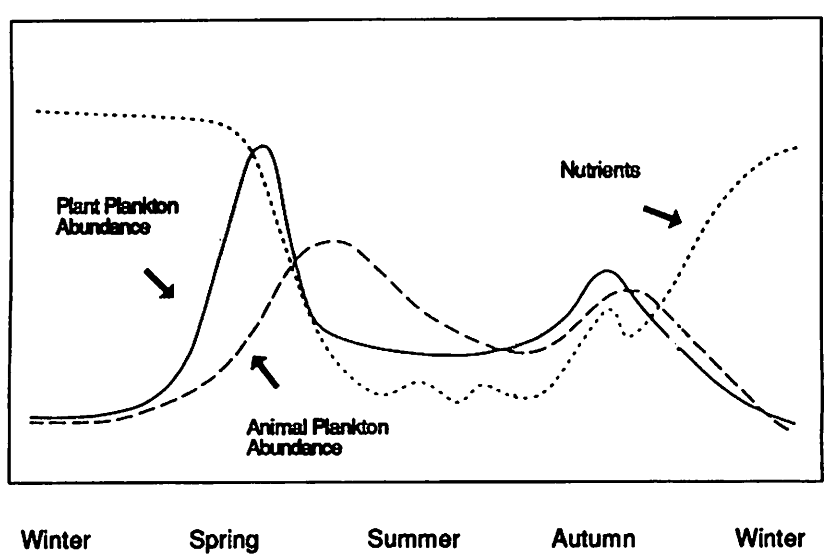
3. The greatest population of animal plankton occur during the spring because it's then that the larvae of shoreline animals fill the waters and feed upon the plant plankton.

Understandings

The students will 1) read a graph to determine how the population of plankton changes with the seasons, 2) infer why the population of plant and animal plankton changes through the year, and 3) infer why plankton is important to all ocean life.

Plankton through the seasons





Teacher Information

The greatest numbers of plankton occur during the spring because then the sun shines longer, nutrients are readily available, and increases in temperature occur, thereby allowing the plant plankton to reproduce rapidly. The plant plankton provide food for the animal plankton as well as other forms of life in the sea. During the spring and summer there can be as many as 300 different species of larvae in a quart of seawater. But in late summer the numbers begin to fall because of a decreased food supply and because many larvae have settled to the bottom and changed into adults. Then, after another period of plant reproduction in the fall, the numbers of planktonic plants and animals drop further until they reach their lowest numbers during the cold winter months.

Procedures

1. Ask the students to infer in which season of the year a bucket of seawater would contain the largest populations of plant and animal plankton. Winter? Spring? Summer? Fall? Why?

2. Draw the graph of plant plankton on the blackboard (or make an over-

head transparency). Ask the students the following questions: During what time of year does the number of plant plankton in seawater increase in large numbers? (Spring.) Why? Discuss the long days, more sunlight, and warmer water temperatures. Compare this to what happens on land. (Grass turns green, flowers and plants grow, trees grow new leaves.)

3. What are nutrients? Where do humans get the nutrients they need? (Food.) Discuss the increased availability of nutrients due to upwelling. (See "Sources of Nutrients, pp. 120–122.)

4. Why would the number of animal plankton suddenly increase in the spring? (The larval stages of shoreline animals are in the seawater.)

5. Why does the population of animal plankton fall sharply in the fall? (The larval animals have settled out of the plankton and are on the bottom of the sea.)

6. Are animal plankton left in the seawater during the winter? (Yes, the permanent animal plankton.)

7. Does this graph give us any more clues as to why the numbers of plant plankton decrease sharply over the summer months? (The larval plankton are feeding on the plant plankton.) Why would the numbers of plant plankton increase during the winter? (The larval plankton are no longer feeding on them in such great numbers.)

8. Do you think all the baby animals would live to become adults? Why or why not? Discuss predators. Why do you think there are such large numbers of babies? Discuss baleen whales. Gray whales and Humpback Whales (among many other animals) feed by straining plankton from seawater.

9. Once all the baby larval animals have settled out of the seawater to begin their adult lives, what would an animal eat that feeds on plankton?

10. Brainstorm reasons why plankton is important to all ocean life.

Brain-Buster Questions

1. If you were a scuba diver on our coast, during what months of the year would you prefer to dive? (The winter months because there is less plankton in the water, allowing for greater visibility.)

2. The Exxon Valdez oil spill in Alaska occurred during the month of March. Discuss the effect of oil on plankton populations. Could the Exxon Valdez oil spill have been an even worse disaster? A less severe disaster? Why? Consider the plankton graph.

3. After an oil spill such as the Exxon Valdez, how might the way plankton is dispersed widely help to heal the effects of pollution?

4. Research the Exxon Valdez oil spill and/or other spills. How could such disasters be avoided? How long does oil remain on the shores? In the mud? How long are specific marine organisms affected by such pollution?

Microscopic Plankton

Understandings

The students will be able to 1) observe plankton with a microscope; 2) draw pictures of plant and animal plankton; 3) label the parts of organisms: eye, mouth, antennae, legs, eggs, brood pouch; and 4) learn the proper use of microscopes.

Materials

White paper
Colored pencils
Plankton net
Compound microscopes
Glass beakers or baby food jars
Depression slides
Medicine droppers
Paper towels and lens paper
Transparency of a microscope
Proto slow, or methyl cellulose (optional)

Teacher Information

The study of plankton is one of the most fascinating studies you can imagine. If you're lucky enough to have the use of microscopes during your seashore studies you and your students will enjoy investigating this strange and beautiful collection of plants and animals that can be seen only with the aid of a microscope.

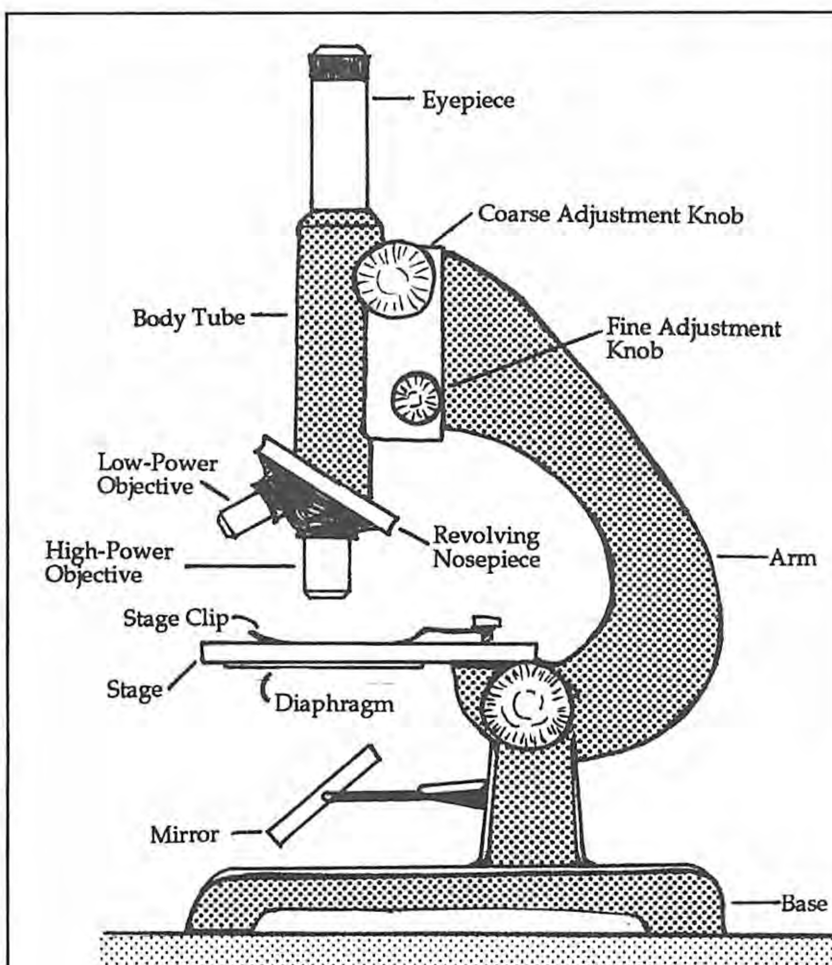
When, Where, and How to Collect Plankton

Anytime of the year is a good time to collect plankton, but March, April, and May are the best months to collect for that is when the plant plankton blooms occur and the larval stages of marine animals fill the water. September and October are also good times to study plankton because then a smaller bloom occurs.

For your plankton study you'll need a plankton net. Plankton nets are inexpensive and simple to make. Some students like to make their own nets and continue their studies at home. (See Appendix). Or make a hand-held net and filter buckets of water to collect plankton.

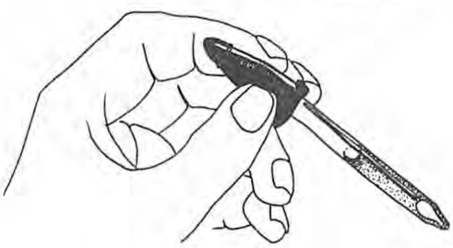
To collect plankton it's a good idea to have the students walk along a rock wall and drag the net behind, or drop the net off a pier and allow the current to flow through the net. Because you may want to make several plankton hauls it may be

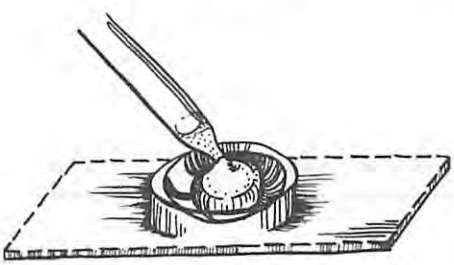
Compound microscope



necessary to ask one or two parents to accompany your students on plankton-gathering trips. **If collecting near deep water, wear life-jackets.**

Plankton will die and begin to disintegrate after two or three days, so collect several bottles at a time and store the bottles in a cool place or refrigerate.





Procedures

1. Pass several baby food jars filled with plankton around the table. Be sure the lids are sealed tight and that detergents have not been used to clean the jars. Tell the students to observe the seawater. Soon they will see tiny dots darting about in the jar. These tiny dots are animal plankton.

2. Brainstorm questions the students have about plankton.

3. Project the transparency and use a microscope to point out the parts of the microscope.

4. Gather the students around a microscope. Engage them in a discussion about the care and handling of microscopes. Discuss the following procedures:

- To carry the microscope, use both hands, one hand grasping the arm and one supporting the base.
- Make sure the low-power (shortest objective) lens is in line with the tube, if not, turn revolving nosepiece until it clicks into place
- Look into the eyepiece and adjust the mirror until the field of view is bright.
- Place a slide on the stage.
- Look through the eyepiece, and slowly RAISE the tube (using the coarse adjustment knob to obtain the clearest possible image of the plankton).
- Search the slide for an interesting part and move that part to the exact center of the field of view.
- Adjust the focus to make the plankter clear.
- Swing the next higher-power objective into position and obtain a sharp focus with the fine adjustment knob. If not immediately successful, return to the lower-power objective.

5. Demonstrate how to prepare a slide. If possible, use depression slides, as illustrated at left. Use a medicine dropper to catch plankters. Carefully drop the plankter onto a slide, attempting to isolate the organism in a drop of seawater. If too much water spills onto the slide, the water will easily run off. Also, the organism simply has more volume in which to swim.

6. The students should draw sketches of the organisms they see. Encourage them to fill the page with one sketch and to include the details as much as possible. By filling the sheet of paper with one organism the students are forced to slow down and notice the details. Look for a stomach, eyes, antennae, legs,

Teacher's Note

I recommend not using cover slips when observing plankton, as they usually crush and kill the organisms, thus destroying the fun and educational value of observing living organisms. Instead, add a drop or two of Proto Slow to the water droplet (it slows the plankters' movements by creating the effect of swimming through jello).

eggs, and brood pouch. Label the parts. Describe the organism: its color, shape, behavior, etc.

Challenges

- Determine which forms are plants and which are animals.
- Try to identify diatoms. Draw three large pictures of different diatoms. Look for different shapes. Look for chains of diatoms.
- Try to identify copepods. Draw a large picture.
- Try to identify three different animal plankton. Draw pictures.
- Look for a stomach, eyes, antennae, legs, eggs, and brood pouch.
- Label your drawings and add information about the characteristics of the organisms by describing their color, shape, and behavior.
- Compare samples taken at different times of the year.

Questions for Discussion

- Which of your organisms had the most unusual shape?
- What colors did you observe?
- Why are so many plankton transparent? (Camouflage in the water.)
- What was the most plentiful organism you saw?
- Do you think these organisms stay this size, or do they change?
- Will the same organisms be in seawater at different times of the year?

Class Mural

Create a class mural of the ocean and its microscopic world. The mural should include the sun, plant plankton, permanent animal plankton, and temporary animal plankton. If appropriate, add filter feeders such as barnacles, clams, and mussels, and even baleen whales such as the Gray Whale and Humpback Whale.

Students collecting and observing plankton.

Capturing speedy planktonic animals can be tricky.

The Life Cycle of a Crab

Concepts

1. The life cycle of the crab includes several stages: egg, several larval stages, and adult.

2. The change in body structure that occurs in the development of animals in which the body structure of the young is entirely different from that of the adult is known as metamorphosis.

3. In order to grow, a crab must molt its hard outside shell and grow a new covering that becomes hard.

Understandings

The students will be able to 1) describe how a crab molts, 2) infer why crabs molt, 3) infer the time of year that crabs molt, 4) brainstorm advantages and disadvantages to exoskeletons, and 5) write a story about a crab molting.

Materials

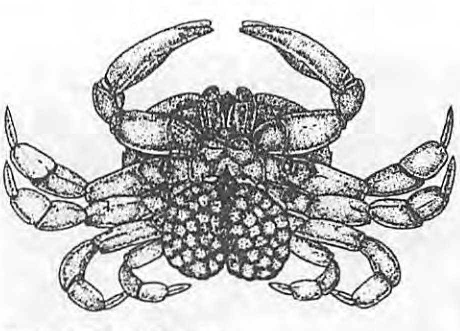
Transparency:

"Life Cycle of a Crab"

Teacher Information

Among most invertebrates there is no parental care of the developing eggs or young.

A Mother Crab Carries Her Eggs with Her Everywhere She Goes



Female crab with eggs.

Although mating between male and female crabs takes place in the spring and summer months, the mating behavior of each species of crab is somewhat different. In some species of crab, the male deposits sperm under the abdominal flap of the female, fertilizing the female's eggs. The eggs are deposited in a special kind of glue-like substance. As more and more eggs are laid, the abdomen or tail is forced out and prevented from closing. The abdomen acts as a spongy cradle for as many as two hundred thousand eggs. The mother carries her eggs around with her in the water for about two weeks before they hatch as larvae. Then, one day at high tide when the mother is covered with seawater, the eggs hatch as larvae and become part of the zooplankton. Although these mothers do not actively tend their eggs, the eggs are nevertheless protected by the mother during the early stages.

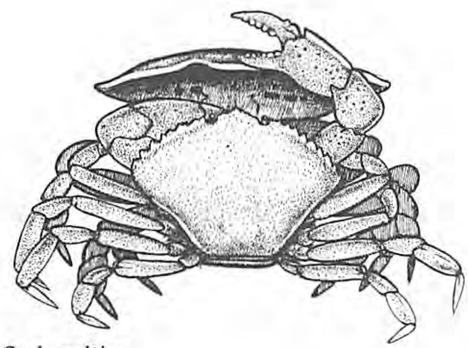
Baby Crabs Become Part of the Zooplankton

Once they hatch from the eggs carried by the mother, baby crabs become part of the zooplankton. Depending on the species, a baby crab goes through several larval stages lasting from one to several months before it becomes an adult. During its first stage of development the young crab is called a zoea, which has a very large spine. The last stage, which looks like a very tiny crab about 4 mm. long with an elongated abdomen like that of a shrimp, is called a *megalops*. During the megalops stage, crab larvae are quite heavily preyed upon by fish, as they're larger than other planktonic forms and are also a brown color, which makes them visible. After the megalops stage the crab settles to the bottom of the ocean and lives out its adult life.

Crabs Molt Their Outside Skins

At the seashore students will frequently find what they think are "dead crabs." These are frequently the castoff shells of crabs that have molted their hard outside skins and moved on. The "molts" are often found on the beach in large numbers, complete with head, eye sockets, and legs.

The hard shell or carapace is not elastic and is molted, or cast off, regularly as the crab grows. When crabs molt, a slit occurs along the line at the back where the body turns under to become the tail. The slit widens like a zipper, and the crab slowly backs out of its shell through the opening at the rear. The new shell that is formed inside the old one is soft and wrinkled. After it has escaped from its old skin, the crab will blow its body up with water to increase its size. For two or three days the crab will do little but hide in the sand or under rocks while the new shell becomes hardened enough to protect its soft body from predators. After molting, and before a new shell has hardened, the crab is known as a "soft-shelled" crab.



Crab molting

The number of molts that a crab undergoes before becoming full grown depends on the amount of increase of each molt and the frequency of molting. Baby crabs molt as many as seven or eight times a year, whereas mature crabs four to five years old may molt only two or three times a year. Even among old crabs, molting retains some value as a periodic "spring cleaning" of old and worn shells, and shells to which barnacles and other organisms have attached.

Procedures

1. Has anyone noticed crabs or shrimps carrying eggs at the seashore? What time of year was it?

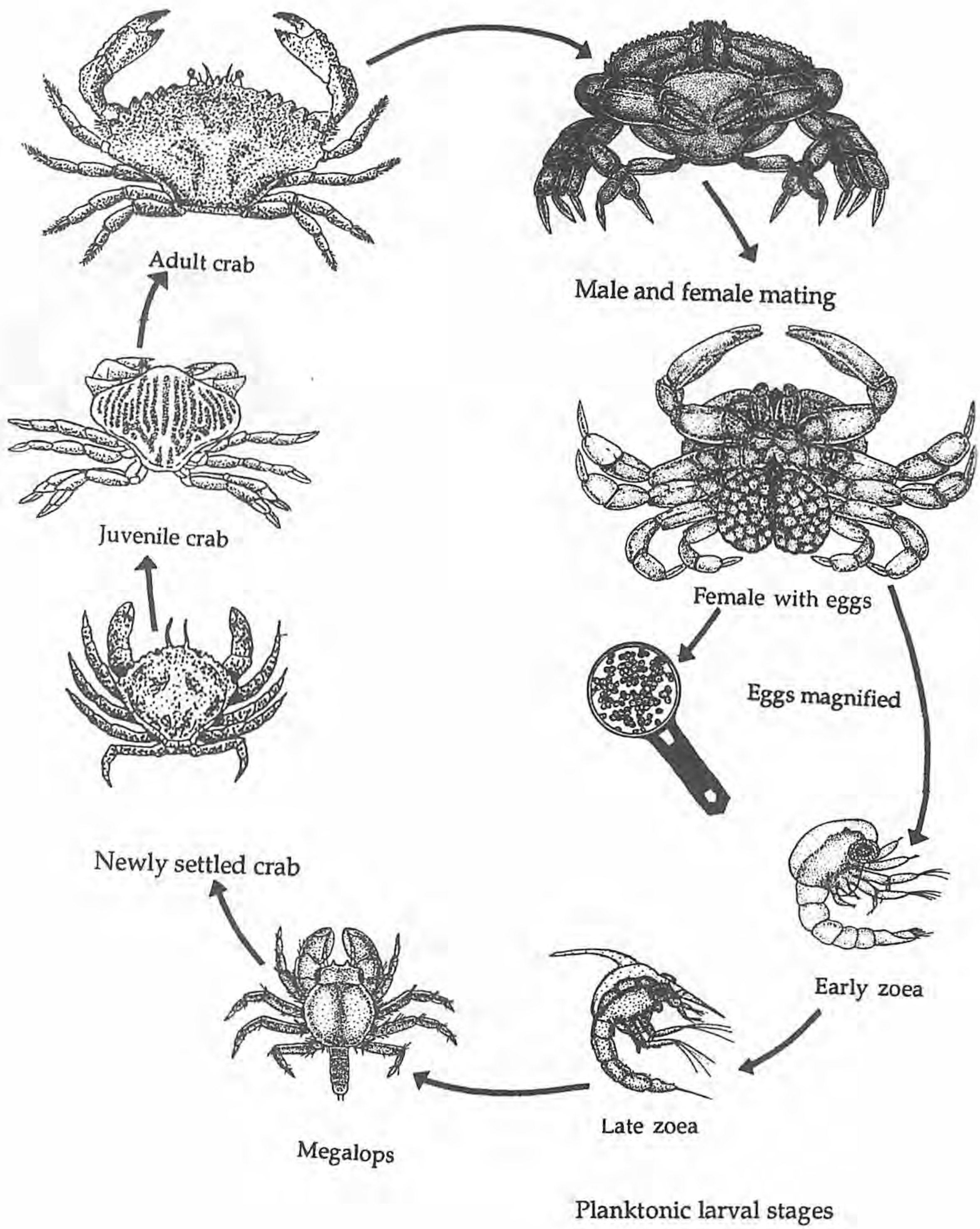
2. To what extent does a mother crab care for her babies? During this part of the discussion there should be no right or wrong answers. Listen to the students' own thinking.

3. Show the transparency, "Crab Life Cycle." Where does the baby crab live while it is a larva? (The ocean.) During this time where does the baby crab travel? (It can drift for hundreds, even thousands of miles.)

4. How does the baby crab change? (It grows and changes shape many times. Then it grows large enough and heavy enough to settle to the bottom of the ocean and begins its life as an adult.) Write the word "metamorphosis" on the blackboard. What does it mean?

5. Show the transparency of a crab molt. Brainstorm the advantages of having a hard outside skin, or carapace. Engage the students in a discussion about hard protective shells, protection from predators, and protection from drying out in the sun. You might compare the crab to an armored tank or living in a suit of

Life Cycle of a Crab



armor. What are the disadvantages of having a suit of armor? How can the crab grow?

6. Some students might know how crabs molt. Allow these students to describe the sequence to the other students, or describe the process yourself. Ask the students to brainstorm questions about crabs molting.

7. How often do crabs molt? Do crabs molt more in the spring or summer than in the winter? Do baby crabs molt more frequently than adult crabs? Why? What is a "soft-shelled" crab? What other animals molt?

Brain-Buster Questions

1. Mother crabs have thousands of babies. What is the advantage of producing 200,000 eggs?

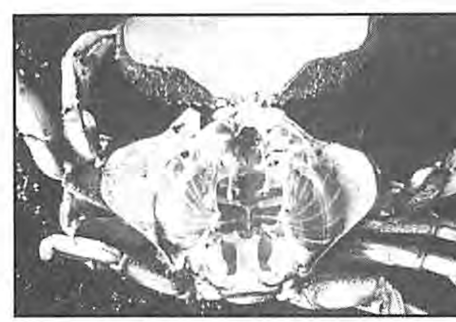
2. How many eggs are needed to reach adulthood in order to continue the species? (One or two.)

3. To what extent does a mother crab care for her babies compared to an octopus? Compared to a Sea Otter? A human? How could we find out?

5. What could a baby crab eat? (Depending on its size: diatoms, copepods, amphipods, and smaller planktonic larvae.)

Observe a Crab Molt

At the seashore look for a crab molt. (This lesson will have more interest if you can find a crab molt and use it as a focus for your discussion.) Ask the students to brainstorm what they think they have found. If you find an empty crab shell, you can determine whether it's a molt or the shell of a dead crab by attempting to lift off the top part of the shell, or carapace. If you have found a molt, there will be a zipper-like slit across the lower abdomen, and you'll be able to lift the carapace easily. The crab shell should be light and the cast off gills likely will still cling to each side of the stomach lining. If you have found the shell of a dead crab, there will be no slit across the lower abdomen and you'll be unable to lift the carapace easily. The crab shell will be heavy, bits of flesh will cling to the inside of the shell, and the entire crab will have a pungent odor.



Crab molt with castoff gills still clinging to the stomach lining.

Enrichment Activities

1. Write a story about a crab molting.

2. Make a papier-mâché or clay model of a crab molting.

Discovering Eggs at the Seashore

Concepts

1. Females are those individuals producing eggs.

2. Eggs come in a variety of shapes, sizes, colors, and textures.

3. A fertilized egg contains the yolk and developing embryo.

4. Some mothers care for their eggs; other mothers lay their eggs and move on.

Understandings

The students will be able to 1) identify the eggs and egg cases of common seashore animals; 2) infer why some mothers care for their eggs while others abandon them; 3) draw, describe, and label the parts of a chicken egg; and 4) list rules for protecting eggs and baby animals at the seashore.

Materials

Transparency: "Eggs at the Seashore"

A dozen chicken eggs

Clear glass containers

Paper

Colored pencils

Teacher Information

Have a scavenger hunt at the seashore looking for the eggs and egg cases of seashore animals. The months of February through June are good times to discover the eggs of a great variety of marine animals. The most obvious eggs are those of shorebirds: gulls, Great Blue Herons, Canada geese, and Bald Eagles, to name only a few. These birds build intricate nests and tend their eggs until they hatch, and then care for their chicks through the juvenile stages.

The jellylike patches on rocks and seaweeds are probably the eggs of some species of snail or nudibranch. Checkered Periwinkles lay their eggs in flat little egg cases that look like jelly. Nudibranchs lay their eggs in soft jellylike masses which they attach to rocks in loops, or flat ribbons that are generally coiled. When the eggs hatch, the larvae are released into the sea to drift as part of the plankton.

Moon Snails lay their eggs in a gluey substance that cements sand together to form a collar shape around their foot. Sandwiched between two layers of sand and mucous are the microscopic Moon Snail eggs. When the eggs hatch, the sand collar crumbles and the Moon Snail larvae are washed out to sea.

Wrinkled Whelks lay their eggs in large clusters of yellow capsules on rocks. Commonly called "sea oats," the egg capsules are the size of large oat grains. Each egg capsule holds 25 to 40 eggs. The early larval stages, which may take two or three months, depending on the sea and air temperature, are passed inside the egg capsule. Following metamorphosis, the juvenile snails crawl out of the egg capsule via an escape hatch and gradually assume the adult way of life.

During the summer months, look for the peculiar leathery egg cases of sharks and rays that wash up on beaches. The female shark lays the egg cases at sea, frequently attached to seaweeds, and abandons them. Depending on the species, the egg case can have one to three eggs packed inside. Nourished by their yolk-filled egg sacs, the young sharks develop on their own. Known as "mermaids' purses," the egg cases occasionally wash ashore with the tiny shark inside alive and swimming. Put the egg case in a saltwater aquarium and watch the tiny shark emerge.

Seashore crustaceans such as female crabs, shrimps, amphipods, isopods, and lobsters carry their fertilized eggs with them until they hatch. The eggs are attached to the abdomen, which acts as a cradle for the developing eggs. As the eggs become larger, they can be easily viewed with or without a hand lens. Once they hatch from the eggs carried by the mother, the babies become part of the zooplankton.

The eggs of many seashore animals are left on rocks or buried under rocks, then abandoned by the parents. Snails, nudibranchs, and most fish lay their eggs and move on. Tidepool Sculpins and many other fish lay their eggs in clusters held together by clear jelly. These can be found intertidally under rocks at the low tide line and are often easy prey to hungry predators.

By contrast, the female octopus lays tens of thousands of whitish, cylinder-shaped eggs from the ceilings of caves and the undersides of ledges. There are frequently about 50 bunches of eggs hanging from the ceiling, and each bunch contains up to 4,000 eggs. Her whole life now centers around her eggs. She cleans them by rubbing them with her arms, and aerates them by shooting out jets of water from her funnel. A courageous mother, she guards and protects the eggs from predators such as hungry fish. Most females will not eat after they have laid their eggs. It often happens that the females die during the period of incubation, or shortly after the hatching.

Procedures

1. Ask the students when they think life begins. Allow for an open-ended discussion in which there are no right or wrong answers.

2. What eggs have students noticed in real life? (Chicken eggs, turkey eggs, eggs in a bird nest, frog eggs, snake eggs, salmon eggs.)

3. Has anyone noticed eggs at the seashore? (Gull eggs, egg capsules attached to rocks, eggs under rocks, etc.)

4. During what months are there lots of eggs on the shore? (February, March, April, May, June.) Why can so many different kinds of eggs be found at the seashore in the spring, but not late summer or winter?

5. What is an egg? Allow for an open-ended discussion. This is a good time to listen to the students' own thinking. Write their ideas on the blackboard.

6. Show the students the transparency, "Seashore Eggs." Ask whether they have seen any of these eggs at the seashore. Are the

eggs of different animals the same size? The same shape? Do different animals have different numbers of eggs? Discuss the terms "egg case" (the eggs are embedded in a protective, jellylike substance) and "egg capsule" (a protective outside capsule contains individual eggs).

7. Discuss the Wrinkled Whelk. When the first snails hatch out of the egg capsule, where do the baby snails get food energy? How are whelk eggs, Moon Snail eggs, chicken eggs, and gull eggs the same? (They all receive food energy from the yolk.)

8. Tell the students, in story form, how the mother octopus tends her eggs. Why do the mothers frequently die? Can the students think of other parents that tend their eggs? (Chickens, gulls, crocodiles, ducks, and geese.) Why do these animals tend their eggs? (Discuss predators, aeration, correct temperature for a particular species, etc.)

9. Many animals such as whelks and Tidepool Sculpins lay their eggs and move on. What are some advantages to parents of laying their eggs and then abandoning them? (Generally, animals that don't tend their young to ensure safety from predators lay many hundreds, thousands, or even millions of eggs. This ensures that at least some will survive to adulthood, mate, and reproduce their kind. Also, the egg case or capsule protects the eggs from drying out.)

10. What advantage do the eggs of shrimps, crabs, and lobsters have over the eggs of snails and sculpins? (Because these eggs are carried by the mother they receive some protection because she is avoiding becoming a meal herself.)

11. Engage the students in a discussion about conservation of eggs at the seashore. What happens when unthinking people crush eggs and egg cases at the seashore? How might eggs be harmed by humans? (Roll stones over and leave eggs exposed to the hot sun, throw Moon Snail egg collars high on the shore.) Discuss problems of moisture loss. What happens when people harass nesting shore birds? Discuss proper behavior at the seashore.

Enrichment Activities

1. Bring a dozen chicken eggs to school. Hold an egg up. Ask the students to brainstorm questions they have about eggs. Write their questions on the blackboard.

Their questions likely will include the following:

What is an egg?

What does the inside of an egg look like?

What is the yellow stuff? The white stuff?

Why does an egg have an outside shell?

Is this egg alive?

Is this egg a male or a female?

2. Divide the class into groups of three or four students. Tell the students that you want them to crack an egg open so they can observe the details of the contents inside. When dividing the class into groups, ask for a volunteer to be in each group who is willing to

crack the egg open. They should carefully crack the egg into a clear container. The students should draw the contents of the egg and describe in detail what the egg looks like.

3. Allow the students to discuss the above questions without closure.

4. Help the students to label the parts of an egg: embryo, yolk.

Brain-Buster Questions

1. Will the eggs we buy in grocery stores grow into baby chickens? Why not? (They need to be fertilized by a sperm.)

2. Why do hens sit on chicken eggs after they have been fertilized? (Discuss temperature, etc.) Where does the fertilized egg get food energy to grow? (The egg yolk sac provides food or fat for the embryo. The white amnion, by enclosing the embryo, provides protection.)

3. Of what importance is the shell to a chicken egg? (Provides protection.) How is the clear, jellylike material around snail eggs and fish eggs similar to the shell of a chicken? (Provides protection.)

4. What other eggs have the same shape as a chicken egg? (Gull eggs, duck eggs, murre eggs.) Why are these eggs shaped like an oval? When might it be important for eggs not to roll easily? (Some birds lay their eggs on rocky ledges or cliffs in shallow nests. It would be easy for a round egg, even if only gently prodded to roll off a cliff, but an oval egg would just wobble and roll about in a small circle.) Try rolling an oval egg in a straight line.

Common Murre with egg.

Enrichment Activities

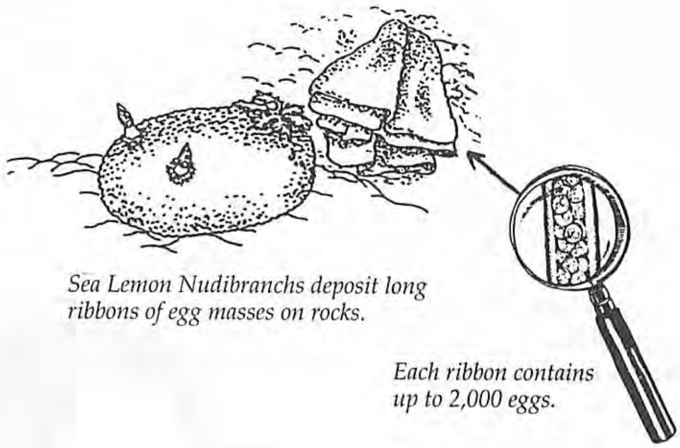
1. At the seashore, look for the egg cases of whelks, Moon Snails, nudibranchs, and fishes. Draw sketches of different eggs. Try to identify these eggs. If you're lucky enough to have a saltwater aquarium, carefully transport a **few** eggs to the aquarium. Keep a record of egg development. When the eggs hatch, take a plankton sample from the aquarium seawater and observe these fascinating larval forms with a microscope.

2. Observe the eggs or egg cases with a hand lens or microscope. Students can often see the embryos at later stages of development inside the eggs—complete with heart and body movements.

3. Hatching chicken eggs is a lot of fun, but it isn't easy. You must buy special eggs that have been fertilized and purchase or build an incubator to keep them warm. You can find good books on how to incubate eggs in any public library.

4. Research the development of an egg in the library. Create a poster. Give a report to the class.

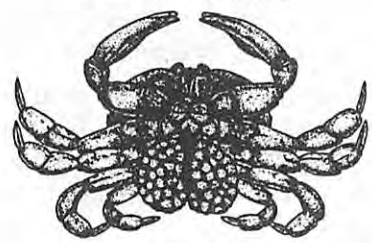
Eggs and Egg Cases



Sea Lemon Nudibranchs deposit long ribbons of egg masses on rocks.

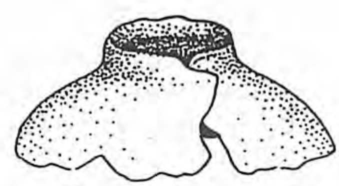
Each ribbon contains up to 2,000 eggs.

Female Red Rock Crab



The abdomen acts like a cradle protecting thousands of eggs.

Moon Snail



Moon Snails lay thousands of tiny eggs that become cemented together into rubberized "sand cellars."

Wrinkled Whelks deposit clusters of yellow egg cases on rocks.

Each egg case contains up to 20 eggs.

Baby whelks hatching.

Baby Marine Animals

Concepts

1. Some baby animals look like miniature adults; others look different from their parents.

2. Baby animals grow and change.

Understandings

The students will 1) describe characteristics of baby animals, 2) match pictures of baby animals with their parents, 3) infer what baby animals need in order to grow, and 4) infer which baby animals are cared for by their parents, and which are not cared for by their parents.

Materials

Handouts:

"Baby-Parent Animals"

"Life Cycles"

Background

1. Ask the students to collect pictures of baby animals. What do baby animals look like? What different kinds of baby animals could they look for: bird, insect, whale, fish, butterfly, snail, horse, pig, crab.

2. Does a human baby look like its parents? How is it different? Similar? Can you tell a human baby from a baby monkey or baby whale or baby insect?

3. Does a baby whale look like its parents? Does a baby seal look like its parents? What other animals are similar in shape to their parents? (In general, birds, whales, seals, sea otters, snakes, alligators, salmon, monkeys, horses.)

4. Do all babies look similar in shape to their parents? That is, do they look like the same species? Does a baby crab look like its parents? Does a baby sea star look like its parents? Does a baby snail look like its parents? Are you sure? How could you find out?

5. What animals are quite different in shape from their parents? (Students may mention butterflies or frogs. Ask them to describe the life cycles of these animals.)

6. Give the students the handout, "Baby Animals." They are to match each baby with its adult and circle the immature (or larva) animals that are part of the plankton.

7. Recall the lesson on temporary plankton. Review the terms "plankton," "larvae," "metamorphosis," and "temporary plankton."

8. Discuss the following questions: How are the baby animals different from their parents? How are they similar? Discuss shape, color, size, etc. What baby/adult animals are easy to identify? Which ones are difficult? Why were these so difficult? (Most likely the students will be unable to match the following organisms: crab, sea star, Moon Snail, sea urchin, barnacle. These are larval forms and at first

don't look at all like their adult forms. However, the students might discover clues, e.g., both the larval and adult crabs have jointed legs. Ask the students to brainstorm why these animals look so different.)

9. If the students are unable to infer why a baby crab does not look like an adult crab, ask them to recall the lesson on temporary plankton; or teach this lesson.

10. Encourage the students to color the pictures, attempting to pay special attention to color differences. What color is a baby eaglet? What color is an adult eagle? How could they find out? (Most larval forms will be basically transparent, which is a form of camouflage.)

11. Give the students the handout, "Life Cycles." Tell them to cut the pictures out and paste them into their marine science notebooks in the correct order of development from egg to adult.

Brain-Buster Questions

1. Of what value is curiosity to a baby harp seal? To a human? What are the dangers of curiosity to a Harbor Seal pup? To a human baby?

2. Can the students think of marine animal mothers that actively teach their babies how to swim and fish for food? (Sea Otters, walruses. A Sea Otter, for example, teaches its baby to swim, dive, collect shellfish, and break shellfish on rocks.)

3. How does a mother seal locate its baby? (The sense of smell and vocal calls.)

Enrichment Activities

1. Divide the class into groups of three or four. Ask each group to choose a marine organism and research how the baby is cared for by the parents during development. The organisms listed below are ones on which school libraries tend to have information:

Humpback Whale	Hermit crab	Bald Eagle
Killer Whale	Octopus	Gull
Sea Otter	Polar bear	Tufted puffin
Harbor Seal	Salmon	Great Blue Heron

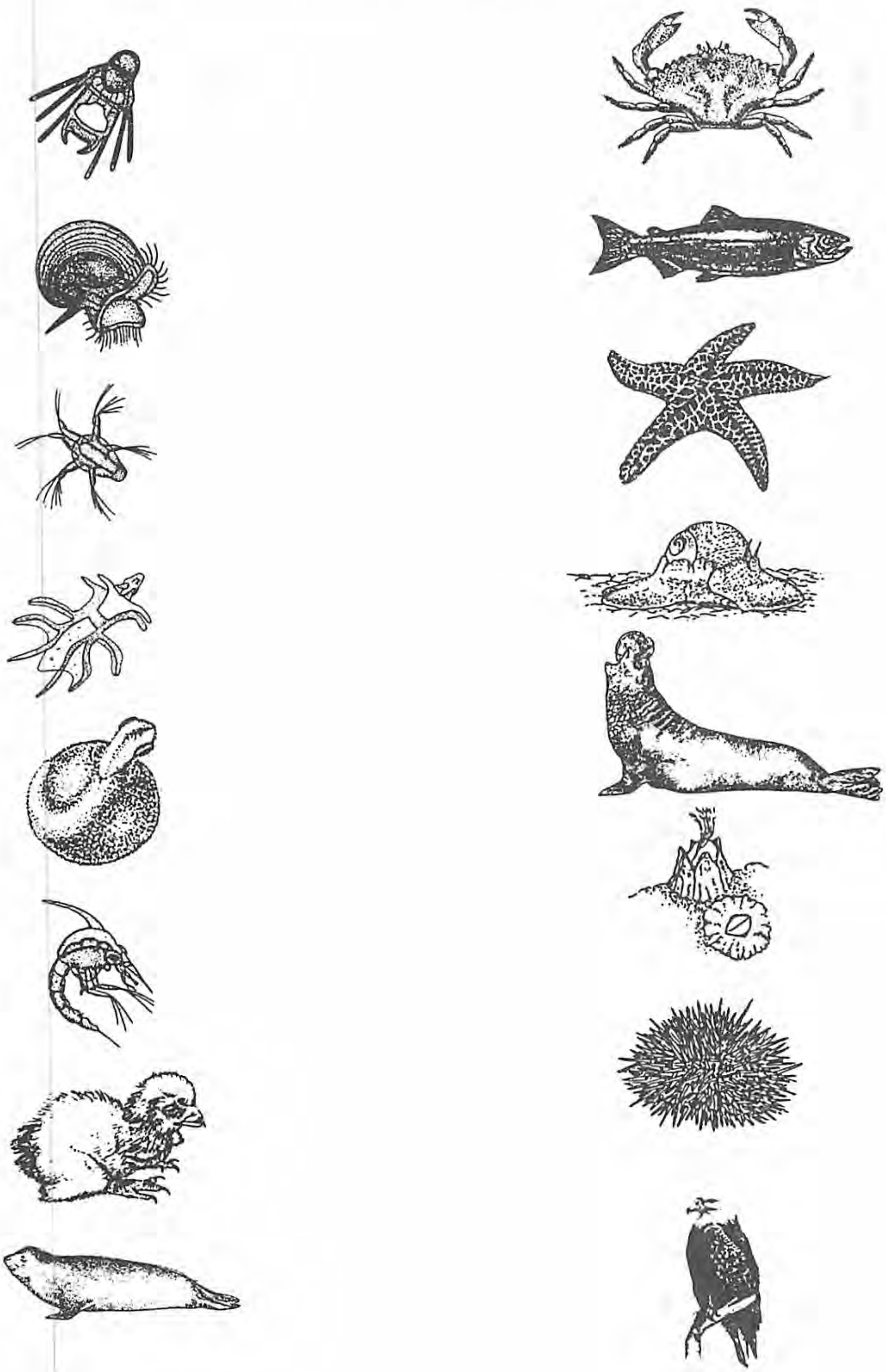
The students should attempt to answer the following questions: a) Does the baby look like its parents? b) What does the baby need to grow and survive? c) How do the parents care for the baby, if at all? d) Do the parents teach their young? e) How long does it take for the baby to grow into an adult? Draw these animals and attempt to show their life cycles. The students should not write lengthy reports, but attempt to answer the questions outlined above.

2. The students should make short reports back to the class. This might take the form of a class discussion rather than a series of written reports.

3. Compare the teaching/learning relationships between the following parent/baby animals: sea star, crab, octopus, gull, eagle, Harbor Seal, Humpback Whale, Sea Otter.

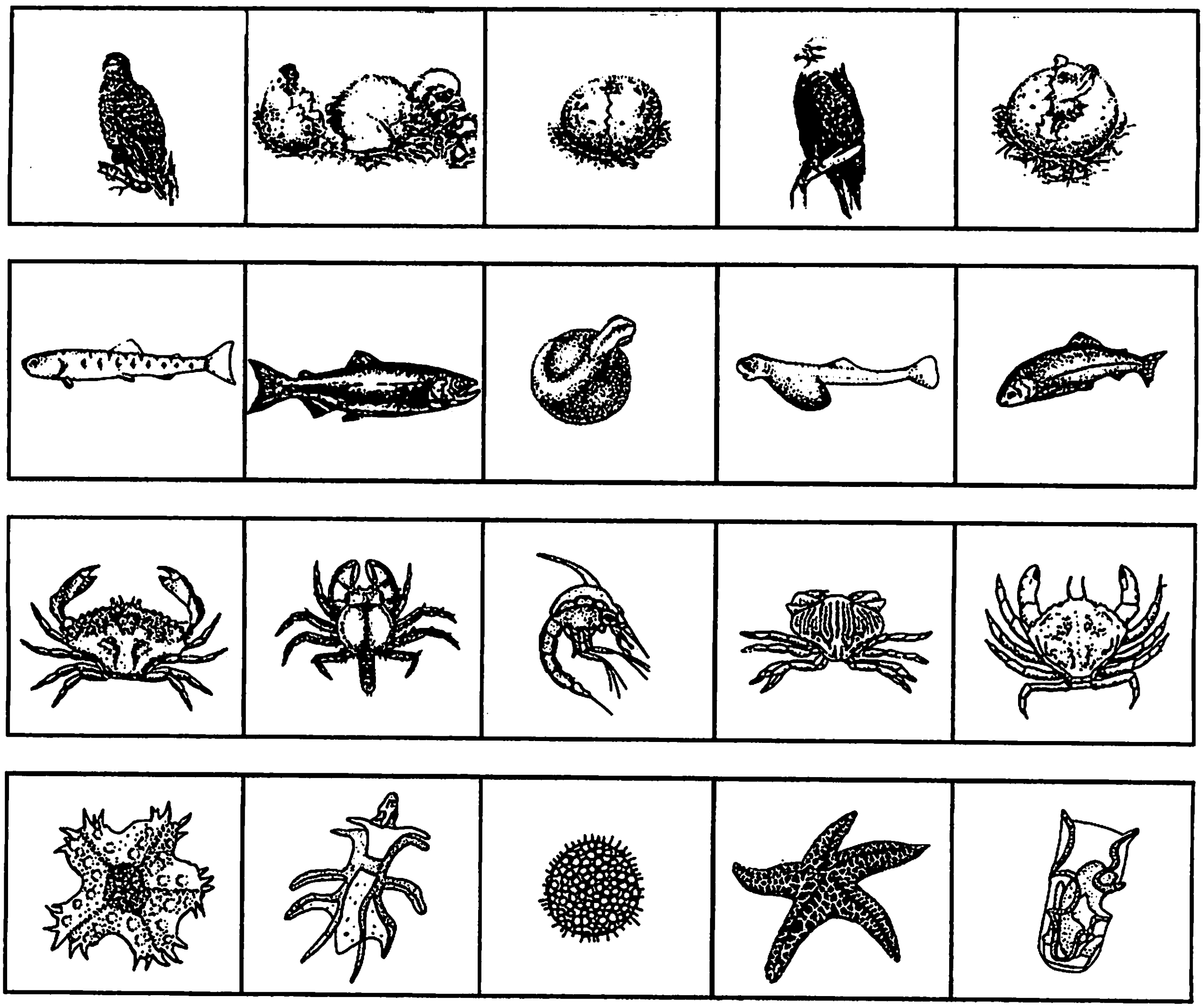
Baby Animals

The pictures below illustrate the following eight adult animals and their immature offspring: Bald Eagle, Humpback Whale, Purple Shore Crab, Sea Otter, octopus, Purple Sea Star, and Moon Snail. Attempt to match the baby or immature animal with its parent.

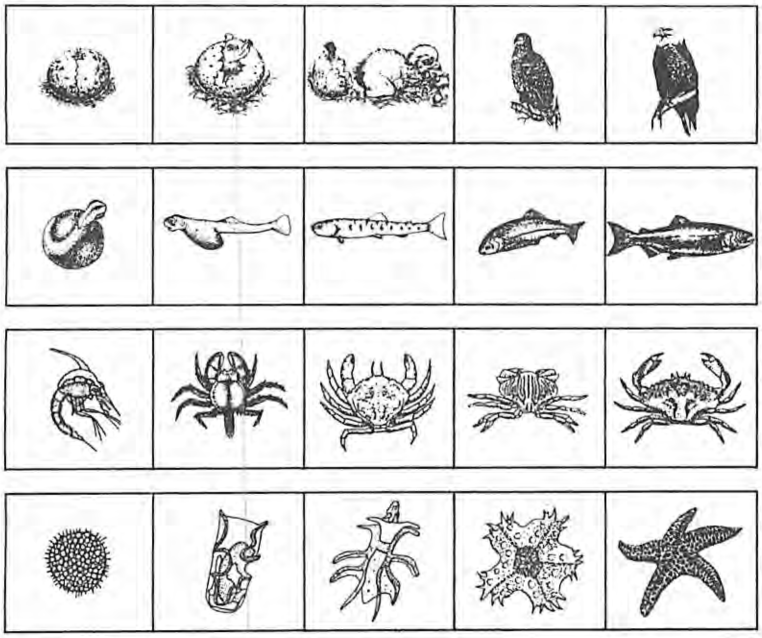


Life Cycles

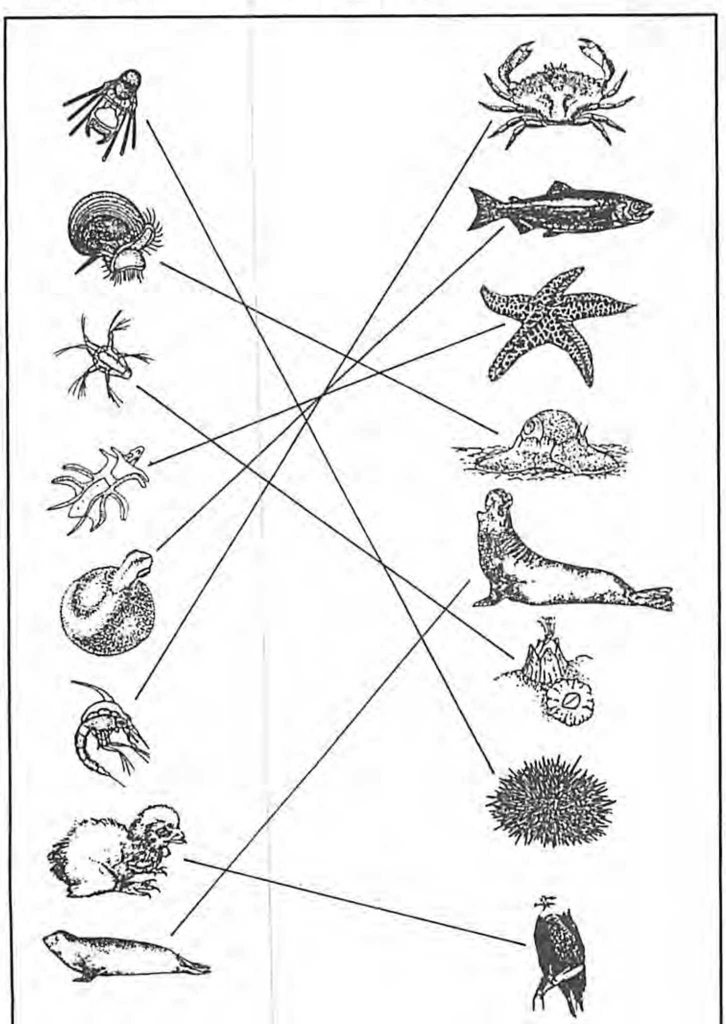
The pictures below illustrate the life cycles of four marine animals. Cut out the pictures and paste in the order of development from egg to adult.



Life Cycles Answer Key



Baby Animals Answer Key



At low tide, the barnacles may show no movement or sign of life at all, but when the tide returns and submerges their stony, cone-shaped shells, they thrust a group of feathery plumes in and out to capture microscopic plankton.

Chapter 4: Food Relationships

An ecosystem is an interacting system that consists of groups of organisms and their nonliving environment. Thus an ecosystem has two main parts: a living part and a nonliving part. The living part includes all the living things in the ecosystem—gulls, sea stars, crabs, plankton, diatoms, seaweeds, bacteria, and others. The nonliving parts include water, rocks, sand, temperature, light, wind, nutrients, and others.

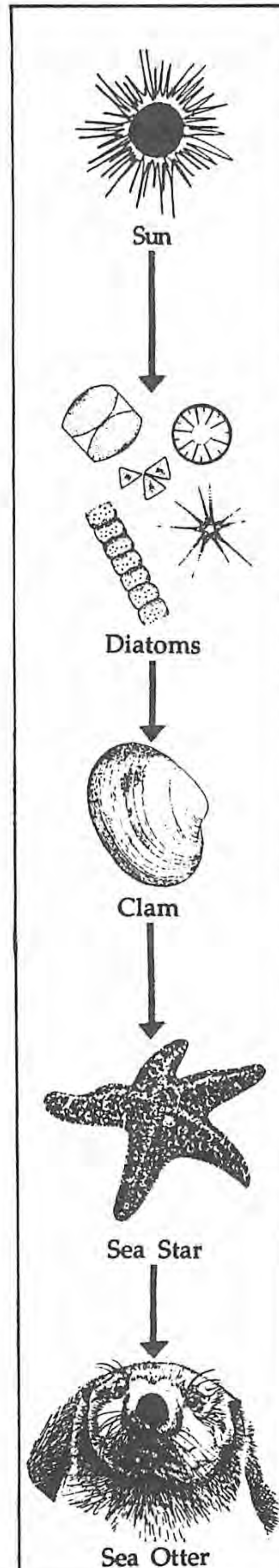
Nutrients and sunlight are two of the most important factors that influence the survival of living things. All living things—plants, animals, and even humans—need nutrients to survive. In order to grow, all organisms need food. Nutrients help living things grow and develop. Plants make their own food by capturing some of the sun's energy and using water and carbon dioxide from the air. Therefore, plants are called producers.

Some organisms cannot make their own food. They must feed on, or consume, other organisms. Therefore, they're called consumers. Checkered Periwinkles, limpets, chitons, and abalones feed on the thin film of diatoms and small seaweed that covers the rocks. Sea urchins feed on large seaweeds. These animals are primarily herbivores because they eat plants. Animals that eat other animals are called carnivores (flesh eaters.) Sea stars, sea anemones, salmon, seals, and Killer Whales are carnivores. Some animals eat dead and decaying plants and animals and are called scavengers. Crabs, crows, isopods, and amphipods can be scavengers. Since organisms are often in more than one food chain, the food chains in an ecosystem are connected. The connected food chains are called a food web.

Many food chains follow the pattern described above; that is, they begin with producers that are eaten by herbivores that, in turn, are eaten by carnivores. However, some food chains begin with dead plants or animals. An example is a Purple Shore Crab feeding on a dead fish. In a sense, even this food chain began with a producer. The fish, when it was alive, was in a food chain that began with a producer. Though many food chains have just the three steps (sun collectors, herbivore, carnivore), others can be quite long. That's because they have several orders of carnivores. The complete cycle results in animal and plant parts being decomposed by bacteria, which in turn will supply the plant plankton and seaweeds with nutrients for growth. Thus the cycle begins again.

In this chapter, students will gain a general understanding of the following concepts:

Predator	Filter feeder	Adaptation
Prey	Grazer	Bacteria
Carnivore	Scavenger	Detritus
Herbivore	Deposit feeder	Nutrient
Predator-prey	Producer	Niche
Food chain	Photosynthesis	Interdependence
Food web	Energy flow	Survival
Consumer	Decomposer	Ecosystem



Ocean food chain.

Sources of Nutrients

Concepts

1. Nutrients and sunlight are two of the most important factors influencing the survival of any living thing.

2. Nutrients are required for living things to grow and develop.

3. Bacteria are the chief decomposers for the ocean system.

Materials

Overhead transparency, "Sources of Nutrients"

Teacher Information

The ocean ecosystem is made up of living and nonliving things. (Some of the nonliving things: water, air, rocks, sand, dirt.) The sun is the most important factor for life on our planet. With very few exceptions, living things depend in some way on the sun's energy. In addition to sunlight, all living things need nutrients. Nutrients help living things grow and develop. Vitamins and minerals are examples of nutrients. The energy from nutrients is needed to "power" life processes such as movement, making new cells, and repairing worn-out parts.

All animals get nutrients and energy from the food they eat. When humans eat, they get vitamins and minerals from the food. By eating a balanced diet we stay healthy. All animals get the necessary nutrients they need to stay healthy from the food they eat. Plants do it differently. Plants make their own food by capturing some of the sun's energy and using water and carbon dioxide. Plants use nutrients to grow, and are then eaten by animals as food.

When dead plants, dead animals, and animal waste (fecal matter) decay, nutrients are released into the water or soil and are deposited in the ocean bottom sediments. Large populations of bacteria live in the surface mud. They are the chief decomposers for the ocean system. They are also food for deposit- and filter-feeders.

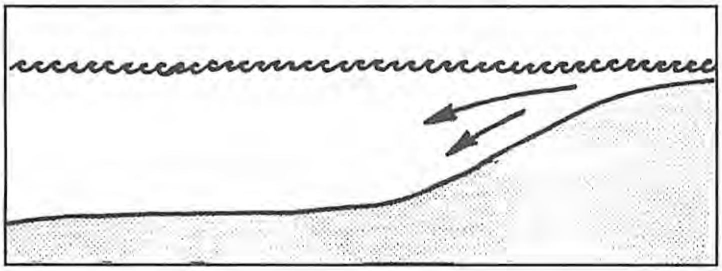
Many marine animals absorb carbon dioxide and calcium from the surrounding seawater and convert it to calcium carbonate, the same material that human teeth are made of. Seashore animals use calcium carbonate to make hard, protective shells, e.g., barnacles, crabs, clams, mussels, oysters, and snails.

Procedures

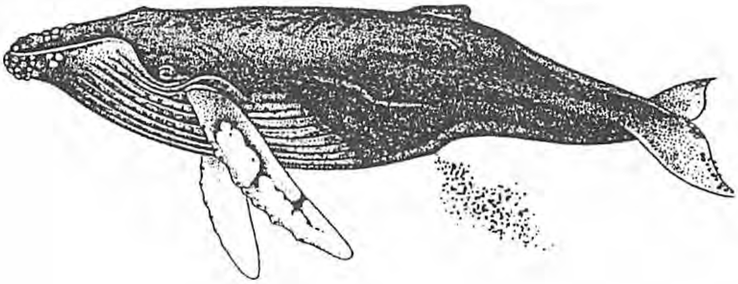
1. Perhaps you have spent a few quiet moments at the seashore and noticed the constant activity of the organisms. (Recall tidepool observations, etc.) What movements do you see? Fish cause ripples in the water, birds fly overhead, crabs scurry under rocks, etc. Beach Hoppers and insects crawl, hop, and fly everywhere. In order to have activity, what is needed? (Energy.) Where do organisms get the energy they need? (Ultimately, from the sun.)

Sources of Nutrients

1. Some minerals are found on the ocean bottom in sedimentary deposits. The minerals come from soil and rocks carried to the ocean by rivers.

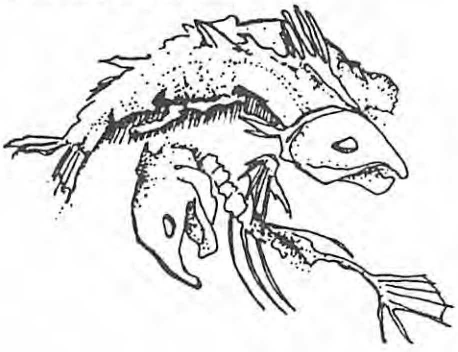


2. Some nutrients found in the ocean come from animal waste.



3. Some nutrients found in the ocean come from decaying plants.

4. Some nutrients found in the ocean come from decaying animals.



2. Brainstorm what all living things need in order to survive. What do humans need? Plants? Ocean animals? Do a webbing activity for humans and for ocean animals. Review the lesson "All Living Things Have Needs," on page 62.

3. What do humans need in order to build strong, healthy bodies? What do humans need for strong bones? Clear skin, and so on? (Discuss a balanced diet, vitamins, calcium for strong teeth, etc.)

4. Brainstorm what specific marine animals need in order to have strong bodies. For example, what does a clam need in order to grow a strong, hard shell? (Calcium.) What does a crab need in order to grow a strong outside shell covering? (Calcium.)

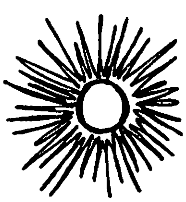
5. Brainstorm sources of nutrients. Show the overhead transparency. Engage the students in a discussion about the need for energy from food and the sources of nutrients.

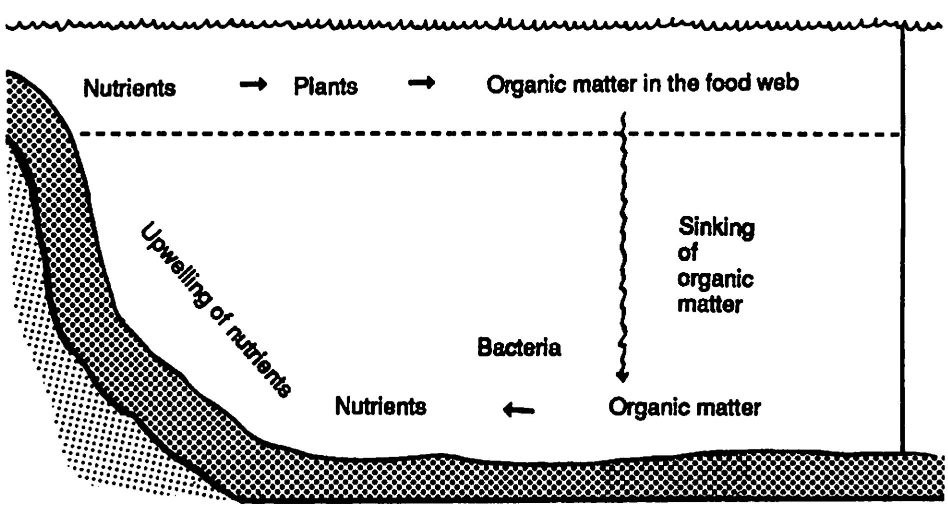
6. What happens to dead plant and animal material? What is decay? Decomposition? What important invisible organisms are in every ecosystem? (Bacteria.) What happens to the food energy locked inside the dead animal? (Bacteria use the food energy for growth and reproduction, while also breaking down the cells of the fish to release nutrients. Water recycles the nutrients in decaying organisms.)

7. What is animal waste? (Animal feces.) Is food energy locked up in animal waste? (Yes.) Where does this food energy go? (Water recycles the nutrients in animal waste.)

8. What would happen to life in the ocean if there were no nutrients? No sun? What would happen to life on land?

Nutrient Cycle





The Sunlight Food Factory

Concepts

1. All living things need energy to live and grow.

2. The sun is the source of energy for most living organisms.

3. Like all green plants, diatoms and seaweeds use energy from sunlight to convert carbon dioxide, water, and nutrients into food for themselves.

4. Marine plants get dissolved nutrients from the water.

5. The process whereby green plants produce their own food is called photosynthesis.

Understandings

The students will be able to 1) describe the process of photosynthesis, and 2) compare the process of photosynthesis to a food factory metaphor.

Materials

Transparency: "Sunlight Food Factory"

Teacher Information

All living organisms require food in order to live. Food contains the materials used to build bodies of plants and animals. In the ocean, animals obtain food by eating microscopic plants and seaweeds or other animals. Marine plants, like their terrestrial counterparts, do not eat. They make their own food by a process called photosynthesis. Photosynthesis occurs when the plant combines the energy in light with the raw materials it takes in from its surroundings. The amounts of light, carbon dioxide, and water must be available within certain ranges for photosynthesis to take place. The interaction of light energy and these materials results in the production of plant food. Some of the food green plants photosynthesize is used to maintain their living processes, including growth and reproduction. The rest is stored. Humans and other animals benefit from this stored food when they eat seaweeds and other plants. Plants use this stored food to support living processes whenever photosynthesis cannot take place. Because plants are the original source of all food for organisms, biologists refer to plants as producers.

Plant plankton also produce their own food by using the action of sunlight during photosynthesis. Chlorophyll, which is green, uses the energy in the light that filters down through the water to form sugars (or glucose) from carbon dioxide and water, giving off oxygen in the process. The oxygen that is produced dissolves in the water.

$$\text{Carbon dioxide + Water + Light energy} \xrightarrow{\text{chlorophyll}} \text{Glucose + Oxygen}$$

Photosynthesis produces oxygen and uses up carbon dioxide.

Because plants need light to grow, the part of the ocean that is lighted by the sun is crowded with plant plankton, but there are no plants where the sea is dark.

Teacher's Note

Photosynthesis is a complex abstract concept. Depending on the grade level, it may not be necessary that students understand how the process occurs. A common misconception is that students think green plants use the sun's energy to produce their own food, rather than plants using energy from the sun to *convert* raw materials into food for themselves.

Procedures

1. Use the Sunlight Food Factory transparency to help the students make connections between the abstract concept of photosynthesis and a food factory.

Teacher's Note

See pages 74, 85, and 261 for additional metaphorical thinking activities.

In the metaphorical illustration below, the building for the Sunlight Food Factory (or photosynthesis factory) is plant plankton, kelp, or other seaweed. The energy source of the factory is sunlight (the solar panel could be green chlorophyll). The raw materials for the factory are carbon dioxide and water. The product is food in the form of sugar, or glucose, which is used for energy. The byproduct that the factory produces is oxygen. The good thing about this byproduct is that it is not a pollutant. In this environmentally friendly factory there is also a good recycling program, for the oxygen waste products are recycled by animals which breathe in oxygen and breathe out carbon dioxide, thus creating a balanced system.

2. Show the transparency, "Sunlight Food Factory." Write the following metaphorical questions on the blackboard. Then engage the students in an open-ended discussion that attempts to reinforce their understanding of photosynthesis.

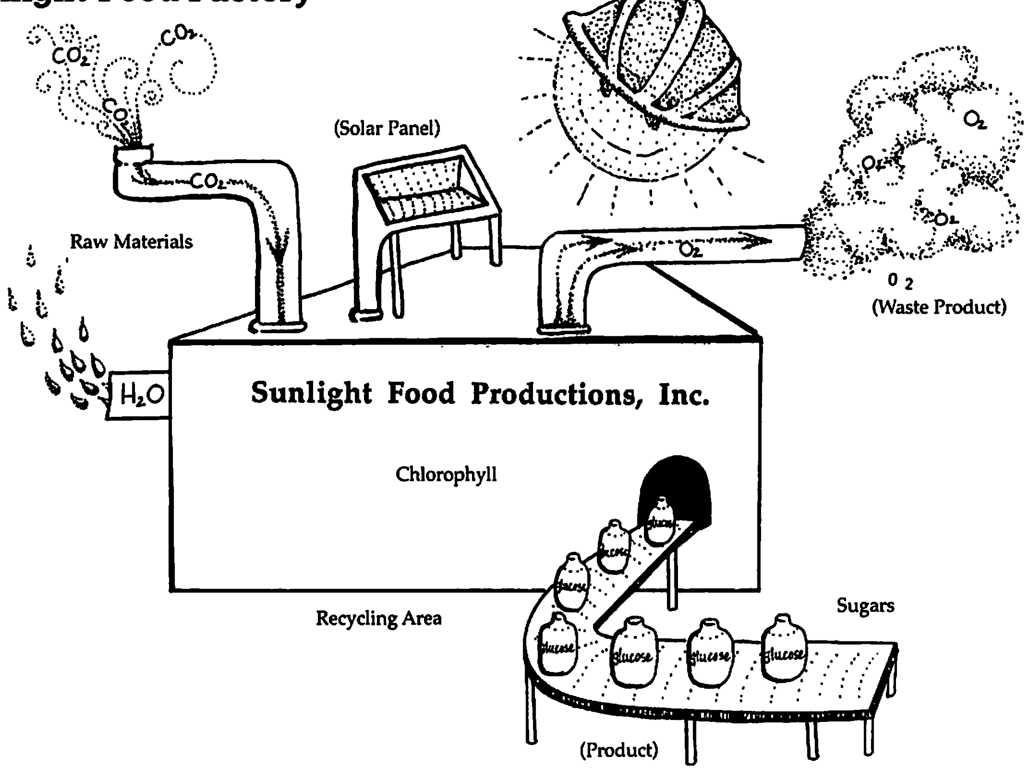
If the process of photosynthesis could be compared to a food factory, and seaweed were the building, what would be the:

Energy source	Raw materials
Product	Waste materials
Name of the food factory	Why?

Would this be an environmentally friendly factory?

Would there be pollutants? Explain.

Sunlight Food Factory



Getting Food

Concepts

1. Animals that capture and kill other animals for food are called predators.

2. Grazers feed on attached seaweeds and the film of diatoms and other tiny seaweed that carpet the rock surfaces.

3. Filter feeders strain microscopic plankton from seawater.

4. Scavengers are animals that eat most anything they can get, including relatively fresh material, plant and animal waste, as well as dying and long-dead organisms.

5. Deposit-feeders feed on bottom deposits of dead plant and animal matter, called detritus.

Understandings

The students will be able to 1) describe how seashore animals collect or capture food; 2) keep a record of food relationships at the seashore; 3) identify food relationships at high tide and at low tide; 4) identify animals as predators, grazers, scavengers, filter feeders, or deposit feeders; and 5) describe and draw feeding structures.

This learning cycle could be spread out over your seashore unit so that the class collects information on every beach walk.

Materials

Pacific Coast Information Cards

Transparency: "Getting Food"

Field Notebooks and pencils

Teacher Information

When the tide is low, most seashore animals show no movement or life at all. They hide in their shells, in crevices, or among seaweed. Without the water, there's no food for filter-feeders to eat, movement is impossible for many animals, and few shields from the sun. But when the tide covers the seashore, the animals spring to life. The feast is on!

There are many different kinds of feeding behaviors at the seashore. These can be grouped into feeding types: predators, filter feeders, grazers, scavengers, and deposit-feeders.

Predators

During high tide, crabs scurry over rocks, crawl sideways into narrow passageways, and creep among swaying seaweeds looking for food. Crabs aren't picky about their food. Some use their pincers like a can-opener to chip open the shells of barnacles, mussels, and clams. Others clip seaweed from the rocks and use their pincers to carry food to their mouths. Many feed on whatever they can get, the dead and the dying.

Hungry sea stars use their tube feet with suction-cup tips to open shellfish. The tug-of-war can last for days, but when the shellfish tires and gapes open, the sea star slips its stomach between the shells and starts to digest its meal.

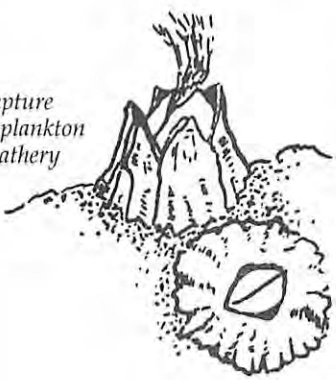
The incoming waves bring amazing changes to seashore life. Anemones open like flowers. They have a saclike body and a ring of stinging tentacles around the mouth. The tentacles have poisonous darts that can sting and temporarily paralyze small animals such as animal plankton, snails, small shrimps, and fish. Should a shrimp wander too close, the tentacles quickly fold over it. All the tentacles curl inward and the saclike sea anemone closes up, like a purse string drawn tight. The sea anemone then digests the shrimp.

The Moon Snail drills a hole through the shells of clams with its radula.

Certain snails such as the Moon Snail and Wrinkled Whelk are active predators that use their specialized tongue (or *radula*) to drill holes in the shell of mussels, clams, and oysters upon which they feed.

Also, at high tide, strange-looking fish dart here and there on the bottom of the sea. The Tidepool Sculpins have big heads, large powerful jaws, and large spiked fins and tails. They "walk" on their forward fins or silently glide from rock to rock gobbling up small barnacles, tiny crabs, snails, and whatever else they can get.

With the ebbing of the tide, the shore birds probe with their bills in the cracks, crevices, and seaweeds for small snails, limpets, crabs and other crustaceans, and worms. Gulls pry mussels, clams, and sea urchins loose, fly with them into the air, and let the shellfish drop to smash open on the hard rocks.



Barnacles capture microscopic plankton with their feathery legs.

Filter Feeders

When the tide returns, tiny drifting plant and animal plankton flood the shore. Barnacles, thrust their curled, feathery legs in and out, like a fisherman's net, to catch microscopic plankton. Mussels and clams have sieves to strain the water. When covered with seawater, the shells open slightly, and like the barnacle, they dine on plankton soup.

Grazers

Limpets, chitons, and abalones use their radula, or file-like tongue, to scrape the seaweeds and the thin film of diatoms from the rocks. The radula is a ribbon of hard protein studded with microscopic teeth, which are often capped with iron or other hard metals. As the teeth are worm smooth from use, they're replaced by a new set of teeth, which the animal rolls forward as needed.

The red abalone grazes on kelp with its file-like tongue.

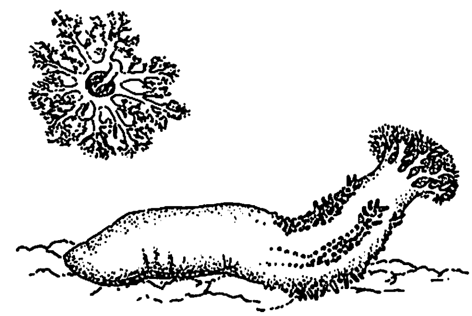
Sea urchins feed mainly on seaweeds. The urchins have five movable teeth in their mouth, which is located on the underside of the animal that come together like a powerful scraper.

Scavengers

At low tide, many amphipods and isopods swim in tidepools or jump among the seaweeds and rocks. Beach Hoppers are the largest of our amphipods, and are commonly found scavenging in decaying seaweeds. Most crabs are part-time scavengers, feeding on dead mussels, clams, barnacles, and almost anything they can get. Even eagles are opportunist and will dine on freshly caught salmon, the decaying remains of fish, or anything else they can get. Together they form a kind of cleanup squad as they feed on dead and dying sea life.

Deposit-Feeders

This is the main method of feeding on the bottom of the ocean. Deposit-feeders, also called detritus-feeders, feed on bottom deposits. Some of these animals are selective in their choice of food; others feed on whatever edible items are in their path. Sea cucumbers and worms are examples of deposit-feeders.



The Orange Sea Cucumber uses its tentacles to select particles of food in the bottom sediments.

Procedures

1. Ask the questions: When is dinner time at your house? Why do we eat dinner in the evening?

2. When is dinner time at the seashore? Would it be high tide, low tide, or all the time? Discuss the significance of the phrase, "When the tide is high, the table is set."

3. Brainstorm what might be on the menu at the seashore. Ask the students to recall their observations of animals at the seashore. List possible items to eat on the blackboard.

4. Can anyone think of another name for an animal that captures and kills other animals for food? (Carnivore, hunter, predator.) What land animals are predators? (Cougar, polar bear, wolf.)

5. Can anyone think of another name for an animal that is eaten by a predator? (Prey, the hunted.)

6. Are all animals predators? In different words, are all animals meat eaters? Are all people meat eaters? Discuss vegetarians. Tell the students that we call animals that don't eat meat "grazers." Discuss land animals that are grazers (horse, cow, deer, elephant). What do these animals eat? Engage the students in a discussion about the thin film of green diatoms that covers the rocks, boulders, mussels, and seaweeds at the seashore. Why are the rocks so slimy? Why is it easy to slip and fall on the rocks? Tell the students that this thin film of diatoms provides food for numerous grazers at the seashore.

7. Can anyone think of another name for an animal that eats dying or dead plants and animals? (Scavengers.) What land animals are scavengers? What seashore animals are scavengers?

8. Ask the students to recall the chapter on plankton soup (page 91). Brainstorm how a marine animal might feed on plankton soup. How would the animal catch or trap the plankton? Discuss how clams have fine sieves or filters and barnacles have featherlike legs (or cirri) to trap microscopic plankton.

9. Recall what happens to decaying plants and animals. Tell the students that some animals feed on decayed plant and animal matter that drifts in the ocean, or is deposited on the bottom. These animals are called deposit- or detritus-feeders. Brainstorm what animals are deposit-feeders. (These include sea cucumbers, sand dollars, and many species of worms.)

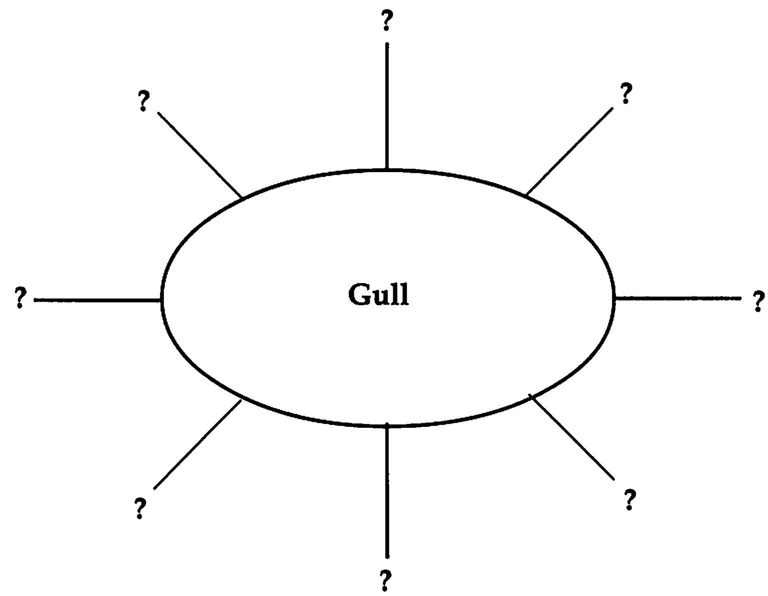
10. What shore animals might come down to the seashore at low tide to feed on seashore plants and animals? (Shore birds such as gulls, crows, eagles, and oyster catchers; and other animals such as raccoons, river otters, mink, rats, mice, snakes, and humans.)

11. What deep water animals might come to shore at high tide to feed on seashore plants and animals? (Big fish with big teeth such as rock cod, ling cod, etc.)

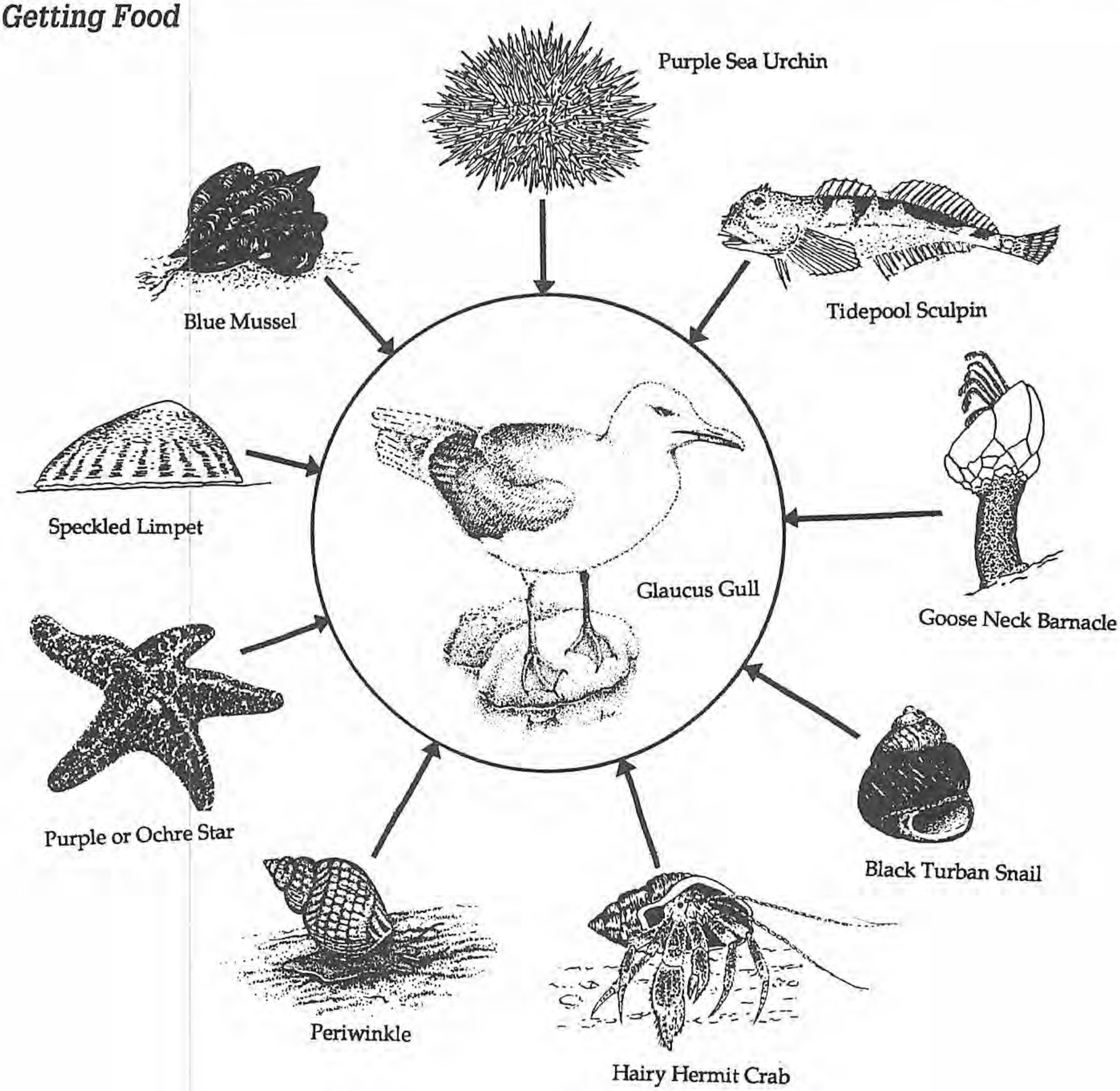
Word Webbing Activity

Choose an obvious predator at the seashore, such as a gull or shore crab. Do a word webbing activity where the students recall from their previous experience observations of gulls shopping for a meal.

Repeat this same activity after the students have observed gulls in a more systematic way at the seashore. (See transparency, "Getting Food.") Do this for crabs, anemones, sea stars, sea urchins, etc.



Getting Food



Seashore Observations

Tell the students that throughout the time they're at the seashore, they should make observations of seashore organisms feeding (e.g., crabs, sea anemones, sea stars, birds, fish.) It will be difficult to observe seashore animals eating when the tide is out because most animals stop moving. They should look for animals moving and eating in tidal pools, around dock pilings, and in shallow water.

The students should observe specific animals carefully and make notes in their field notebooks (or record into the tape-recorder.) Keep records on the following:

- What it's eating
- How it obtains its food
- Whether it moves, how it moves, how fast it moves
- How it captures, holds, and eats its food

Look for evidence of animals that have been eaten; empty crab shells, empty clam shells, empty sea urchin shells, shell fragments around sea anemones, etc.

If you're lucky enough to have a saltwater aquarium, keep a record of feeding relationships in the aquarium.

From the students' observations at the seashore and from their readings, make a class chart of feeding types.

Feeding Types

Predators	Grazers	Scavengers	Filter Feeders	Deposit Feeders

Brain-Buster Questions

Analyze the above information, then discuss the following:

- Can an animal be both a predator and a scavenger?
- Can an animal be both a meat eater and a plant eater?
- Why are Tidepool Sculpins, Purple Shore Crabs, and Bald Eagles grouped both as predators and scavengers?

Classifying Activity

Have the students read the information on the back side of the Pacific Coast Information Cards, then sort all the cards according to feeding types.

Library Research

Consult local field guides and books for additional examples of food items and feeding techniques at the seashore. What do the following animals eat: Pacific Octopus, Tidepool Sculpin, mussel, Acorn Barnacle, Butter Clam, Harbor Seal, California Sea Lion, Killer Whale, Humpback Whale? How do these animals capture their food?

Survival Tricks

Concepts

1. Animals protect themselves in a variety of ways.

2. Animals have special behaviors that help them escape predators.

3. Animal have special structures that help them escape predators.

Understandings

The students will be able to 1) identify ways seashore animals protect themselves from predators, 2) identify and sketch examples of behavioral adaptations, and 3) identify and sketch examples of structural adaptations.

Teacher Information

At the seashore, competition for food and space is great because there are so many plants and animals living together in close association. Because there are so many predators, intertidal animals must protect themselves in a variety of ways from being eaten. These adaptations help the animal survive.

Ways animals defend themselves from predators include camouflage, hiding, decoys, hard shells or shields, sharp spines or claws, poisons, digging or burrowing, tube building, and speed. Many of the ways animals defend themselves from being eaten are also ways they obtain a meal for themselves. For example, the camouflage of a Tidepool Sculpin protects it from detection by hungry shore birds, and at the same time helps it to lie in wait for an unsuspecting meal.

Eighth-grade student observes Purple Sea Star eating mussels.

Classroom Organizer

Before going to the seashore, have the students think of all the different ways an animal might protect itself from predators (camouflage, weapons, shields, decoys, quick escapes). The students will probably think of lots of ways you hadn't thought of. To begin, consider the following organisms: Acorn Barnacle, Purple Shore Crab, Tidepool Sculpin, Checkered Periwinkle, Purple or Ochre Sea Star.

Seashore Observations

At the seashore, find an animal and observe it in its habitat. Watch its behavior as well as its color and shape. Add it to your list if you feel it's a good example.

Purple or Ochre Sea Star feeding on a Butter Clam

Classroom Follow-up

Engage the students in a discussion about adaptations that enable animals to 1) capture food and 2) avoid or escape predators. Discuss the difference between behavioral adaptations (change color, squirt ink, display claws) and structural adaptations (hard shells, sharp claws, pointed spines, stinging cells).

Food-Getting Tricks (adaptations that enable animals to capture food)
From your observations and readings, make a class chart of feeding adaptations:

Animal	Food	Feeding Structures	How this animal gets its food
Gull	Sculpins, snails, clams, barnacles	Sharp beak	Turns over rocks, cracks barnacles open, chases other birds, drops clams on rocks
Purple Shore Crab	Barnacles, periwinkles, Sea Lettuce, worms	Razor-sharp pincers, large claws	Crushes small barnacles with its claws, eats dead animals, tears seaweeds apart and eats it
Acorn Barnacle	Plankton	Feather-like legs	Strains seawater for tiny plants and animals

Animal Survival Tricks (adaptations that enable animals to avoid predators)

Animal	Structural Adaptation	Behavioral Adaptation	How this adaptation helps the animal to avoid its predators

Discuss the fact that many survival adaptations also enable an animal to capture its prey.

- Can methods of feeding be related to other aspects of an organism's way of life, especially such things as immobility and locomotion?
- Can methods of feeding be related to habitat?

Library Research

Consult the Pacific Coast Information Cards, as well as field guides and books, for additional examples of food-getting methods and survival tricks at the seashore.

Food Chains

Concepts

1. The sun is the source of energy.

2. Food energy flows from one living thing to another in a series of steps called a "food chain."

3. Plankton is the base of the entire food chain in the temperate oceans.

4. The food web has three levels—producers, consumers, and decomposers.

5. Generally, each animal in a carnivorous food chain eats organisms that are smaller.

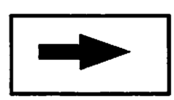
Understandings

The students will be able to 1) construct diagrams of food relationships, 2) construct food chains with picture cards of seashore organisms and arrow cards to show the direction of food energy flow, and 3) infer what happens to the size of organisms at the top of a food chain compared to the bottom.

Materials

Pacific Coast Information Cards for Rocky Shore

Make a set of 100 Arrow Cards (10 cm x 5 cm)



Teacher Information

The Sun Collectors

All living things need energy in order to live and grow, but only plants are able to trap energy from the sun. The energy that plants capture is used to produce food in the form of sugars. Some sugars are used by the plant to grow; some is stored in the plant in the form of sugars. Animals are able to get that stored energy when they eat plants. Because plants are the original source of food for organisms, they are called "producers." Almost all food chains begin with the sun.

Plant Eaters

In the ocean, plant eaters eat diatoms and a great variety of seaweeds. Each time a plant eater eats a plant, the stored energy in the plant is transferred to the animal as food energy. Plant eaters are called "herbivores."

Meat Eaters

Meat eaters, or carnivores, are animals that eat other animals for food. Each time a plant eater is eaten by a meat eater, the stored energy in the plant eater is transferred to the body of the meat eater as food energy. In turn, each time a meat eater eats another meat eater, the energy stored in the body of the prey animal is transferred to the body of the predator.

The Cycle of Nutrients

Producers get their nutrients from the water. Plant eaters get their nutrients when they eat the producers. Animals that eat plants or other animals for food are called "consumers." They get their nutrients from the food they eat. Then decomposers break down animal wastes and dead organisms. This releases the nutrients back into the mud, the gravelly bottoms, and the water so producers can use them again. In this way, nutrients are recycled through an ecosystem.

Increasing Size

Recall that the seawater is filled with millions and millions of phytoplankton (plants) and zooplankton (animals). The animal plankton eat the plant plankton, and bigger animal plankton eat smaller animal plankton. Then filter feeders such as clams, mussels, and oysters eat plant plankton, then they in turn get eaten by predators such as sea stars, octopuses, and Sea Otters. Generally, larger animals eat smaller animals.

Procedures

1. Ask the students to recall their observations of animal eaters at the seashore, and the word webbing activity where they listed observations of gulls shopping for a meal. Ask the students: When a predator such as a gull eats a mussel, which is the predator and which is the prey?

2. Write the predator-prey relationships outlined below on the blackboard. Continue the discussion as follows. As we have seen, when a gull eats a mussel, the gull is the predator and the mussel is the prey.

(Prey)	(Predator)
Mussel	Gull

When a predator such as a gull eats a mussel, the food energy stored in the mussel's body is transferred to the gull. Hence, the food relationship between a predator and its prey can be shown in a diagram by using arrows to show the direction of food energy flow (food energy flows from the prey to the predator).

Mussel ➔ Gull

3. Food relationships among filter-feeders, grazers, and scavengers can also be shown in a diagram by using arrows to show the direction of food energy flow. The following are a few examples of food relationships at the seashore. Which direction would the arrows point to show the direction of food energy flow?

Example:

Barnacle ➔ Purple Shore Crab

Clam ➔ Purple or Ochre Sea Star

Sea anemone ← Shrimp

Plankton ➔ Barnacle

4. Tell the students that like simple food relationships, food chains can be illustrated by constructing simple diagrams:

Sunshine ➔ Diatoms ➔ Clams ➔ Sea stars

Remind the students that when constructing food chains, the arrows should point toward the organism that is being eaten by another organism.

Food chains grow rapidly. Here are three simple chains. The students can add organisms to form larger food chains. What other plants are eaten? What eats those animals?

Sun ➔ Kelp ➔ Sea urchin ➔ ? ➔ ? ➔ ?

Sun ➔ Diatoms ➔ Clams ➔ ? ➔ ? ➔ ?

Sun ➔ Diatoms ➔ Animal Plankton ➔ Barnacles ➔ ?

5. Tell the students that there are many different kinds of food chains, for example:

Decaying seaweed ➔ Beach Hoppers ➔ Raccoon

Dead crab ➔ Purple or Ochre Sea Star ➔ Sea Otter

Ask the students to notice how energy is passed through the different food chains. Discuss the following:

- Which plant or animal is at the bottom of the food chain? The top?
- What happens to the size of animals at the top of the food chain compared to the bottom?
- Infer how many snails, for example, would an Oyster Catcher eat each day?
- Infer how the death of a specific species affects the whole food chain.

Brain-Buster Food Chain Game

Divide the class into teams of six players each. Line them up in individual rows in front of the blackboard. The first player from each team writes on the blackboard or a tacked-up piece of paper the name of a plant found at the seashore (Rockweed). The second player adds to the list the name of an animal known to feed on the plant (Rockweed Isopod, Checkered Periwinkle, Speckled Limpet). The third player adds the name of a predator known to eat that animal, and so on. The team that makes the longest food chain at the end of the given time (10 minutes or so) wins. An example of a food chain might be Rockweed, Checkered Periwinkle, Tidepool Sculpin, Glaucus-winged Gull.

Food Webs

Concepts

1. Few animals rely on a single source of food.
2. Interlocking food chains form food webs.
3. Food webs are part of every ecosystem.

Understandings

The students will be able to 1) construct interlocking food webs using picture cards and arrow cards; and 2) construct food webs for a tidal pool, rocky shore, and sandy beach.

Materials

Transparency: "Food Web for a Rocky Shore"

Pacific Coast Information Cards

Teacher Information

"Food chain" is somewhat misleading because it suggests that animals depend on only one source of food. A few animals do depend on a single food source, but most eat a variety of organisms. Some animals eat both plants and animals, or they eat more than one kind of animal. They form interlocking food chains, which are called "food webs." Food webs are a part of every ecosystem.

Procedures

1. Ask the students to think of a seashore animal that relies on a single source of food. Ask the students to think of a food source consumed by more than one kind of animal. Discuss how a food chain can be misleading because it suggests that an animal depends on only one source of food. A few animals do depend on a single food source, but most eat a variety of organisms.

2. Brainstorm how animals eat more than one source of food. For example, a crab can be a predator feeding on barnacles, but also be a scavenger that eats both plants and other animals, but doesn't much care whether its food is living or long dead. When food is listed only once, the food chains interconnect to produce what is called a "food web." Food webs are part of every community.

3. Write the following example on the blackboard:

↗ periwinkle ↘

sunshine → kelp → sea urchin → gull

↘ limpet ↗

↗ mussel ↘

plankton → clam → sea star

↘ oyster ↗

Engage the students in a discussion about the interconnecting flow of food energy. How are organisms in a tidal pool interconnected? How do they depend on one another for survival?

4. How many predator-prey relationships and food chains can you find? Use the transparency of a "Tidepool" (page 187), or better yet, duplicate a class set and give one to each student or group of students. Challenge the students to look carefully for examples of predator-prey relationships and food chains. List these and construct a diagram with arrows to show the direction of food energy flow.

5. Use the transparency of the surf-swept rocky shore (pages 218–219). Challenge the students to identify organisms and look carefully for food chains and food webs. Construct a food web for the rocky shore.

6. Discuss with the students that such simplified food webs don't show every food source for every animal, because almost all of them eat many things not included in the diagram. Even so, the complexity of the pattern of interconnecting food chains is apparent. This interlocking pattern of food chains and food webs exists in the ocean, and in every other natural community, such as a desert, forest, or freshwater pond.

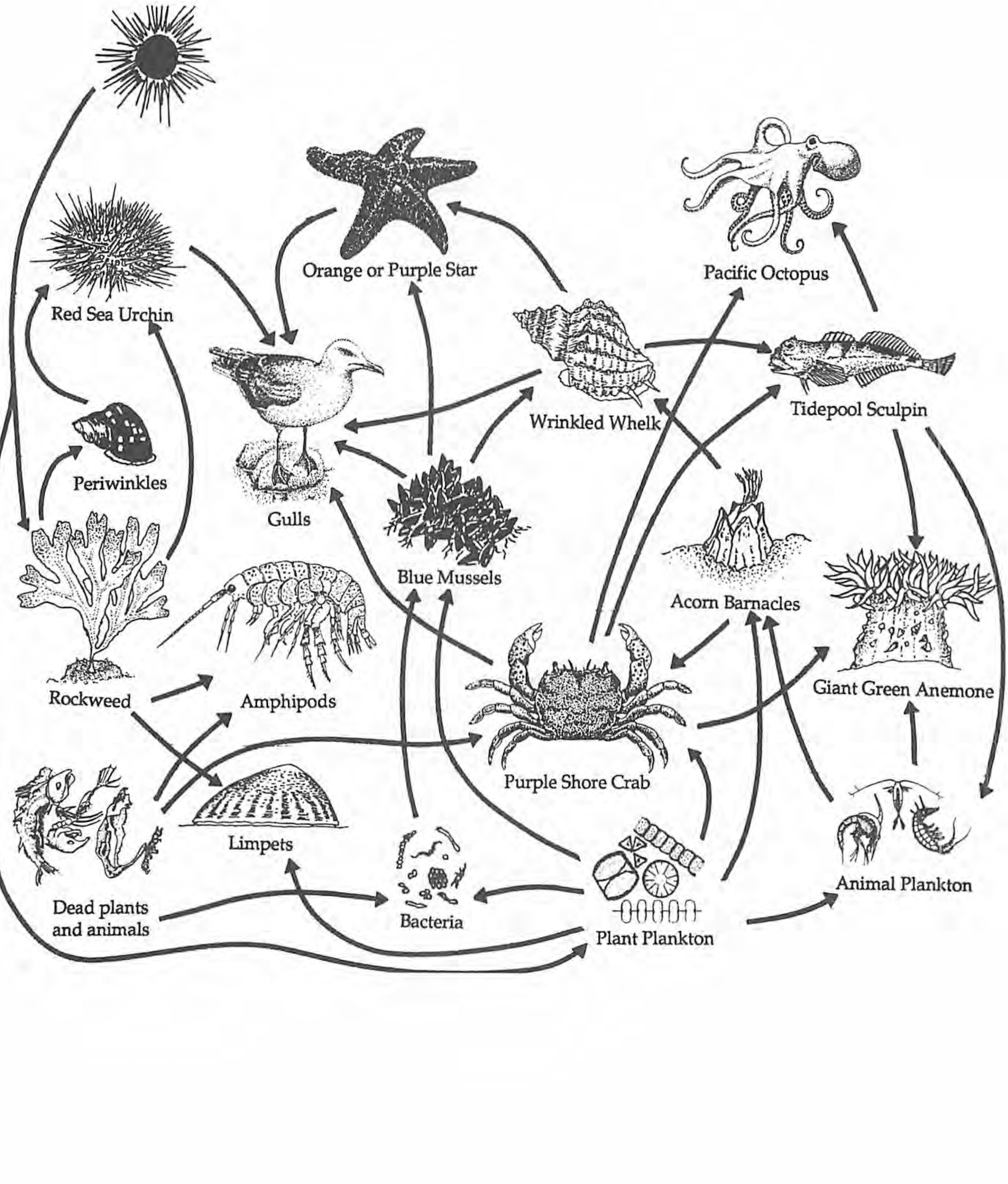
7. Engage the students in a discussion about the interconnecting flow of food energy in a food web. How do plants and animals depend on one another for their survival? How are organisms in a tidal pool, a mussel bed, a rocky shore, or a sandy beach interconnected?

Enrichment Activities

1. Construct a food web for a tidal pool, sandy beach, or rocky shore community.

2. Make a food web bulletin board. Use yarn to connect the organisms.

Food Web for the Rocky Shore

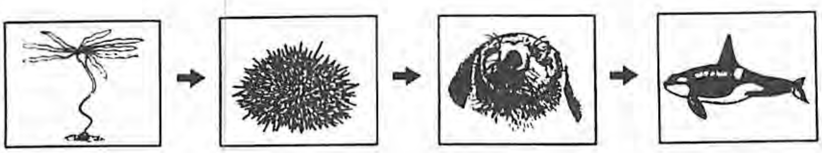


Who Eats Whom? Game

The Pacific Coast Information Cards can be used to build food chains and food webs.

Food Chain Game

Have the students place the plant and animal activity cards into food chains and food webs, as they see it. Use the information on the back side of the cards as a reference.



Web Card Game

This game, which is similar to dominoes, can be used to build both food chains and food webs.

Players—Two to six.

How to Play—The dealer places the first card from the deck face down on the table. The cards are dealt until each player has seven cards. The remaining cards are placed on the table.

The card in the center of the table is turned face up. It serves as a starting point for the food web to be built. The player to the left of the dealer plays first, and may build up or down on the starting card, using a card representing an organism that eats (place above) or is eaten by (place below) the starting organism.

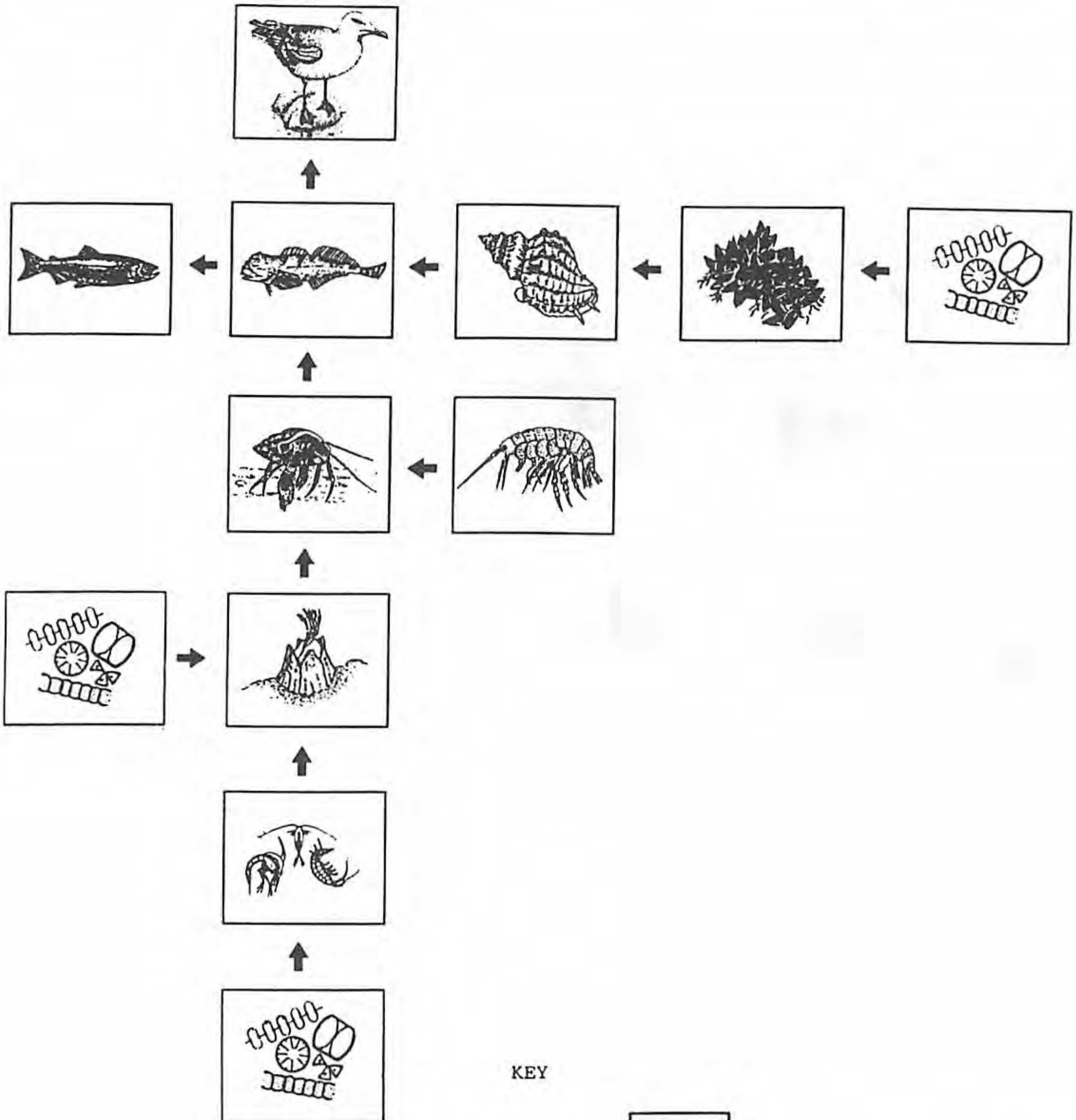
EXAMPLE: **(Base Card)**

The player could add barnacle, for example, to the bottom, or gull to the top. If the player does not have a card for an organism that eats or is eaten by an organism represented on the table, he or she must draw from the deck until a card that can be played is drawn. If no cards are left in the deck, the player must pass.

Play continues to the left, with each player adding one card to the food web.

After several rounds, the food web could look something like this:

The winner is the first player to play all of his/her cards.



KEY

	seagull			
salmon	sculpin	whelk	mussel	diatoms
	hermit crab	amphipod		
diatoms	barnacle			
	animal plankton			
	plant plankton			

Every Organism Has a Role

Concepts

1. An organism's niche is its role or place in an ecosystem—including how it interacts with other organisms.

2. An organism's habitat is the range of environments in which it can occur.

3. All organisms in an ecosystem are dependent on one another for survival.

Understandings

The students will be able to 1) describe an organism's habitat and role, 2) create an art piece depicting an organism's habitat and role, and 3) infer how organisms depend on one another for survival.

Materials

The following Pacific Coast Information Cards:

Checkered Periwinkle	Bald Eagle
Purple Shore Crab	Killer Whale
Tidepool Sculpin	Rockweed
Black Lichen	Spiny Lobster
Chinook Salmon	Moon Jellyfish
Sand Dollar	Sunflower Star
Krill	Diatoms
Copepods	Pacific Herring
Bull Kelp	Beach Hoppers
Glaucus-winged Gull	Red Sea Urchin

Art Supplies:

Construction paper	Glue
Pastels	Scissors
Crayons	String

Teacher Information

All plants and all animals have a role or niche in the forest ecosystem, the pond ecosystem, and the seashore ecosystem. A plant's niche includes the fact that it is a producer. The niche of a Bull Kelp includes the fact that its holdfast, or anchoring structure, provides a habitat for small worms, Brittle Stars, and crustaceans. An animal's role includes its place in the food chain. The role of animal plankton includes the fact that plankton forms the base of the food chain, while a Killer Whale is at the top of the food chain. An organism's role, then, includes how it interacts with other organisms in an environment. The plants and animals in an ecosystem are interdependent, with each species contributing to the functioning of the overall system.

Procedures

1. Tell the students that every person in a community has a role or job to perform. Some people are housekeepers; some are teachers, garbage collectors, farmers, truck drivers, policemen, doctors, and so on. What roles do some of their parents have? Do parents depend on other parents in the community for various things to be done? How?

2. Discuss the term "role." Just as every person in a community has a role, every organism has a role. Every plant and every animal has an important role in its particular community; the forest community, the pond, or the seashore. An organism's role includes its place in the food chain; whether it is a producer, predator, grazer, filter feeder, scavenger, or deposit-feeder. An animal's role might relate to the fact that it provides a home for other animals to live in. Or a plant or animal might die and its decomposing remains would provide food for other animals.

3. Write the terms "habitat" and "role" on the blackboard. Tell the students that to remember the term "habitat," we could say that my habitat is my address—the place where I live. By comparison, my role can be compared to my "occupation."

4. Have the students work with a partner. Each pair should choose one of the Pacific Coast Information Cards listed above. (Students might want to choose the same organism as in the previous lesson, although the above list of organisms was selected to illustrate a range of roles.) The students should disperse and discuss how the concepts of habitat and role apply to their organism. How is the organism's habitat different from its role? What plants and animals depend on their organism for food, shelter, etc.?

5. Gather the students together to discuss the concepts of habitat and role. Ask three or four pairs to describe their organism's habitat and role. Again, stress that the habitat of an animal is its "address" (where it lives), and its role is the animal's "occupation" (how it interacts) at that address. An animal's role is how it makes its living. Biologists refer to an animal's role as its niche.

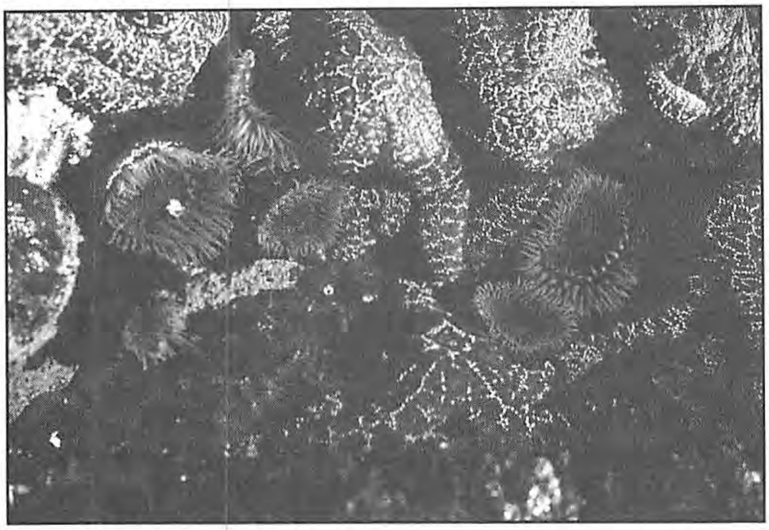
6. Discuss the word "interdependence." How do people in a neighborhood or community depend on one another for the common good? Discuss the fact that people in the city depend on farmers, truck drivers, and grocery stores to provide them with food. They depend on cars, hydroelectricity, refrigerators and sanitation departments to help them meet their needs. How do organisms in a particular habitat depend on one another for survival of the whole?

Enrichment Activity

Ask each pair of students to create an art form representing their organism's habitat and niche. Use pastels, crayons, construction paper, etc. Some students might want to construct a mobile. The students should share their art forms with the class and tell how their art illustrates the organism's habitat and niche. They should be prepared to describe the animal's role in its habitat. What other plants and animals depend on their organism for food, shelter, etc.?

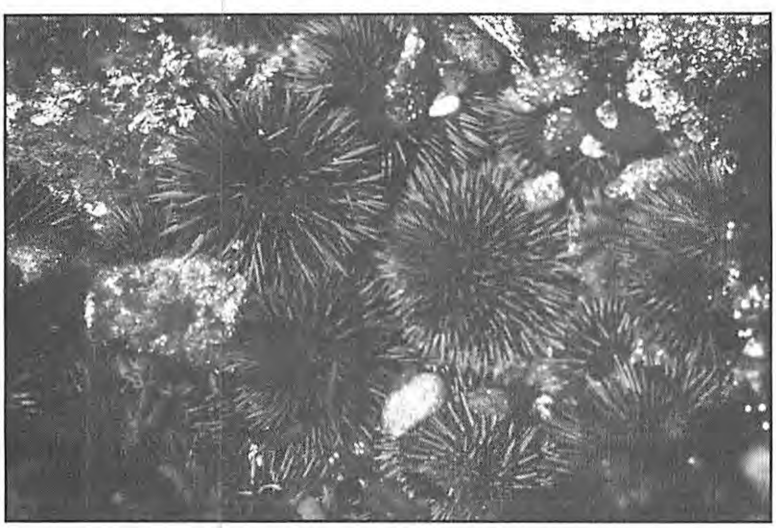
Teacher's Note

The concepts of habitat, role, and interdependence should be stressed during future lessons; for example, when learning about the rocky shore, the sandy beach, the estuary, and the mud flat.

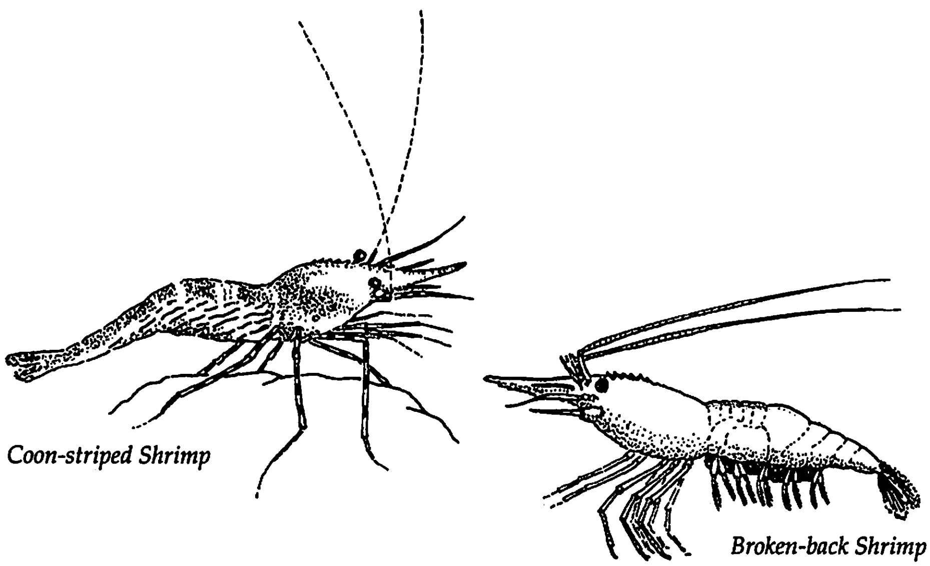


Giant Green Anemones and Purple or Ochre Sea Stars, a typical low tidepool of the exposed Pacific Coast.

The sunflower star is the largest and fastest sea star afoot, and can travel up to three meters a minute!



Purple urchins gather in large numbers to graze on kelp.



While exploring the tidepools, chase after the fairy-like shrimp. These animals are fun to observe as they dart forward and backward and perform amazing loops with ease, all the while propelling themselves with their swimming legs and by a sudden flick of their tails.

Chapter 5: Science Inquiries with Seashore Animals

Animals are neat. Every student knows that. Small seashore animals bring all the fascination of larger, better-known ones such as whales, seals, or sharks to the classroom. Many seashore animals are ideal for learning because they invite immediate fascination and curiosity. Animals are not fully predictable, no matter how long they're studied. Questions flow naturally and lead to organized and enthusiastically independent investigations. Seashore animals lend themselves to inquiry. Their size is convenient for study, as most are large enough to observe easily. Investigations can emphasize observing, predicting, inferring, classifying, measuring, and recording, and the data can be interpreted and reported to the class.

In this chapter, students have several exploratory activities with living organisms. In the process of learning the skills of discovery, they develop some understanding of the following concepts:

- Living
- Nonliving
- Organism
- Senses
- Behavior
- Protect
- Tentacles
- Tube feet
- Antennae
- High tide
- Low tide
- Sun
- Camouflage
- Locomotion
- Adaptation
- Predator
- Prey
- Survive

Jane Barron sketches a Coon-striped Shrimp (result above).

Using Questions to Guide Investigations

Though unguided exploration is an indispensable way to begin seashore inquiries, there is a point at which exploration needs to be structured by a teacher. When students explore the seashore and encounter new, often discrepant phenomena—strange sea creatures, the ebb and flow of the tide, an empty crab molt—their natural curiosities are excited. These firsthand experiences with nature provide a framework to formulate questions, which in turn give rise to new questions and further investigation and discovery.

It is essential that teachers be non-controlling and non-inhibiting to student participation, especially in the beginning stages. In short, teachers should talk less and listen more. To paraphrase philosopher Paul Tillich, we should avoid throwing answers like stones at the heads of those who have not yet asked the questions. Clearly, students ask fundamental questions—relevant and appropriate questions—which need to be communicated and explored. The sensitive teacher listens to the students' thoughts, ideas, and questions, and provides the necessary words to formulate and extend their ideas. The teacher listens to the students and extends and changes her or his plans to encourage further exploration and discovery.

While the students work, the teacher encourages them to talk about what they're doing. Initially their absorption may be too intense to do this. There is a great deal of skill in knowing when and how to initiate discussion, when to join in on conversations, and when to allow the students time to work alone. The skill of knowing when to offer guidance and when not to comes with experience, through observing the students, and by knowing each individual.

How to Get Answers to Questions

Students ask questions that require varying levels of sophistication to answer. This puts teachers in awkward situations. I frequently encounter elementary teachers who feel hesitant to teach nature programs because they say they lack "scientific" skill and knowledge. Let's get one thing straight: You don't have to know all the right answers before teaching a unit on the seashore! In fact, knowing too many answers destroys the thrill of finding out, both for yourself and for your students. I recall many happy times when my students burst their buttons because they figured out the answers before I could. After all, what's more important—getting the right answer or knowing how to find the right answer? Of course both are important. But when students know how to ask questions—and know something about how to answer questions—they have learned how to learn, and are capable of investigating whatever they're interested in knowing.

Questions that can be Answered Through Observation

Many of the questions students ask at the seashore can be answered through careful observation. These questions are easy to check, but you will have to do some observing and questioning of your own. Examples of such questions are:

What do crabs eat?

Can barnacles move?

How do mussels attach to rocks?

It's not so important that students know what crabs eat or whether or not a barnacle can move. What is important is that students learn that they can answer questions by observing.

Questions that can be Answered by Measuring and Recording

Some questions have answers that can be determined to be reasonably correct or incorrect, provided you observe the students while they work, that you do some investigating on your own, and that you measure and record the results. Examples of such questions are:

How far can a snail move in one minute?

How long does it take the tide to go out?

How many barnacles are in a square meter?

It's not so important that students learn how far a snail can move in one minute or how many barnacles are in a square meter. What is important is that students learn that they can answer questions by measuring and recording data.

Questions that can be Answered by Setting up Simple Investigations

Some questions that students ask are more difficult to answer. They require that the young investigator state several inferences and invent simple investigations to test possible answers. Such questions often have several correct answers, but usually one answer or combination of answers is best. Examples of such questions are:

Why do shore crabs walk sideways?

Why do hermit crabs have eyes on long stalks?

How do clams dig into the sand?

It's not so important that students learn why crabs walk sideways or why hermit crabs have eyes on long stalks. What is important is that students learn they can answer questions by setting up simple investigations.

Questions that Have Answers Difficult to Verify

Some questions that students ask are extremely difficult to answer. They require the young investigator to test old and new theories and invent new investigations. Many questions require investigations that must be conducted over long periods of time. Even if you could find the answers in books, the books themselves—indeed, many scientists—would disagree on the answers. Examples of such questions are:

Why are sea stars bright colors?

Are Checkered Periwinkles becoming land snails?

Why are some limpet shells quite low and some limpet shells quite high?

It's not so important that students learn why sea stars are bright colors or why limpet shells vary in height. What is important is that students learn that there will be disagreement over answers and that answers that seem correct today may be proven incorrect tomorrow.

Questions that can be Answered by Reading Books

Some questions that students ask can be answered by consulting books and other resources such as local experts, aquaria, etc.:

What is the biggest starfish in the world?

What's inside a barnacle?

How do crabs make baby crabs?

How do starfish breathe?

What causes the tide to go in and out?

The students should realize that books are an excellent source of information, but they can use their own creative imaginations to answer many of their questions, and that many questions will go unanswered.

Setting up a Simple Experiment

A good way to help students conduct experiments is to begin by having the whole class brainstorm what they know about a particular organism from their past experiences (e.g., crabs, sea stars, sea anemones, or gulls). Or you might encourage the students to observe an organism firsthand, and then brainstorm what they know about the organism from their observations. Another idea that works quite well is to use a large picture or to project a slide of an organism onto a screen.

The following ideas about Purple Shore Crabs were generated by a second-grade class after they had observed the living organism:

Purple Shore Crab

What We Know About Purple Shore Crabs

Its shell is purple and its claws have purple dots.

It has a hard shell that covers its body.

It has big claws that pinch.

It walks sideways and backwards.

It can pinch hard.

It has big eyes that move.

It blows bubbles.

After the students have observed the organisms (or a slide or large picture), encourage them to brainstorm questions:

What We Want to Know About Purple Shore Crabs

Why are shore crabs purple?

Why do shore crabs walk sideways?

What do crabs eat? How do they eat?

Do crabs have enemies?

Why do crabs blow bubbles?

How do crabs make baby crabs?

Do all the crabs that live under a cobblestone belong to one family?

Why do crabs hide under rocks?

Where do crabs go when the tide is high?

Do shore crabs always come back to the same cobblestone? Is the cobblestone like their house?

Can I keep a crab in a shoe box under my bed?

Then, when the students have exhausted their thinking, they should be encouraged to identify a favorite question, and then think of a simple investigation to test possible answers.

Are any students stuck? Does anyone need help? In the beginning some students will find it difficult to observe an animal in detail, ask questions, and investigate to find the answers. The following questions are provided to help these students get started. Other students are very curious about their organisms and will need little or no prompting. As much as possible, allow these students to continue their investigations without teacher help.

1. What does the animal look like? Make a large, detailed drawing. Include several close-up views of interesting parts.

2. Does the animal move? If so, how? Is the animal attached? If so, how?

3. How does the animal catch food? What does it eat? How does it eat? How could you find out?

4. Does the animal have any peculiar behaviors? What are they?

5. How does the animal protect itself from other animals?

6. Can it sense which way is up? Can it right itself?

7. How does the animal respond to light, dark, heat, cold, air, seawater?

DANGER! Be sure the animals are not harmed in any way.

What I Learned

After the students have completed their investigations, they should write a paragraph describing what they learned. They should be encouraged to locate more information about their organism's life history in the library. As the students gain new information, they should record their findings on the appropriate data collection sheet (see next 4 pages). Also, see Library Research, page 175.

Name:____________________________________

Investigating Living Animals

Name of Animal :________________________________

What I know	What I want to know	What I learned

Name:______________________________

Setting up an Experiment

What my animal looks like	Actions of my animal	Questions I have about my animal

Name:________________________________

My Experiment

My animal is a

My question

What I did

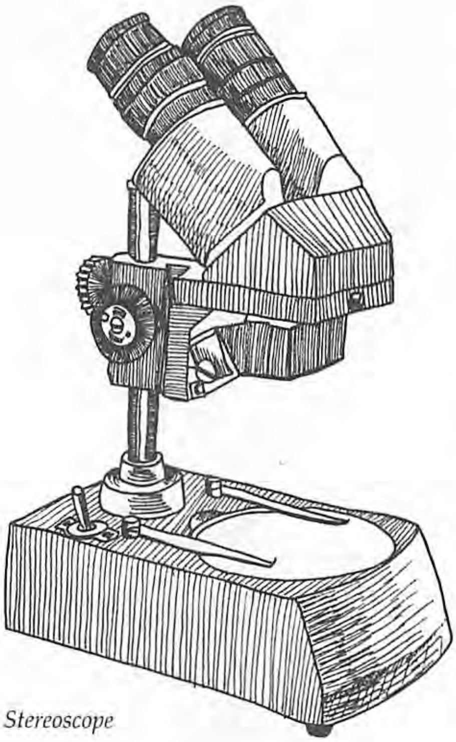
I predict

What happened

What I learned

Observing Animals with Microscopes

Seashore animals such as barnacles, crabs, and sea stars are large and can be studied nicely with the naked eye and the aid of magnifying lens. But seeing a barnacle sweep the water with its feathery feet, the mouth parts of a crab eating, or the blue eyes and long tentacles of a snail through the eyepiece of a microscope is enough to knock the socks off anyone, student or adult. Most schools have compound microscopes, that is, microscopes that can be used with slides to view small specimens such as microscopic plankton, onion skin, or human hairs. Unfortunately, most elementary schools don't have stereo microscopes (or dissecting microscopes) that enable the viewer to observe the details of larger specimens such as rocks, grasshoppers, leaves, feathers, crabs, barnacles, and sea stars. You may be able to borrow stereo microscopes from a high school or district resource center. The rewards are well worth the effort.



Stereoscope

Materials

15 stereo microscopes

15 magnifying lenses

White paper

Colored pencils

Extension cords

20 petri dishes and/or finger bowls*

Paper towels and lens paper

*Clear glass custard dishes can be substituted for finger bowls

Protect Seashore Animals

Tell the students that far too often people unwittingly condemn seashore organisms to death by stressing the animals beyond their ability to survive; for example, by allowing the water to warm up beyond the tolerance level of the animal. Ask the students to brainstorm safety rules for the proper care and handling of seashore organisms. (See page 158, "The Care and Handling of Seashore Animals," and also pages 34–35, "Protect Seashore Animals.")

Preparing the Organism

Place the organism in a clean finger bowl or clear glass custard dish. Fill the bowl with enough seawater to cover the organism. This allows the animal to be in its own water-filled environment and to move freely about.

Finger bowl

Using Stereo Microscopes

Ask the students to brainstorm rules for the care and handling of microscopes. Write their ideas on the blackboard. Tell the students to carry the microscopes with both hands, one hand grasping the arm and one supporting the base. Gather the students around a microscope and demonstrate the following procedures step by step:

- Point out the parts of the microscope.
- Plug in the microscope.

- Look through the eyepiece and slowly raise the tube (using the coarse adjustment) until you see the organism.
- Use the fine adjustment to obtain the clearest possible image of the organism.
- Slowly move the finger bowl on the stage, noting what happens to the image when you do so.
- Search the finger bowl for an interesting part and move that part to the exact center of the field of view.

A stereo (or dissecting) microscope consists of a pair of ocular lenses, one for each eye. The object is seen three dimensions because each eye has a different view. The magnification is lower than in a compound microscope, but the images you see are much more spectacular.

Field microscopes are light and compact so they can be carried around outdoors. The Discovery Scope (below) is one type of field microscope designed for viewing the incredible variety of small living things found in every backyard, forest, pond, or seashore. The chamber allows you to study the larvae of crabs, sea stars, sea urchins, and shrimp collected in a plankton net. Observe eyes, legs, antennae. Discover how organisms move, breathe, feed, and interact in a water-filled world. Explore the rocks and tidepools and drift line. Put in small organisms, shells, driftwood, pieces of seaweeds. The most common items hold surprises when viewed with field scopes. (See "Supplies," page 280.)

Enrichment Activity

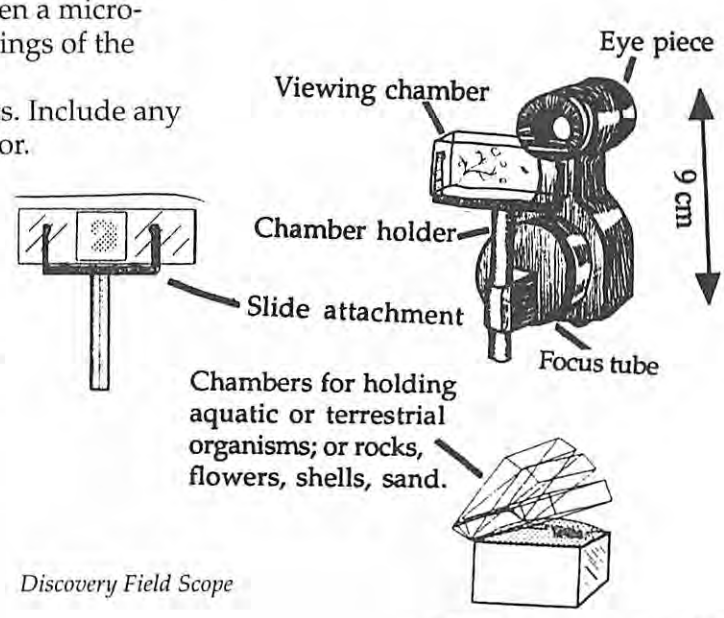
Supply each student with a sheet of legal-size drawing paper. Have them fold the paper into three parts. Label the first space "naked eye," the second "magnifying lens," and the third "stereo microscope."

Observe the animal with the naked eye. Draw a detailed sketch of the entire animal in the first space on your paper. Include as much detail as possible. Label the parts. Repeat the above procedure using a magnifying lens and then a microscope. Each student will end up with three drawings of the same organism, showing more and more detail.

Try to identify the organism and label the parts. Include any observations of shape, color, pattern, and behavior.

Engage the students in a discussion on the benefits of microscopes for observing plants and animals.

A variation on the above activity is to view the same organism (provided it is relatively small) with a compound microscope. (See page 101 for information on how to use a compound microscope.)



Discovery Field Scope

Becoming an Animal Expert

The best time to introduce inquiry activities with seashore animals is after the students have had several exploratory experiences at the seashore. Encourage the students to observe, question, infer, compare, predict, measure, record, build models, and interpret data.

Choose a Topic

Choose an interesting topic or group of animals and become "experts" on one type of organism such as crabs, snails, sea stars, or gulls; or possibly only one species of snail such as Checkered Periwinkles.

Research Teams

Have the students work in teams of two to four to thoroughly investigate a topic or an animal. Groups should attempt to demonstrate originality by the way they ask questions, generate ideas, and approach and solve problems. The students can brainstorm questions, invent investigations, and divide up the work. At times, you may want one student to act as a recorder for the team. In this way the students help each other with their investigations by describing the results to one another and interpreting the data by reaching consensus.

Research Questions

Some students are very curious about their animal and will need very little or no prompting. Allow these students to continue their investigations without teacher help. Other students will find it difficult to observe an animal in detail, ask questions, and investigate to find the answers. The following questions are provided to help these students get started:

1. What does the animal look like? Make a large, detailed drawing. Include several close-up views of interesting parts.

2. Does the animal move? If so, how does it move? Is the animal attached? If so, how?

3. How does the animal catch its food? What does it eat? How does it eat? How could you find out?

4. Does the animal have any peculiar behaviors? What are they?

5. How does the animal protect itself from other animals?

6. How does the animal respond to light, dark, heat, cold, air, seawater?

DANGER: Be sure the animals are not harmed in any way.

During these investigations, you'll need to listen to the students' questions and use questioning strategies that promote critical thinking and active participation.

Keep a Log Book or Field Notebook

Students should write everything having to do with the project in their field notebooks as they do it. Every time they work on their project they should record what they did and what they found out. They should include in detail all their plans and ideas, everything they measured and observed, and all their conclusions. Their field notebooks are the main source of information for their final written report.

The Written Report

The students may want to copy notes from their field notebooks into a proper report. They could organize their material under the following headings:

- Observations. Describe the animal's appearance: color, patterns, structure, movements, special features.
- Sketches. Draw several sketches. Include at least one large drawing of both the top side and the underside, as well as several close-up drawings showing special features.
- Questions. Make a list of at least 10 questions about this animal.
- Investigations. Choose only one or two major questions and try to invent ways to answer your questions. Predict what you think will happen.
- Describe your experiment (or experiments.) Include sketches showing what you did.
- Measuring and recording. Include measurements of time, size, trials, etc. If appropriate, include graphs and tables.
- What I learned. Include a summary statement explaining what you learned about your animal. Also, what did you learn about "doing" science?

Group Presentations

Part of the reward of doing an inquiry activity is sharing the findings with others. Each group could plan an exhibit and make a presentation to the class. The presentation should include sketches, photographs, diagrams, apparatus, etc. The presenters should describe their observations, the questions they asked, and how they attempted to answer their questions.

The Care and Handling of Seashore Animals

Whether conducting investigations at the seashore or in the classroom, handle organisms as little as possible and put them back in their original location on the shore. Disrupt an area as little as possible. Conduct inquiries with the animals kept submerged in cold seawater—in tidal pools, or in clear plastic bags or containers. **Be sure that no bleach or detergents have been used to clean any of the containers. Clean fingers are also necessary.**

When conducting investigations with living organisms in the classroom, extra precautions must be taken. If possible, set up a proper saltwater aquarium several days prior to collecting organisms (see pages 171–173). If a saltwater aquarium isn't possible, a limited number of investigations can be conducted in the classroom provided all of the following rules are strictly adhered to: a) collect a very limited number of organisms at a time—for example, a few snails or shore crabs or barnacles attached to a rock; b) collect only the hardier organisms located high in the intertidal (the spray zone or high tide zone); c) keep the animals submerged in seawater and keep the water temperature cold by floating ice cubes sealed in plastic zip-lock bags; d) aerate the water with an aeration stone or by periodically pouring it back and forth from one bucket to another; e) keep the organisms in the classroom for only two or three hours; f) return the organisms immediately to their original location on the shore; and g) collect only from designated seashores.

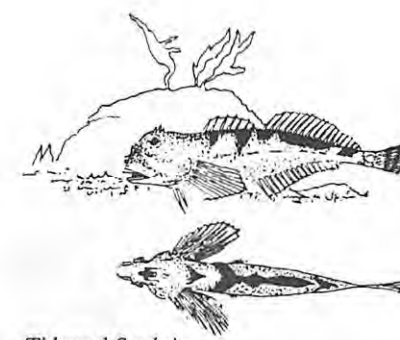
A primary objective of the chapter is to develop a sense of responsibility for living things. Some students will become fond of their animal friends and want to take them home. How many students have taken hermit crabs or shore crabs home to be kept in a shoe box under the bed? Students of all ages need to learn that seashore animals are hardy, but they're perfectly equipped to live only in their own homes at the seashore. They need to learn that responsibility comes with caring for others, be they snails, crabs, or people.

Inquiries with Fish

Have fun looking for different kinds of fish at the seashore. Look in tidal pools, under cobblestones, among eelgrass beds, and in shallow, sandy sea bottoms. Use dip nets to carefully capture Tidepool Sculpins, High Cockscomb Blennies, and Sand Soles. **Never capture or handle fish with your hands.** The slime covering protects the fish from infection and disease.

At the seashore, have the students sit quietly and observe a tidal pool. Notice the colors of seaweeds, barnacles, rocks, etc. Look for small fish. What colors are the fish? Discuss how and why the colors of most fish blend beautifully with their surroundings.

Put fish in zip-lock plastic bags filled with seawater. Pass the baggies among the students. Ask the students to watch how the fish swims, opens and closes it mouth, moves its fins and tail. Do the mouth and gills open at the same time or at different times? How does the fish keep upright in the water? What does a fish eat? How could you find out?



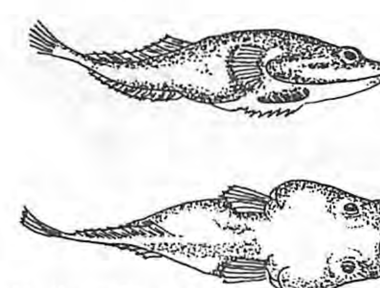
Tidepool Sculpin

Tidepool Sculpins

Put the sculpin in a jar filled with seawater. Close the lid tight. Turn the jar upside down. Carefully turn the jar around and around. How does the fish keep from turning upside down? Draw three pictures. Ask three questions about sculpins.

Observe sculpins in a tidal pool. Why do sculpins have such large fins? Notice how they appear to "walk" on their fins. How might such large fins help them when the tide goes out?

Why do sculpin have big teeth? What does a sculpin eat? What might eat a sculpin?

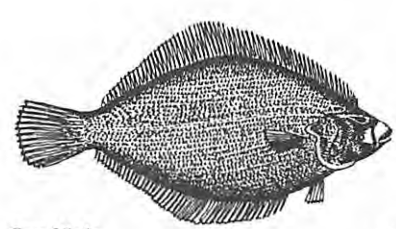


Northern Clingfish

Color-Change Artists

Collect three Tidepool Sculpins. Put one sculpin in a container filled with seawater. Surround the jar with black paper. Put one sculpin in a second container surrounded with white paper; and the remaining sculpin in a jar surrounded with pink paper. Wait 20 minutes, and then put all three sculpins together. Record what happens. What have you learned about sculpins?

Sand Soles

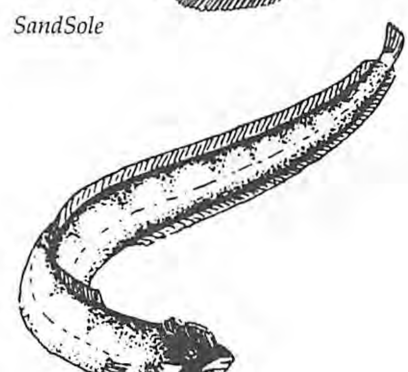


SandSole

Collect three cans of variously colored beach sands. Pour these sands into three containers. Add beach pebbles, broken shell, or beach mud to create three different types of sandy bottoms. Consider color, texture, and pattern. Fill the containers with seawater. Wait for the water to clear. Put a Sand Sole in one of the containers. Wait 20 minutes. Record your observations. Put the Sand Sole in the second container. Record your observations. Draw three pictures. What have your learned about Sand Soles?

Blennies

Look under cobblestones at low tide for High Cockscomb Blennies. How does a blenny move under rocks? Compare the shape of blennies to other fish. Why are blennies long and thin? Why do blennies slither under rocks at low tide? Ask three questions about blennies.

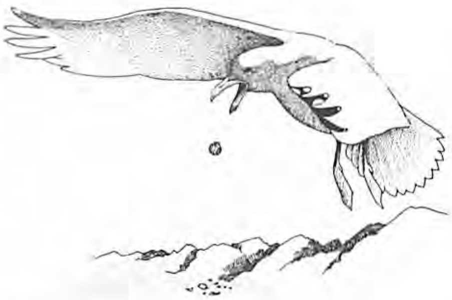


High Cockscomb Blenny

Inquiries with Shore Birds

Sit well above the high tide line to watch the drama that unfolds with the ebbing tide. Observe the gulls, crows, herons, eagles, sandpipers, and other shore birds as they search for food. Binoculars are helpful to have along to identify distinctive features of each bird. A tape recorder is also handy to record bird calls and songs.

Early morning is a good time to observe. Walk slowly along sandy and rocky areas of the shoreline. Look at different birds. Try to pick out the main differences. How many different species of beach birds can you see? Can you name any? Which species is most common?



Glaucous-winged Gull

Watch where different birds gather to feed. Have the students speculate on why the birds choose a particular area. Is the water shallow? In tidal pools? Among rocks? In the sand or mud? At the tide line? Is there an abundance of seaweed? What kind of food do they eat? Do they gather their food by diving, digging, probing, or harassing other shore birds to give up their catch?

Place some food (herring, shellfish, dog food) at widely separated spots on the beach, then sit back and quietly watch to see what happens. Listen to the sounds and watch what goes on.

Northwestern Crow

Choose one obvious bird. Note its size, color, and markings; the length and color of its legs; the shape, size, and color of its beak; the length of its neck; and where it spends most of its time (e.g. soaring, wading, running on sand). Repeat until you know five birds.

Choose one species of bird. Follow a bird of the species and write about everything it does. Observe its feeding habits. What does it eat? How does it collect or capture its food? How does it eat?

How do shore birds behave at high tide and at low tide? At high tide, where do shore birds go? How could you find out?

Has anyone seen a gull or crow drop a clam, mussel, or sea urchin from a height onto the rocks below? What happens? Has anyone seen a Great Blue Heron at a tidepool capture a Tidepool Sculpin or Cockscomb Blenny?

Look for tracks of wading and swimming birds; the large imprints of the Great Blue Heron or the webbed footprints of ducks and gulls. Make plaster casts that retain the details of the original tracks.

Watch Western Sandpipers or Sanderlings at the seashore. After they leave the shore, look at their footprints and bill prints in the sand. What do you think they were eating? How could you find out?

During spring and summer months, shore birds molt their feathers. The greatest number of feathers can be found at this time. The students will have fun classifying the feathers according to species. Be on the lookout for different types of feathers—wing, body, tail, and down.

Why do some birds such as herons and cranes have long legs like stilts? Why do ducks and geese have short, webbed feet? Is there a connection between leg forms and feeding habits?

Great Blue Heron

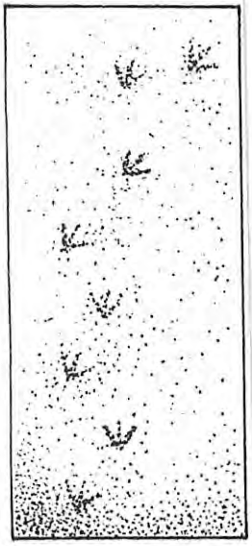
Between beak forms and feeding habits? Between what a bird eats and its feeding habitats?

The chart below is a good way for the students to record their observations:

Name of bird	Sketch of bird	Food	Type of beak (sketch)	Type of feet (sketch)	How this bird gets its food

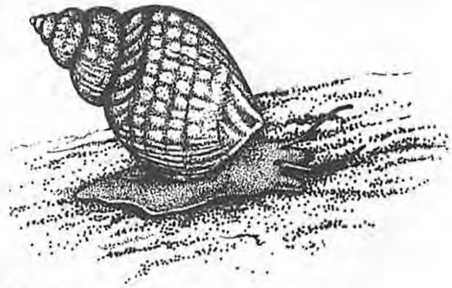
Footprints in the Sand

An easy way to find out who uses a beach is to look for different kinds of footprints in the sand. Note in your field notebook how many different kinds of prints you see. Draw examples of footprints. Look for prints of birds, small mammals, worms, snails, insects, people, or crabs. Look for footprints that tell a story.

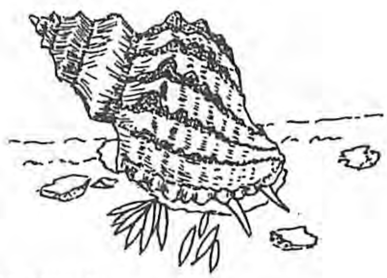


Bald Eagle

Western Sandpiper

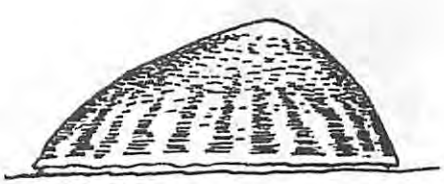


Checkered Periwinkle



Wrinkled Whelk

Moon Snail



Speckled Limpet

Animals with a Muscular Foot

Inquiries with Snails

Look for any of the several species of snails crowding into rock crevices, among seaweeds, and in tidal pools. The students might come across Checkered Periwinkle or Black Turban tracks in the sand of a tidal pool. These animals leave behind narrow lines as they move from place to place.

Observing Snails

Put some snails in a jar filled with seawater. Watch the animals move up and down the jar. How do snails move?

Look for the mouth on the underside. Use a hand lens to look for the tentacles...the eyes.

Look for the bony plate (operculum) on a tip of the snail's foot. How does the bony plate act as a little trap door? How do snails keep from drying out at low tide? Draw three pictures.

Snail Races

How fast can a snail move?

Collect several different kinds of snails.

Observe the size, shape, and foot of each snail.

Predict which snail is the fastest.

Put the snails one at a time in a glass container filled with seawater.

Use a felt pen to trace how far each snail moves in one minute. Two minutes. Three minutes.

Draw three pictures.

Is there a connection between the size and shape of a snail's foot, and its speed?

Can a snail move equally well on glass, rock, sand, or mud? How could you find out?

Is there a connection between the speed of a snail and its habitat?

Inquiries with Limpets

Search the high and middle tide zones for any of several species of limpets that crowd into moist crevices. If possible, find a limpet on a small rock and put the limpet in a container filled with seawater. The limpet will slowly come out of its shell to explore its surroundings. **Do not try to remove limpets from the rocks.**

Use a hand lens to locate the tentacles, eyes, and mouth.

How does a limpet use its tentacles? Its muscular foot?

Why do you think limpets cling tightly to rocks?

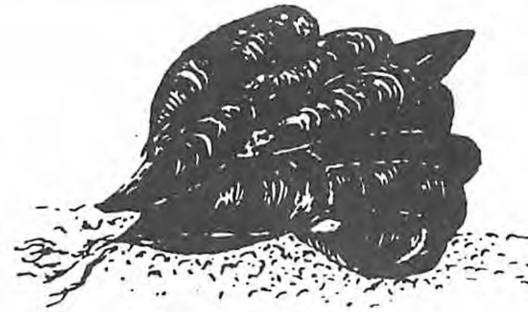
What do you think a limpet eats? Some limpets are said to have a "home" or spot to which they always return. They wander out at high tide to find food and return home by the same path. Prove or disprove this theory.

Inquiries with Blue Mussels

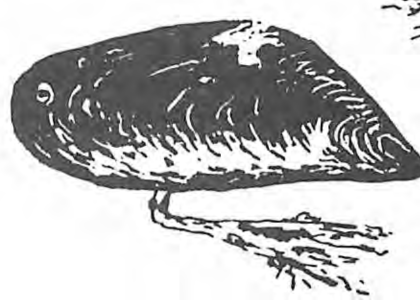
How do mussels attach to rocks?

Draw a picture. Do mussels move? Are you sure?

Leave a mussel undisturbed in a dish filled with seawater. What happens? Put some mussels in a bucket filled with seawater overnight and see what happens.



Edible Blue Mussel



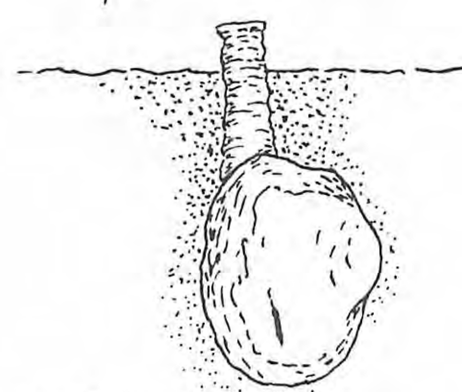
Inquiries with Clams

Put a clam in a shallow pan filled with seawater.

Allow the animal to relax and open its shell.

Look for the siphons (straw-like tubes) that the animal uses to move water in or out. Look carefully for water currents near a siphon. Through which siphon does the animal draw water in, and through which siphon does it draw water out? Describe what you see. Place a tiny amount of food coloring in the water very close to the siphons. Draw what happens. Try to identify the incurrent siphon and the outcurrent siphon. What does a clam eat?

Place a clam in a bucket half filled with sand and half with seawater. Watch what happens.



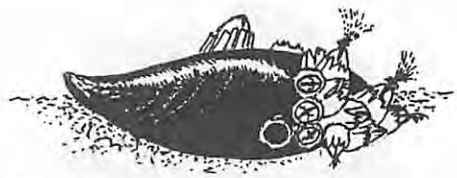
Horse Clam

Animal Cousins

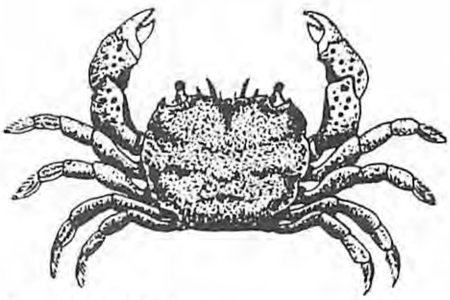
List three reasons why snails, limpets, mussels, and clams are related.

The chart below is a good way for students to record their observations of animals with shells:

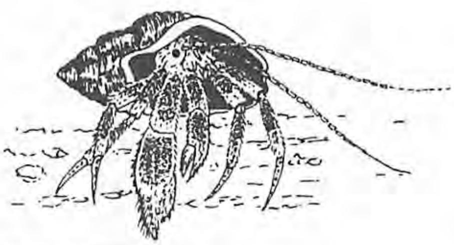
Organism	Drawing	Height	Width	Interesting Characteristics



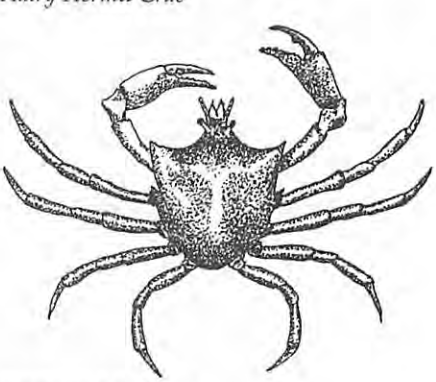
Common Acorn Barnacle



Purple Shore Crab



Hairy Hermit Crab



Northern Kelp Crab

Animals with Jointed Legs

Inquiries with Acorn Barnacles

Have the students explore the seashore at high tide and at low tide to see what the barnacles are doing. Observe barnacles in tidal pools or lie down flat on a boat dock close to the water's edge. If possible, collect two or three small rocks covered with barnacles. Put these in a clear plastic container filled with seawater to observe up close, or bring them back to the classroom and observe with microscopes.

Look for barnacles high on the shore.

What does a barnacle that is out of seawater look like? Draw a picture.

Watch barnacles under seawater. Draw a picture.

Make three observations.

What do barnacle eat? How could you find out?

How does life for a barnacle change from high tide to low tide? How do barnacles keep from drying out at low tide?

What animals live among the barnacles? Look closely. Draw a map of the barnacle cities.

Do barnacles move from rock to rock? How could you find out?

Considering that barnacles "cement" themselves to rocks, how did they get here? How could you find out?

Inquiries with Crabs

Shore Crabs

Look closely at the eyes, antennae, legs, and pincers. Watch a shore crab walking. Draw three pictures.

Try feeding the crab a piece of hamburger, lettuce, or clam meat. Predict what will happen. Draw a picture of a crab eating. Describe the crab's mouth. How does the crab use its mandibles? Its legs? Its claws? Use a hand lens.

Ask three questions about crabs.

Hermit Crabs

Put two or three hermit crabs in a jar of seawater. Drop in four or five empty snail shells. Watch what happens.

Why do hermit crabs live in snail shells?

Where are the hermit crab's eyes? Can a hermit crab see behind its snail shell? How could you find out?

Invent a way to give a hermit crab an eye test.

Why does a hermit crab have one large claw?

Watch what it does with its large claw.

What does a hermit crab eat? How could you find out?

When is a Crab Really Dead?

Seashores are frequently strewn with what appear to be dead crabs. Take a closer look to see if the crab is dead or is the castoff "molt," or skin, of a living crab.

Carefully try to lift the back of the body away from the abdomen. If the back lifts easily and is mostly empty inside, it's a molt. If it wiggles and tries to pinch you, it's a living crab.

Why do crabs shed their outside skins?

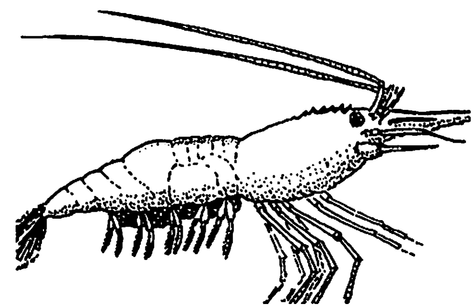
What other seashore animals "molt"?

Comparing Crabs

Compare three different species of crab.
Why are they shaped differently?
Some crabs live in seaweeds, some live under rocks, some are swimmers, and some dig into the sand. Investigate to find out where different kinds of crabs live. How are the legs of every crab the right kind of legs for where the crab lives?

Inquiries with Shrimp

Shrimp are excellent swimmers.
Put a shrimp in a large, clear jar or aquarium.
Watch how the shrimp swims.
How does the shrimp use its tail?
How does the shrimp use its legs?
How does it use its antennae?
How many different ways can a shrimp swim?
Draw pictures of shrimp swimming.



Broken-Back Shrimp

Inquiries with Isopods

Look carefully among the Rockweeds and eelgrass beds for any of several species of isopods.

How does an isopod move on rocks? How does it move on seaweeds? How does it move under water?

Draw three pictures of an isopod moving.

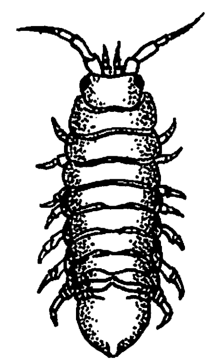
What do isopods eat? How could you find out?

Make predictions, then set up an experiment to test your predictions.

What color is the isopod? What color is the seaweed?

Why do you think the isopod is the same width and color as the seaweed fronds?

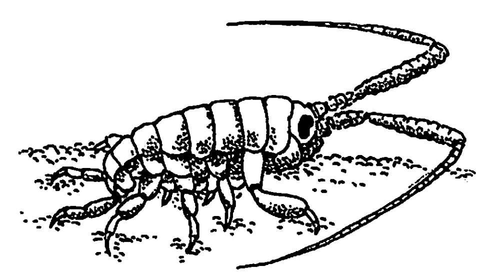
Isopods are great swimmers. Observe a tidal pool at night with a flashlight. Why do you think they come out at night?



Rockweed Isopod

High-Jumping Beach Hoppers

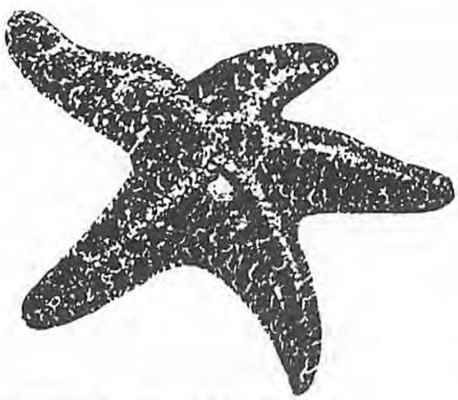
Look for Beach Hoppers high on a sandy beach or among decaying seaweeds. To find their dens, look for round holes high on the upper part of the beach. How many legs do Beach Hoppers have? Estimate the number of Beach Hoppers amongst the seaweeds. What are the Beach Hoppers doing? What do Beach Hoppers eat? How could you find out? Use a hand lens. Draw three pictures. How high do Beach Hoppers jump? Why do Beach Hoppers jump so high?



California Beach Hopper

Animal Cousins

Identify three reasons why barnacles, crabs, shrimps, isopods, and Beach Hoppers are related.



Common Purple or Ochre Sea Star

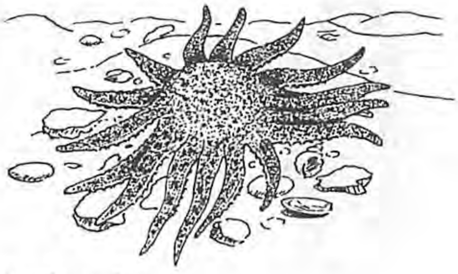
Animals with Spiny Skins

At the seashore, observe sea stars in tidal pools or put sea stars in large containers filled with seawater. A student's wading pool is excellent, but be sure no bleach or detergent has ever been used to clean the pool. **Never attempt to remove sea stars that are firmly attached to rocks.** Removing sea stars from rocks rips off tube feet and leaves them vulnerable to predators and waves with the returning tide.

Inquiries with Sea Stars

Watch a sea star out of water. Does it move? If not, why not? Put the sea star in a large container filled with seawater. Draw three pictures of a sea star moving. How does a sea star move? Count the number of tube feet on the underside of one arm. Estimate the number of tube feet altogether.

Put a Sunflower Star or Purple or Ochre Star in a tidal pool or very large tub filled with seawater. Put other seashore animals in the tub: snails, limpets, hermit crabs, shore crabs, clams. Watch what happens. How do the various animals attempt to protect themselves? How does the sea star know where it's going? Where is the sea star's mouth? Draw three pictures.



Sunflower Star

A Flipping Sea Star Contest

Observe sea stars in place.

Collect several sea stars of different sizes and shapes.

Put the sea stars upside-down in a large tidepool or in deep water. Predict how long it will take a sea star to turn over.

Predict which one will turn over first, second, last.

Watch what happens. Draw what happens.

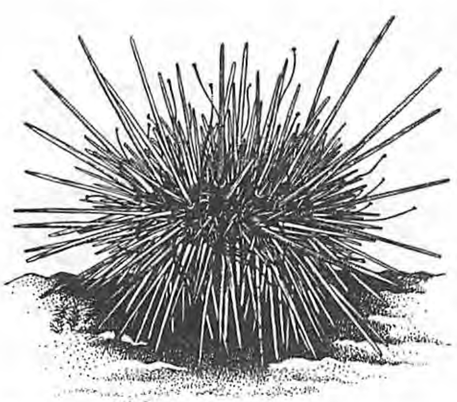
Describe how a sea star turns over.

Which sea star was the fastest? The slowest? Why?

Invent an investigation.

Inquiries with Sea Urchins

At the seashore observe sea urchins in tidal pools or briefly put them in buckets or clear plastic containers filled with seawater. Use hand lenses (or view with a stereoscope) to observe their three different kinds of spines.



Red Sea Urchin

Sea Urchins

Put a sea urchin in a large container filled with seawater. How does a sea urchin move? How does it use its spines? Its tube feet? Turn a sea urchin upside-down. Time how long it takes for the sea urchin to right itself. Locate the mouth on the underside. Observe the mouth parts and the five movable teeth.

What type of food would you expect a sea urchin to eat at the seashore? Drop pieces of seaweed, clam meat, or hamburger on the sea urchin. Watch what happens. Use a hand lens. Draw at least three pictures. Ask three questions about sea urchins.

Sea Urchin Shells

Explore the shore to find the brittle white "test," which resemble shells of dead sea urchins. Look closely at the pattern on the test. What caused the rows of bumps? Where was the mouth? The teeth? Draw the test and the pattern. How is the test a clue to the sea urchin's relatives?

Inquiries with Sea Cucumbers

At the seashore, observe a sea cucumber in a tidal pool or in deep water. Or, place a sea cucumber in a large container filled with seawater. After a few minutes the animal will relax and begin to move. Count the rows of tube feet. Describe how the animal moves. Look closely at the mouth and the branched tentacles that surround the mouth. Use a hand lens.

Can you see the animal pump seawater through its body? Through which end does the animal draw in seawater, and at which end is water pumped out?

What do you think the animal eats? Invent an investigation to find out. How do you think it breathes? Draw at least three detailed sketches.

Replace cucumbers carefully to their homes.

Inquiries with Sand Dollars

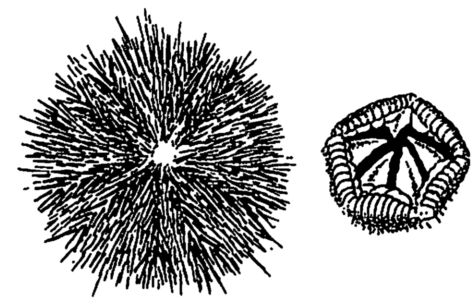
What does a sand dollar look like?

Draw a detailed picture of the top side, and a detailed picture of the underside. Is the sand dollar alive or dead? How can you tell? Look closely to see the tiny spines and tube feet. How does it move? Locate the mouth and the food grooves on the underside. With a hand lens or stereo microscope, attempt to watch food particles moving along food grooves to the mouth. Drop pieces of graphite on the sand dollar. Wait patiently. Describe what happens. What do you think a sand dollar eats?

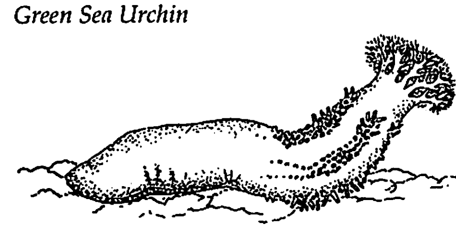
Do not remove living sand dollars from the beach.

Animal Cousins

Identify three reasons why sea stars, sea urchins, sea cucumbers, and sand dollars are related.

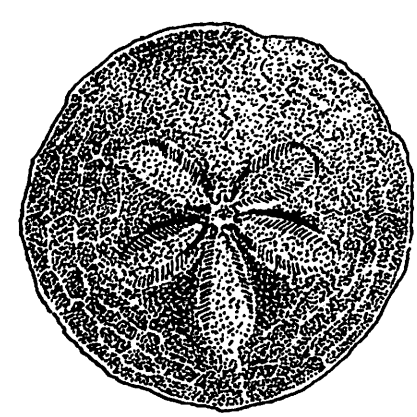


Green Sea Urchin

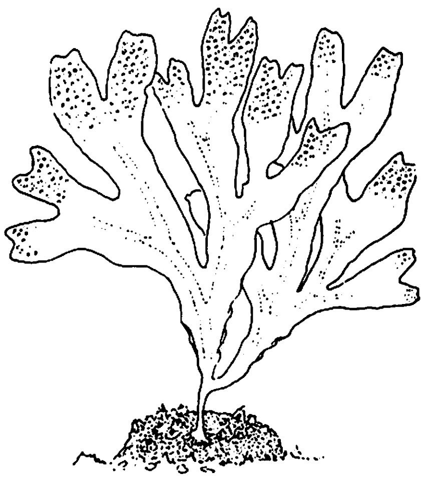


Miniature Red Sea Cucumber

Giant California Sea Cucumber



Sand Dollar



Rockweed

Inquiries with Seaweeds

The students will enjoy investigating the great variety of colors, shapes, textures, and patterns of seaweeds. Observe similarities and differences. Note how hard and brittle seaweed is that has dried out. Watch what occurs when it is returned to the water!

Rockweed Nurseries

Slowly run your hands across the fronds and stems of Rockweeds.

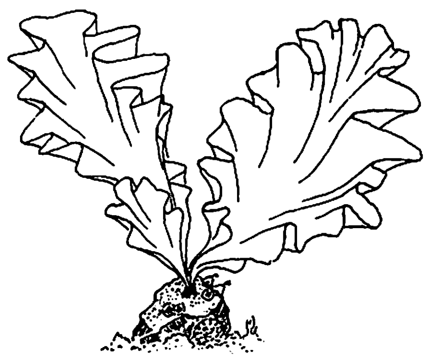
What does it feel like? Look carefully for different animals living among Rockweeds.

Why do so many juvenile seashore animals live among the Rockweeds?

Why are seaweeds slimy? What advantage does this have for the Rockweed? The juvenile animals?

Why are Rockweed beds called "nurseries"?

Pop one of the gas-filled bladders on the tips of the frond. Why do Rockweeds have air-filled bladders?

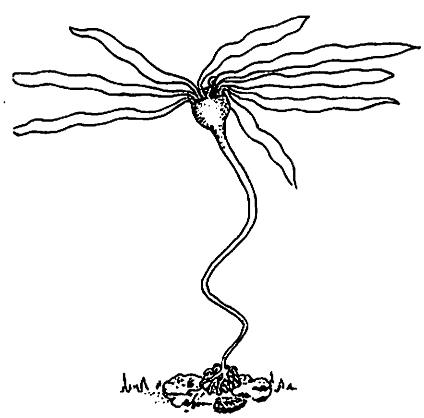


Sea Lettuce

Sea Lettuce

Look for bright green seaweeds that cover the rocks like tissue paper.

Wash Sea Lettuce in clean water. If the Sea Lettuce has been collected in clean seawater, away from sewage systems, you can taste this seaweed. What does it taste like?



Bull Kelp

Bull Kelp

Look for this seaweed which often floats ashore.

Observe the long fronds, air bladders, and anchoring holdfast.

How does this seaweed attach to rocks?

Why does it have gas-filled "floats"?

Look for the hordes of animals that live among the decaying seaweed stems and front. What are these animals doing here?

Map Seaweed Patterns

Measure the length of seaweed found at the high tide, middle tide, and low tide zones.

Why does the length of seaweeds change with their location on the shore?

Draw a map of the seashore.

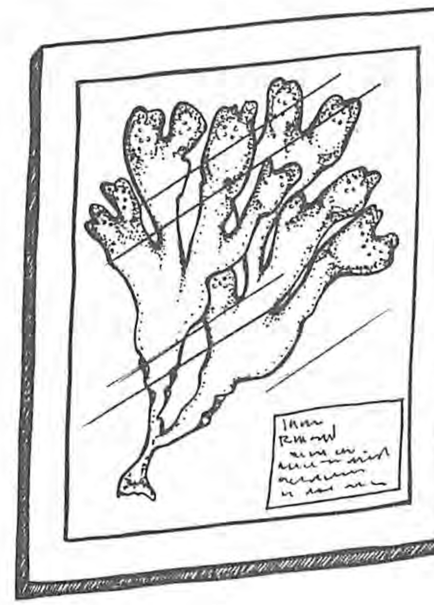
Show where the various types of seaweed occur.

Notice that the colors change from browns, to greens, to reds. What might explain such a pattern?

Pressing Seaweed

Pressing seaweed is easy and the mounted specimens can be identified and patterns of distribution noted. Pressed seaweeds add color and interest to classroom bulletin boards, and can be arranged artistically into seascapes and endless artistic impressions.

Look for a range of species, and take only a few specimens of each kind. Collect young or mature specimens (old ones lose their color and become ragged and mushy).



Materials

Herbarium paper or any shiny white paper

Wax paper

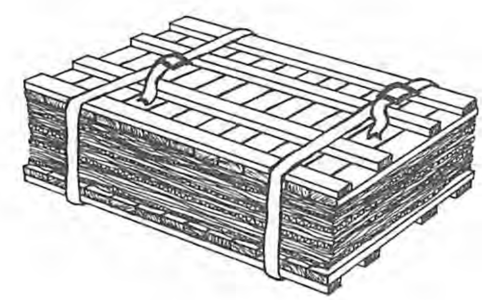
Blotting paper or white absorbent paper

Sheets of corrugated cardboard

Straps or rope to bind the press together

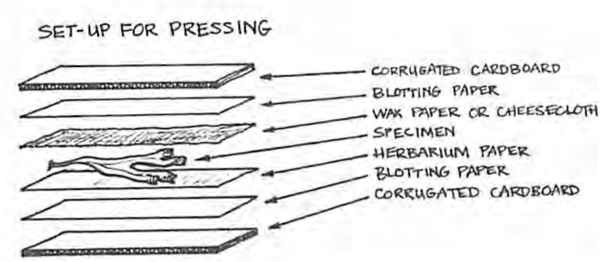
Cookie sheets or cafeteria trays

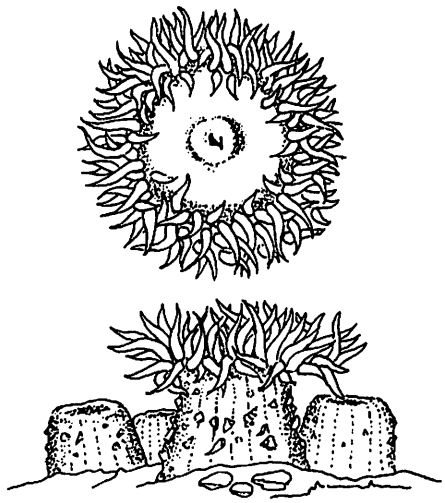
- Carefully wash specimens to remove sand or tiny animals.
- Put shiny paper on the bottom of the pan.
- Float the specimen on shallow water in a cookie sheet or other large flat pan.
- Arrange the specimen to show its fronds and stems.
- Carefully lift the paper (from the middle so that water drains).
- Final arrangements can be made with squirts of water from an eyedropper.
- Thick specimens may not adhere to the mounting paper and can be glued on after being pressed and dried.
- Label the specimen. Include the common name, Latin name, date, collection site, tide zone, and type of seashore.



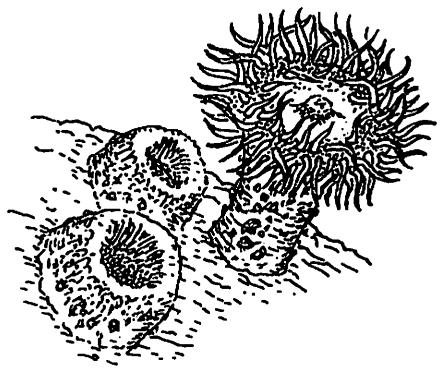
The Seaweed Press

Plant presses can be purchased, or constructed from corrugated cardboard and two rigid frames or sheets of plywood. The simplest method by far is to use two classroom tables as the plant press frames. Since kids seem to favor large specimens, the tables work well in allowing for several sizes of specimens. Place the second table upside down on the stack of seaweeds. Have one or two students carefully sit on the top table while the straps or ropes are pulled tight and tied.

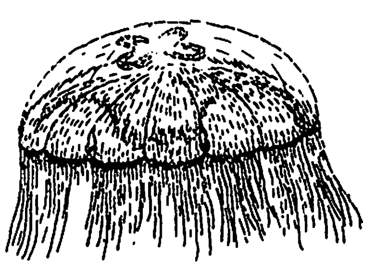




Giant Green Sea Anemone



Aggregate Anemone



Moon Jellyfish

Animals with Stinging Cells

Inquiries with Sea Anemones

If possible, observe anemones in tidal pools at the seashore, or find a small anemone that is attached to a fairly small rock and bring the attached anemone and its rock back to the classroom. Keep the anemone in an aquarium. **Never attempt to remove a sea anemone from a rock as it will seriously harm the animal.**

Put a sea anemone in a container filled with seawater. Wait patiently for the anemone to open up and show its tentacles. Gently touch the tentacles with your fingers. What happens?

Never touch a sea anemone with your tongue!

Drop a small pebble on an open sea anemone. What happens? How long does it take the anemone to spit out the pebble? What does a sea anemone use its tentacles for? Draw three pictures. What does a sea anemone eat? How could you find out?

Drop pieces of raw mussel or clam or barnacle on an open sea anemone. How is the food brought to the mouth? Can it pick up food placed beside it?

Place a sheet of paper on an open sea anemone. Predict what will happen. Draw what happens.

Soak the paper in mussel or clam juice. Place the paper on the anemone. Predict what will happen.

Draw what happens.

Inquiries with Jellyfish

Look for jellyfish around dock pilings and in tidal pools. Where is its mouth? How does a jellyfish move? Why are jellyfish transparent? What does a jellyfish eat? How does it capture its food? **Do not pick jellyfish up with your hands.** Some jellyfish can cause a severe sting.

List three reasons why sea anemones and jellyfish are related.

How to Set Up and Maintain a Saltwater Aquarium

The sea offers a host of fascinating creatures that can be watched for pleasure or studied as a rich source of information. Whether your school is in the city or within reach of salt spray, a salt water aquarium can provide hours of absorbing interest.

Purchasing an Aquarium

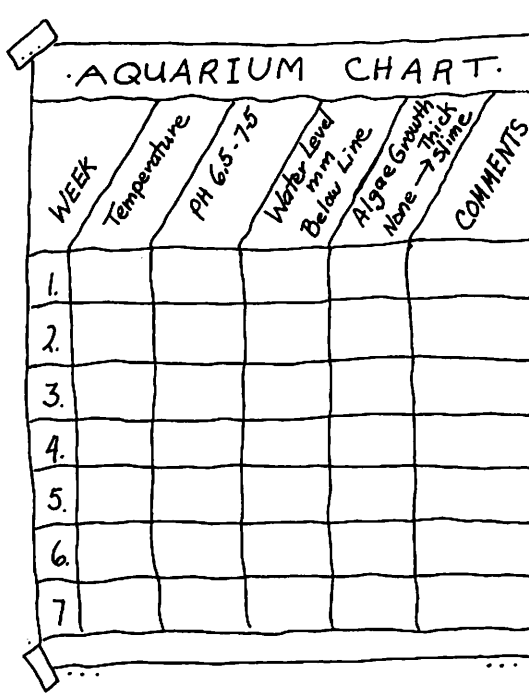
The best size for a salt water aquarium is 40–50 gallons. Smaller aquariums are usually unable to maintain a mid-range pH for long periods of time. A proper salt water aquarium can be purchased at a biological supply house for approximately $1500.00 in the U.S. If your school is unable to purchase a tank, the information below describes how many teachers have invented "jerry-rigged" aquariums that work well.

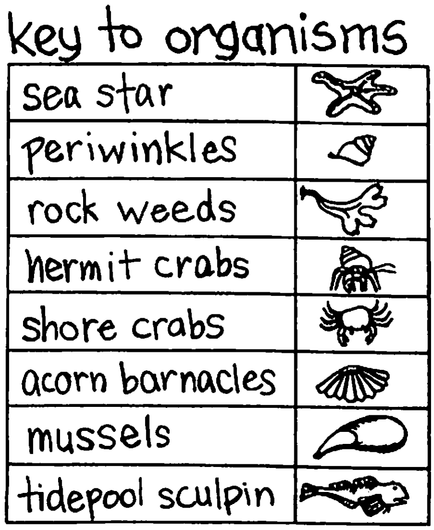
Setting Up the Aquarium

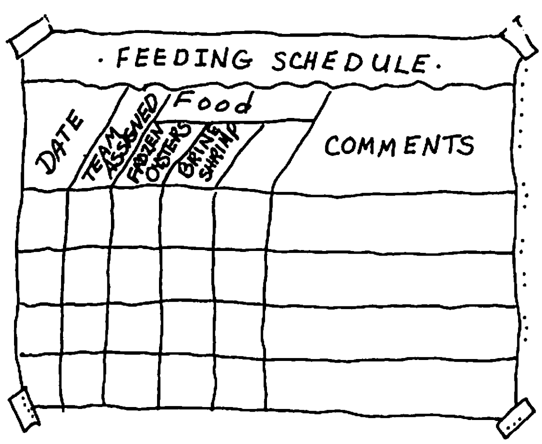
Begin to set up the aquarium two weeks before the saltwater organisms will be added. Involve the students in all the planning phases, and let them watch all the preparations. The students should brainstorm what will be required to create a proper salt water environment. Write their ideas on the blackboard. Lead the students to understand that they will be building a model to duplicate as closely as possible the same temperature, oxygen level, salinity (or salt content), and pH level as the ocean. In addition, they will want to put beach pebbles and small cobblestones in the aquarium to add interest, and to allow organisms to hide among the shadows and crevices.

Temperature

The most critical feature of a saltwater aquarium is to keep the temperature down between 48–58 degrees F (C 10–12). A freezer unit such as a Coca-Cola cooler is a great way to keep the aquarium at a constant temperature. The freezer unit should be kept separate from the aquarium and the pipes run over to the aquarium and back and forth through the sand underneath. Another way is to drill two holes through the side of an old refrigerator until and into the freezer compartment. Aquarium water can then be pumped through plastic tubing which runs from the aquarium into the freezer compartment where it is coiled several times, and then pumped back into the aquarium. Another way of keeping the temperature down is to run a continuous stream of cold tap water through a hose that is coiled several times underneath the sand. But first check to see that your tap water is below 50 degrees F (C 10).







Filtration

Since inter tidal organisms are accustomed to a high degree of aeration brought about by the breaking of waves in their natural habitat, an air pump and filter must be provided. An underground filter is best for the marine aquaria, although an ordinary charcoal filter can be used.

Lighting

Keep the aquarium out of direct sunlight. If artificial sunlight is used for more than a few hours each day, algae will grow too rapidly on the sides and bottom of the tank.

How to Empty and Refill the Aquarium

The best way to empty and refill the aquarium is by siphoning.

Collecting and Caring for the Organisms

It's best to start collecting organisms from those areas on the beach that are exposed to the widest range of environmental factors (the uppermost zones first, then the middle and lower zones). These organisms are better adapted to hard environmental conditions and have a better chance of surviving in an aquarium.

Transporting the Organisms

Plastic ice cream buckets are good containers. Do not use any buckets that have contained detergents or bleach. One container of contaminated organisms can readily kill the entire population of aquarium animals. The organisms will have a better chance of surviving if they are transported in an open bucket with wet seaweed, rather than a bucket of water. If the organisms are left in buckets for more than an hour, it may be necessary to aerate the water by pouring it back and forth from one bucket to another.

What to Collect

It's important to limit the size, number, and kinds of organisms you collect. For a 20-40 gallon aquarium, the following organisms might be collected:

2–3 hermit crabs	2–3 shore crabs
2–3 small sea stars	2–3 clams
7 limpets	8–10 sculpins
15 snails	2–3 rocks with barnacles

Once the aquarium is going well and you're sure that you can maintain a temperature below 55 degrees F, you might want to add cautiously:

1–2 small sea anemones	2–3 scallops
1–2 small sea urchins	2–3 shrimp and/or isopods
1–2 small edible crabs	2–3 small sea stars
2–3 nudibranchs	3–4 small fish

Keep in mind that seaweeds do not fare well in artificial environments. Green or red seaweeds can be added cautiously, but brown seaweeds very quickly go slimy and smelly. Small amounts can be added as food for some of the animals; remove uneaten parts if they start to rot.

Floating the Organisms

Avoid sudden changes in temperature. Before putting any organisms into the aquarium, it's a good idea to float them in plastic bags on top of the water until the temperature equalizes.

Feeding the Organisms

Aquarium organisms, other than fish, need to be fed only three times a week. Feed them small amounts of chopped, frozen or fresh, oyster, shrimp, scallops, or horse heart. Occasionally feed them pieces of finely chopped lettuce or carrots. Uneaten pieces must be removed $^{1}/_{2}$ hour later; otherwise the rapid growth of certain bacteria will kill organisms in the tank. Live brine shrimp can be obtained at any pet store, or raised in the classroom, and left in the water. Some organisms, such as Pipefish, eat only live food. If you are doing plankton studies, add the plankton to the tank once finished observing (assuming no chemicals have been added!).

Illness and Death

Organisms that are dead or dying should be removed from the tank at once. The bacteria that clouds the water can kill the other organisms. If a number of animals die, the tank should be emptied, sterilized (without soap), and filled with new sea water. Organisms are dead or dying if:

Snails, limpets, and chitons will not retract into their shells when touched.

Mussel, clam, and oyster shells will not close when touched.

Sea anemones will not readily close up when touched.

Crabs will not close their pincers when something is put in their claws.

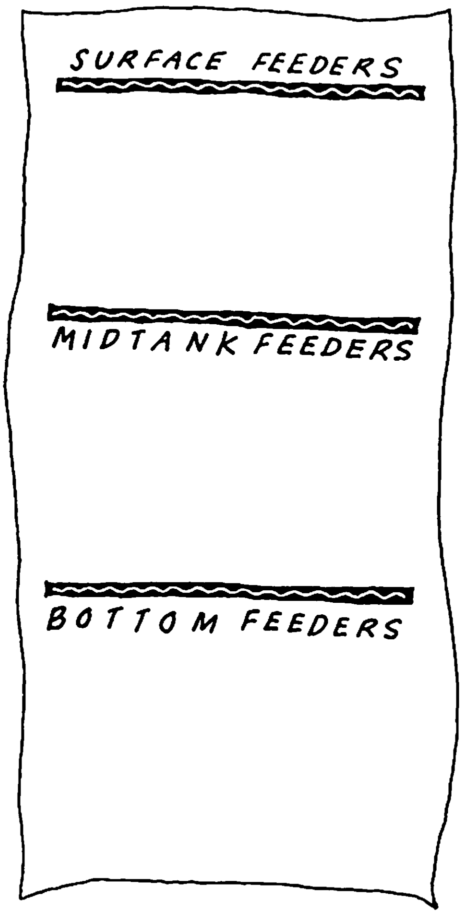
Hermit crabs fall out of their shells.

Fish have trouble swimming.

WHAT ORGANISMS NEED TO SURVIVE

ORGANISM	FOOD	SHELTER	TEMPERATURE	SPACE	SPECIAL NEEDS

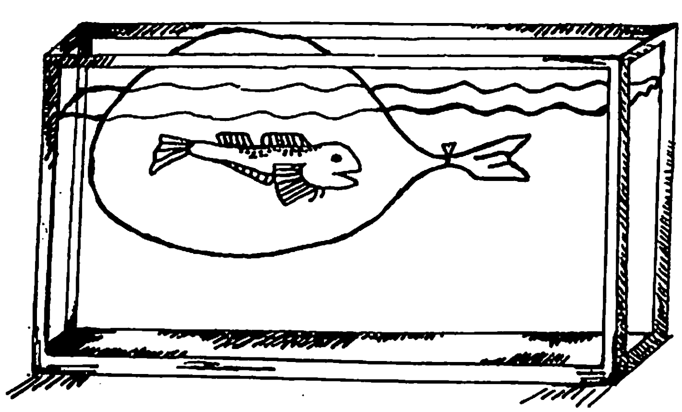
Student Projects for Saltwater Aquariums



- **Diary of Daily Events.** Record observations of events that occur in the aquarium. Include sketches and drawings. Younger students might prefer to choose only one animal and keep a daily diary of its activities.
- **Diary of Change.** Record changes that you think are important. For every change, write some inferences (possible reasons) that you think might explain why the change took place. What evidence is there that might support your inference?
- **Counting Populations.** Make an inventory of all the organisms as they are put into the tank. Periodically record the date and number of organisms counted. Are the populations increasing or decreasing? Have there been any births? If death occurs in the tank, record the probable cause of death.
- **Measuring Animal Movement.** Have races using various organisms as contestants. Time how long it takes an organism to move 5 cm, 10 cm. Compare the speeds of various snails, limpets, sea stars, sea urchins, etc. Try to predict which organisms will travel the fastest.
- **Eating Behavior.** Drop food into the tank in the same corner each day. Record carefully the eating habits of the various organisms when they come to eat. Does a pattern evolve? What organisms eat first? What organisms eat last? Some organisms may try to collect a "cache" of food in a hidden area of the tank. Check occasionally under rocks to determine whether that is occurring. Do some organisms tend to stay at the surface, in the midtank, or on the bottom?

  Keep a list of the various foods that each population of organism eats. Try to determine which populations are plant eaters, which populations are animal eaters, and which populations eat both plants and animals.

  How has living in the aquarium affected the eating behavior of the animals in the tank? Is there an artificial food web?



Float organisms in plastic bags filled with seawater to equalize the temperature.

- **Protective Devices.** Observe carefully how each organism protects itself against its enemies. Record your observations. Do some organisms seem to have more predators than others? Explain. How does an organism's size, speed, color, and presence of specialized devices determine which predators will prey upon it?
- **Territorial Rights.** Observe the general movements of each population of organisms. Do some organisms tend to stay in one location rather than move freely about? If so, how do they behave when other organisms move into their area?

Library Research

Now that you have observed your organism in detail, you will want to locate more information about its life history in the library. See if you can find answers to some of the questions that you were unable to answer from your observations and inquiries with the living animal. Some of this information will be hard to find. You will rarely be able to find information about a particular species of hermit crab. So if your project is on a particular species of hermit crab, look up information about crabs in general. Your report should include the following information:

- Identification—The animal's common name, Latin name, and if possible, its phylum.
- Habitat—Describe the place where the animal lives. As much as possible, include the type of seashore, the type of habitat, and the tide zone.
- Food—Describe what it eats, and how it catches and eats its food.
- Predators—Describe its enemies and how it is attacked and killed.
- Protection—Describe how the animal attempts to protect itself from predators. Describe how the animal attempts to protect itself from drying out at low tide.
- Life cycle—Describe how the animal reproduces. Describe a typical life story from "birth" to death.
- How does this animal sense its environment? Does it have eyes, eye spots, antennae?
- Internal structures—What does this animal look like inside? Does it have a digestive system? A heart? A nervous system?
- Importance—Describe ways in which your animal affects other organisms in its environment. You may include: providing food, shelter, or oxygen.
- Value to humans—If the animal is of value to humans, include this information here. Consider food, medicine, recreation, decoration, etc.
- Other interesting features—Include here anything that you find interesting about the animal here that fits nowhere else.

Project Format

Your project should look as follows:

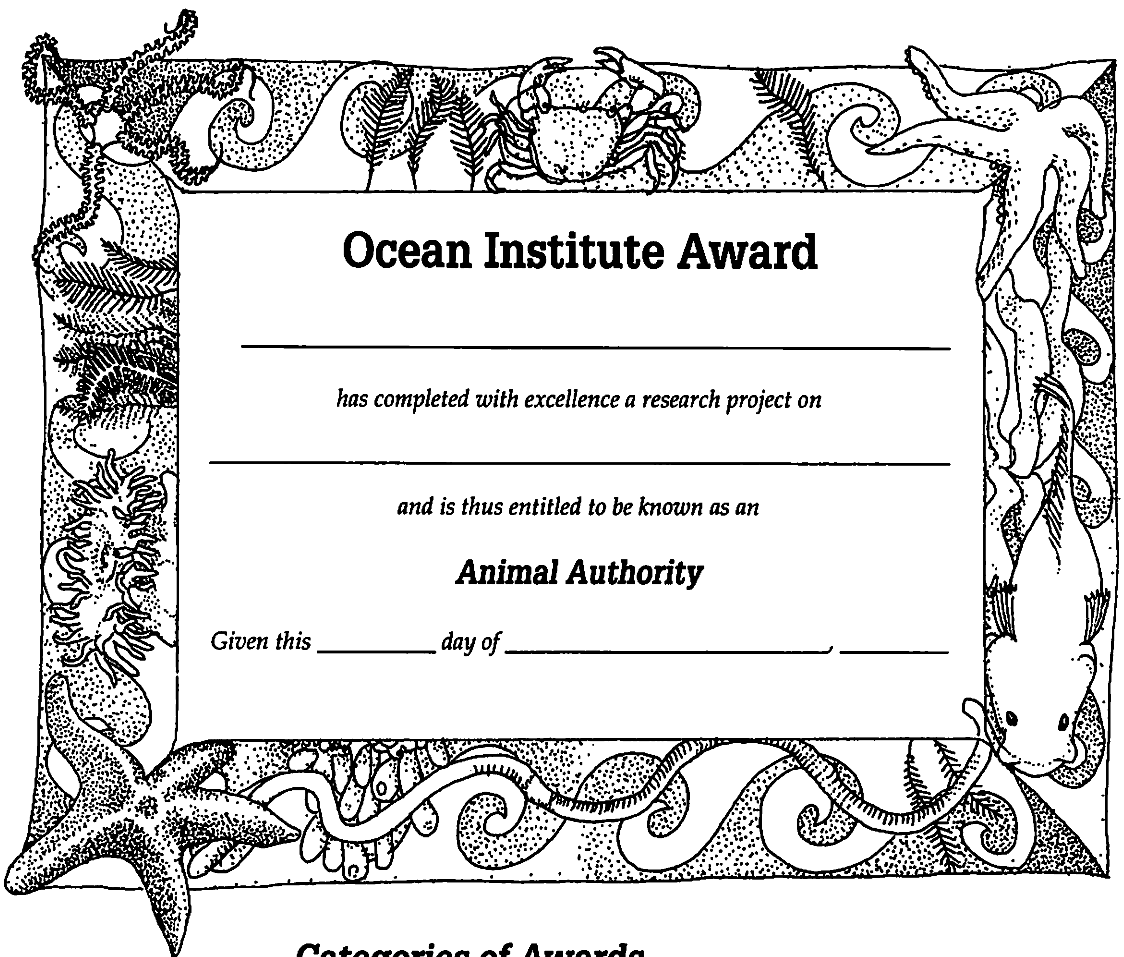
1. Make an attractive, colored book cover or title page.
2. Use clear, neat headings for the different sections.
3. List all books used as references. Include author, title, pages used.

Choose parts of your project that can be illustrated. Attempt to include large detailed sketches, photographs, pictures from magazines and posters, newspaper items. If possible, you might interview a marine biologist, scuba diver, or fisheries person about your organism.

Ocean Institute Awards

The Ocean Institute Award is a certificate showing that a student has accomplished outstanding achievement in the field of marine biology. Awards are granted to individuals and groups who have achieved outstanding research work.

The teacher, or the class, can act as a judge to determine the best projects. Winners—ideally, all the students—can be declared "Animal Authorities" in some category and get an "Ocean Institute Award."



Categories of Awards

Awards are given for the best field notebooks, the best projects with living organisms, the best library research projects, and the best overall projects. In addition to awards given for becoming "Animal Experts," awards can be given for original projects related to the field of marine biology. Projects might include the following:

Tidal pool study	Study of an animal
Conservation project	Map of a seashore
Plankton study	Presentation to the class
Habitat study	Sketch of an animal
Creative drama	See also "Ocean Caretakers Award" (page 81)

Chapter 6: Rocky Shores

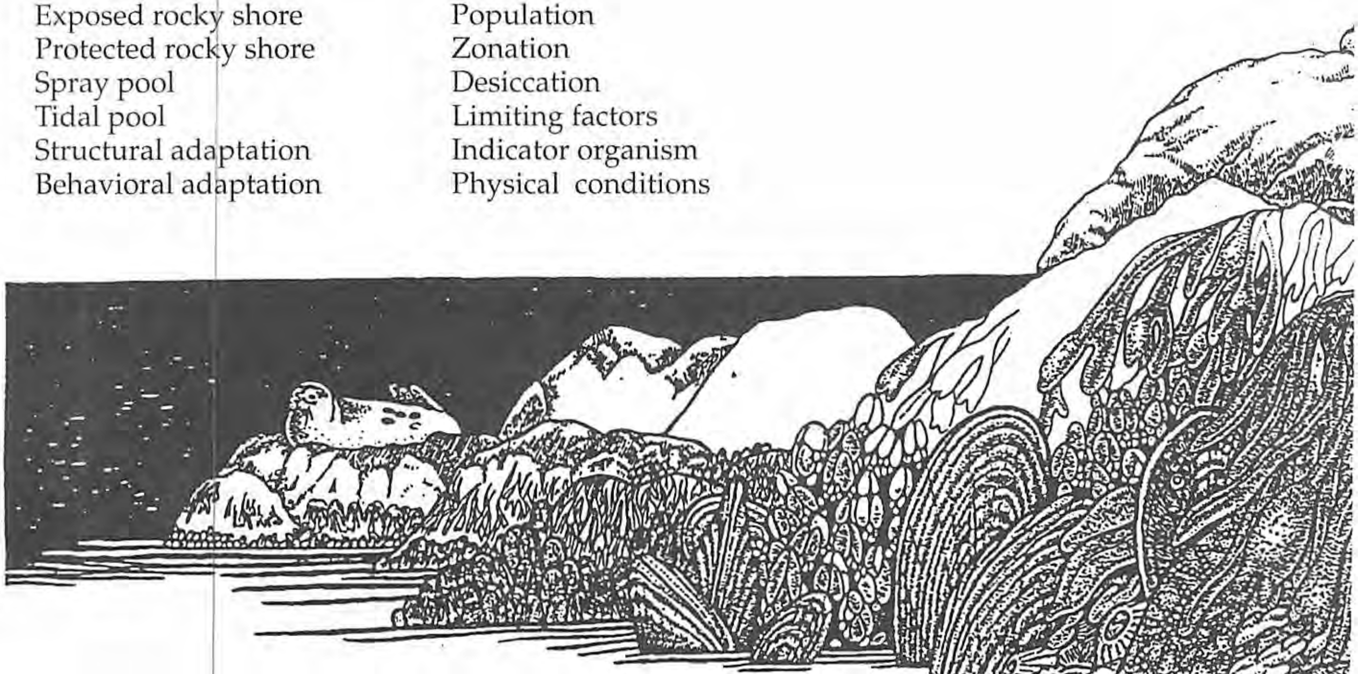
The rocky shore shows the greatest variation of all coastal environments. They range from steep cliffs to almost flat platforms. They may be hard basalt or granite, or soft sandstone. They may be sheer rock and table-like, or strewn with boulders and cobblestones. Waves slowly erode rocky shores, leaving unusual forms and shapes in sandstone.

Not all rocky sites are equally exposed to the elements. Exposed shores take the full force of the beating waves; protected shores receive little wave action, and transitional shores are neither completely protected nor completely exposed to the hazards and surf-swept conditions of the outer coast.

Whether a rocky shore is exposed, transitional, or protected, the dropping tide usually leaves interesting tidal pools, crevices, gullies, and overhangs. The wide variety of environments on rocky shores provides a wide variety of habitats to which variously colored seaweeds can attach and on which animals can feed, move, and attach their eggs. Animals occupy every available space: on rocks, in crevices, under rocks, in tidal pools, among seaweeds, under the protective curtains of seaweeds, on the shells of other animals, and even in other plants and other animals themselves. Rocky shores have hordes of easily found creatures, many so brightly colored and of such bizarre shapes that they seem unreal: barnacles, mussels, snails, limpets, chitons, sea stars, sea urchins, sea anemones, sponges, seaweeds, and worms. Generally speaking, a rocky shore is a stable home, and because it's stable, it's home to the greatest variety and the greatest number of seashore organisms.

In this chapter, students will gain an understanding of the following concepts:

- Exposed rocky shore
- Protected rocky shore
- Spray pool
- Tidal pool
- Structural adaptation
- Behavioral adaptation
- Population
- Zonation
- Desiccation
- Limiting factors
- Indicator organism
- Physical conditions



The rocky shore at Tamu, Queen Charlotte Islands, B.C., is home to a large variety and a great number of seashore organisms.

Protected Rocky Shores

Concepts

1. The rocky shore is a stable home.

2. Rocky shores have more types of habitats than any other type of seashore.

3. Because it is the most stable and has the greatest variety of habitats, the rocky shore has the greatest diversity of plants and animals.

Understandings

The students will be able to 1) describe and sketch a rocky shore, 2) identify and observe a variety of rocky shore organisms, and 3) infer why so many organisms live on rocky shores.

Teacher Information

Rocky shores are "protected" because they have offshore islands to shelter them, or bays and inlets to provide shelter from the full force of waves. These sheltered bays are comparatively rich in plants and animals that are out of danger from the waves and strong currents.

Even on the outer coast, distant headlands, outlying bars, or nearby islands provide a degree of protection that makes the animals correspond more closely to a protected coastline. An offshore kelp bed will serve the same purpose, smoothing out the water to such an extent that many years ago small coasting vessels used to seek shelter inside the beds and take advantage of their protection whenever possible.

Rocky shores in protected areas are the home of a great diversity of plants and animals. Protected shores provide habitats for organisms that would be unable to survive if exposed to the full fury of the waves.

Rocky Shore Observations

After the students have had a period of unstructured play at the seashore, gather them together. If possible, choose a relatively high location overlooking the shore. Ask them to sit down in a comfortable spot and be very quiet and still. Focus their thinking on the following:

- What colors do you see? Do you see patterns of colors?
- What sounds do you hear? Close your eyes and listen.
- What can you smell?
- What observations can you make? What makes you curious?

After 10 or 15 minutes, call the students together. Discuss the following:

- Did you enjoy the experience? Why or why not?
- What colors, patterns, sounds, smells did you notice?

- What type of seashore is this? Rocky shore? Cobble? Sandy beach? Mud flat?
- Is this a protected rocky shore? A surf-swept rock shore? How can you tell?
- Are there different types of habitats? Where?
- Did you notice anything that surprised you?
- What questions do you have about the rocky shore?

Intertidal Observations

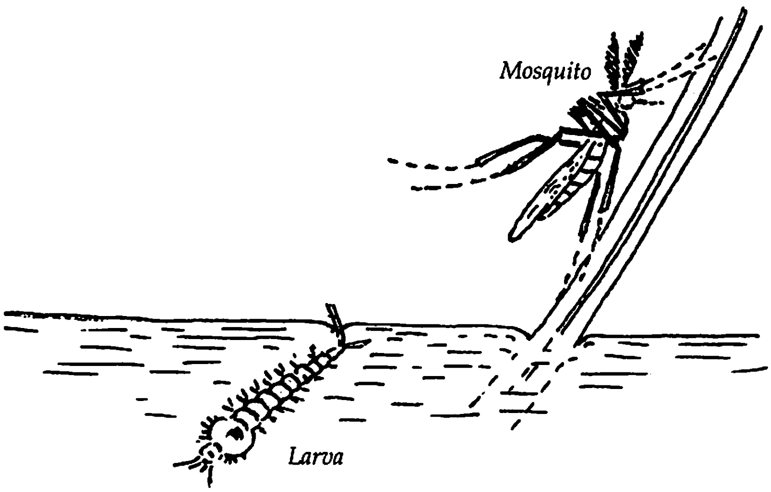
Take a brief walk into the intertidal. Look for the following habitats: on rocks, in crevices, under rocks, in tidal pools, among seaweeds, in sand, and in mud. What plants and animals live in each type of habitat? Do any organisms occur in more than one type of habitat? (See Habitat Data Sheet, page 68.)

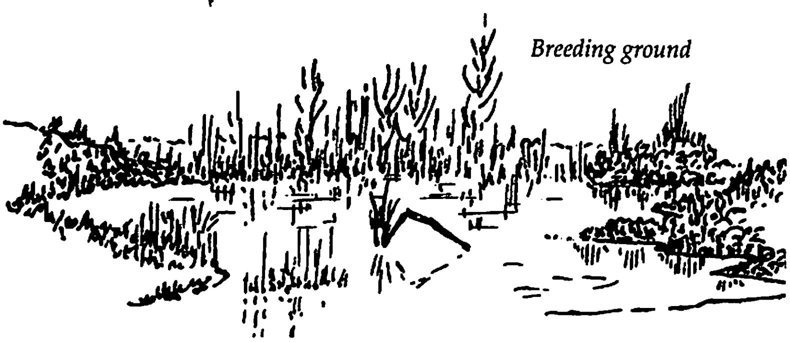
Look for a rocky outcropping bordering a sandy area. What do you notice about the variety of organisms that live on the rock as opposed to the sand?

Questions for Discussion

1. What types of habitats occur on a rocky shore? Do all these habitats occur on a sandy beach? A mud flat? Why not?

2. Why is the rocky shore home to the greatest variety of seashore plants and animals? (The rocky shore is a stable home; there are many types of habitats.)





Spray Pool Study

Concepts

1. Spray pools are mostly rainwater and only occasionally receive ocean spray.

2. The plant and animal life in spray pools must be able to withstand extreme temperature and salinity changes.

3. Spray pools become breeding places for land organisms such as beetles, flies, and mosquitoes.

Understandings

The students will be able to 1) describe characteristics of spray pools, 2) list organisms that live in spray pools, and 3) compare spray pools to permanent tidal pools.

Materials

Freshwater field guides

Thermometers

Collecting jars

Hand lenses

Small dip nets

Discovery scopes

Teacher Information

On many rocky shores, just below the area clearly belonging to the land, there are small pools of water that are mostly rainwater, because pools this high on the beach only occasionally receive the ocean spray. Life in spray pools high in the splash zone is very different from life in true tidal pools in the high tide zone or lower down on the shore, which are regularly covered and uncovered with seawater. The plant and animal life must be able to survive high temperatures in the summer and freezing cold in the winter. They must also be able to survive high salinity (or salt content) during periods of high temperatures and low salinity during rainy periods. During the spring and summer, many of the freshwater pools become breeding places for countless beetles, flies, and mosquitoes that come down from the land.

Spray Pool Study

Explore the rock faces just below the land for pools of water. If possible, have the students lie down on their stomachs beside the pools, with their faces just above the spray pools. Look closely for tiny moving dots the size of pin heads (the mixed salt- and freshwater plankton), as well as beetles and mosquito larvae.

Investigate the following:

1. Describe the color of spray pool water. How is the color different from the color of tidal pool water lower on the shore? If the color is green, what is causing the color to be green? (Green algae.)

2. What would the salt content (salinity) of the water be? High? Low?

3. What is the temperature of the water at the surface? On the bottom?

4. What animals live in spray pools?

5. How does life in a spray pool change from high tide to low tide? Does the sea water actually cover this area at high tide?

6. How might living conditions change from season to season?

7. What are the advantages of living in a spray pool? The disadvantages?

8. How are spray pools different from true tidal pools? How are they different from freshwater ponds?

9. Collect some spray pool water. Put the water in a bottle the size of baby food jars or in zip-lock plastic bags. Pass these around. What can you see? If possible, observe the water with discovery microscopes right at the seashore, or take samples back to the classroom. What organisms can you identify?

Seventh-grade students observing spray pool organisms up close.

Tidal Pools

Concepts

1. A tidal pool is a pool of water left on a rocky shore when the tide goes out.

2. Tidal pools provide shelter for plants and animals that cannot stand exposure to drying out during low tide periods.

3. Tidal pools contain populations of specialized plants and animals.

Understandings

The students will be able to 1) observe a tidal pool, 2) draw a tidal pool, 3) identify organisms in a tidal pool, 4) describe the physical properties of a tidal pool, 5) count and record populations of organisms in a tidal pool, and 6) map a tidal pool.

Teacher Information

A tidal pool is a small pool of water left on a rocky shore when the tide falls and provides shelter for plants and animals that cannot stand exposure to air during low tide periods. Some pools are so small, however, that they may be warmed by the sun and therefore may have a low dissolved oxygen content and salt content higher than that of the sea. Every tidepool contains a community of plants and animals; some are bottom dwellers, some attach themselves to the sides, others are free-swimming.

Life in a tidepool can be very difficult because of the isolation. The plant and animal life must be able to adapt itself to the ever-changing salinity, temperature, and oxygen content.

The tidepool offers protection from exposure during low tide, but has many drawbacks. As there is a limited area to escape predators that come down from the land (shorebirds, raccoons, snakes, etc.), the tidepool is a very good example of interaction between animals. Every tidal pool study is a good focus for teaching the techniques of science inquiry, and is fascinating for the students to observe because so many plants and animals live together in such a very small space.

Classroom Advance Organizer

1. Write the word "tidal pool" on the blackboard. Ask the students to brainstorm answers to the following questions.

- What is a tidal pool?
- What animals live in a tidal pool?
- Do different collections of animals live in different tidal pools?
- How is a tidal pool different from a puddle? A freshwater pond?
- What are the advantages of living in a tidal pool? The disadvantages?

2. Tell the students they're going to study a tidal pool at the seashore. Why would they want to sit quietly and observe a tidal pool? What might they find out? Review mapping skills.

Observing a Tidal Pool

After the students have had a chance to explore the seashore on their own, ask them to disperse to select a tidal pool. Ask them to sit down, find a comfortable position, relax, and be very quiet and still. They need to concentrate fully on what they see, hear, and smell. Look for all the different colors they can find. Look for patterns and textures. Smell the surroundings. Listen. After 15 or 20 minutes, have the students regroup, and discuss the following. What things did you see, hear, and smell? What colors did you see? What patterns did you see? What questions do you have? Did you enjoy the experience? Did anything surprise you? Explain. Have the students share their observations and questions and record their observations in their field notebooks.

Questions for Discussion

- What colors are in tidepools? What patterns of coloration are on the plants and animals?
- Where do the animals live in the tidal pool?

  What animals swim about?

  ...are attached to rocks?

  ...live on the bottom?

  ...live among seaweed?

  ...live in mud?

  ...live in more than one place?
- Are any animals eating? If so, what are they eating? How are they eating?
- Do any animals establish territories? How could you find out?

- How does life in a tidal pool change from high tide to low tide? Or does it?
- Will the same animals return to the same tidal pools after a high tide has come and gone? How might you find out?
- How do the various animals protect themselves from predators? What animal weapons are evident?
- Which animals blend into their surroundings? Why?
- What are the advantages of living in a tidal pool at low tide? The disadvantages?
- When the tide goes out, what animals come down from the land to prey on tidepool animals? (Shore birds, raccoons.)
- Is it surprising to see so many animals living together in such a small space?
- Discuss why a tidal pool is called a "community."

Taste the Seawater (optional)

Have students put their fingers in a tidal pool and lick their fingers. Why does seawater taste so strong? Why does seawater and freshwater taste differently?

What do Tidal Pool Animals Eat?

Drop pieces of frozen oyster, shrimp, or hamburger into the tidal pool. Watch what happens.

Do any Animals Establish Territories?

Do Tidepool Sculpins, for example, return to the same tidal pool after the tide returns? How could you find out?

Further Investigations

1. Graph the temperature of tidal pools in the spray zone, high tide zone, middle tide zone, and low tide zone.

2. Graph the temperature of different habitats at the same time of day.

3. Graph the temperature of tidal pools in the spring, summer, fall, and winter.

Mapping Tidal Pools

Because so many plants and animals live together in a small space, a tidal pool is a good focus for teaching the techniques of mapping, counting or estimating populations, graphing, and interpreting data. Generally, it's a good idea to teach basic mapping skills in the classroom, prior to your trip to the seashore.

Materials

Field guides

Field notebooks

Collecting jars or zip-lock plastic bags

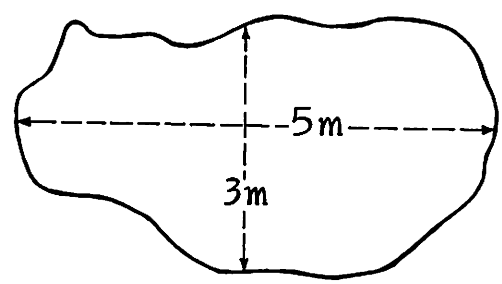
Measuring tape or cord with knots at 10 cm intervals

Hand lenses

Thermometers

Cameras (optional)

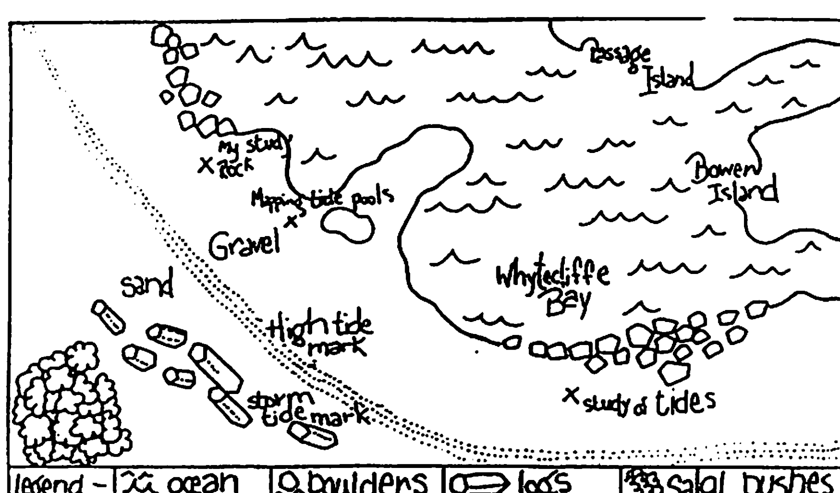
Have the class form groups of three, four, or five. Assign one student in each team to be the recorder, one or two students to count or estimate populations of organisms, and one or two students to use field guides or identification sheets to identify organisms. Each group should find an interesting pool that is small enough to map easily. Or locate tidal pools in the spray zone, high tide zone, middle tide zone, and low tide zone. Assign groups to tidal pools located in different tidal zones (see "Tide Zones," pages 190–192.)



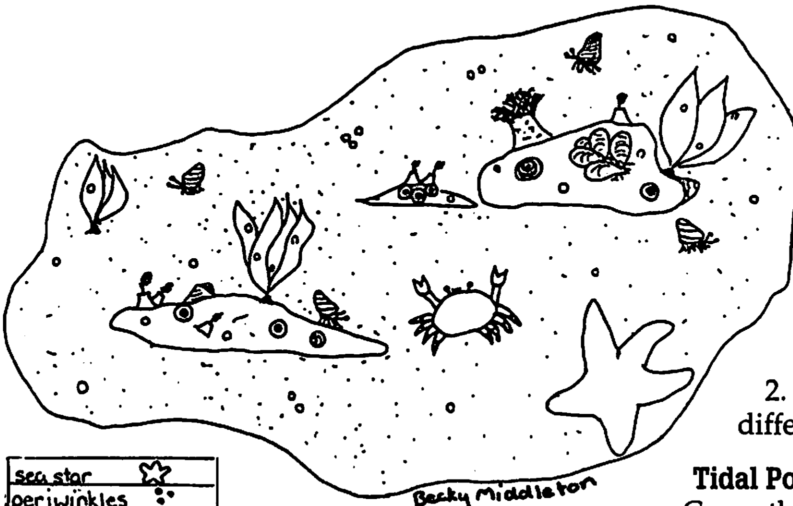
Brainstorm how to measure the depth and size (circumference) of the tidal pool. Use a meter stick to measure the depth in different locations. Measure the width and length of the pool. To measure the circumference, lay a thick string or cord the distance around the pool. Stretch the cord out on the shore and use a measuring tape to measure the length of the tape.

Investigate the Following

- How deep is the deepest spot in the pool?
- How wide is the pool? How long is the pool? What is the distance around the pool (circumference)? Use the knotted string.
- Identify all the plants and animals in the tidal pool.
- Describe in detail the physical characteristics of the tidal pool.
- Draw a rough sketch or map of the tidal pool. Include any distinguishing features such as rocks, crevices, a pebbly bottom, empty clam shells, and the location of plants and animals.
- Count or estimate the number of each species of plant and animal in the tidal pool. List these on a table.



- (Optional) Draw a rough sketch of the shore. Locate the tidal pool on the shore.

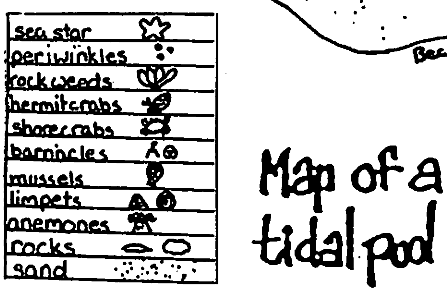


Tidal Pool Map

Upon returning to the classroom, each group of students should draw a new map and include a common legend of symbols to represent the various organisms.

Brain-Buster Questions

1. How is a tidal pool different from a spray pool high on the shore?
2. How is a tidal pool in the high tide zone different from one in the low tide zone?



Tidal Pool Mural

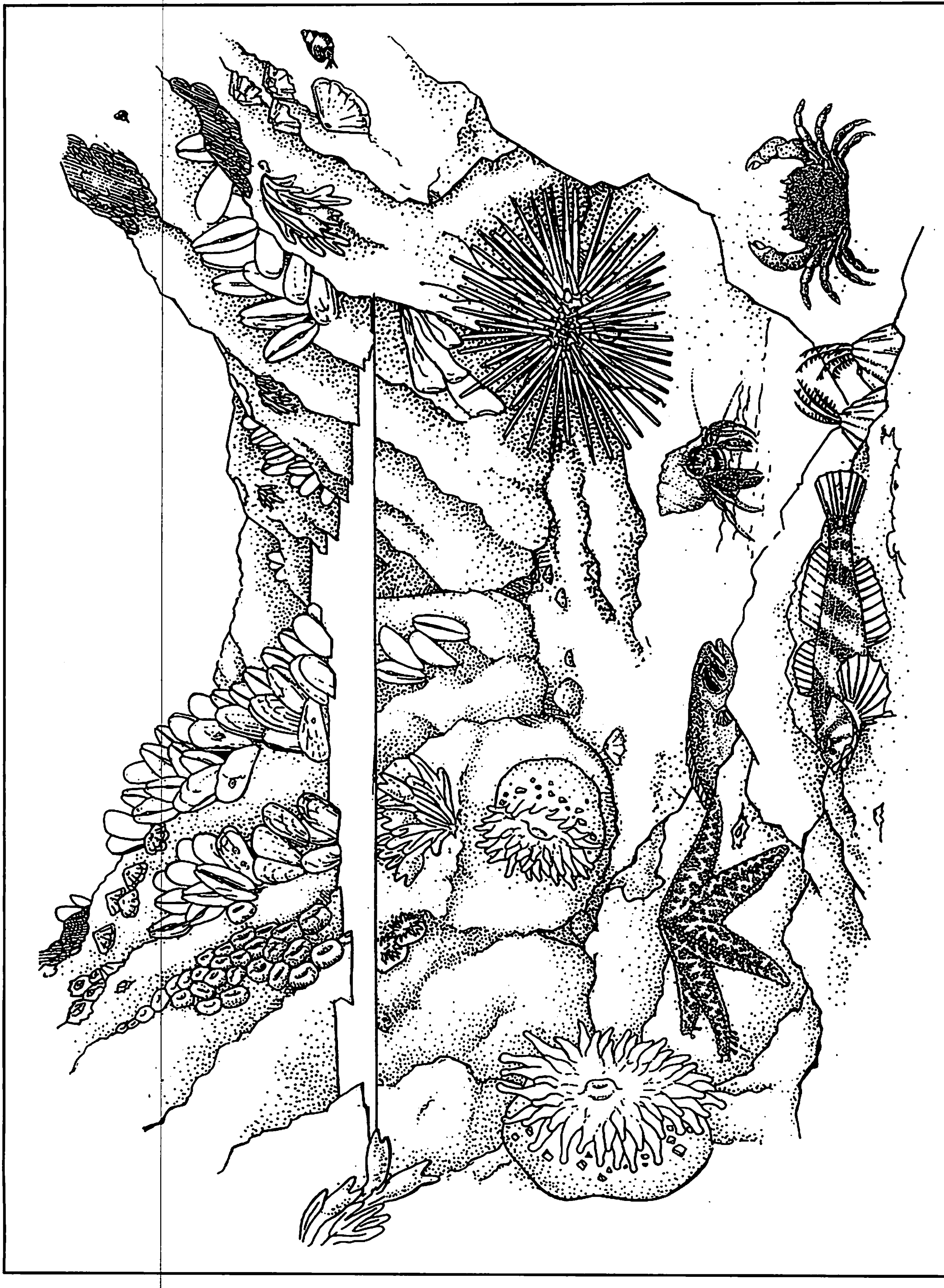
Cover the background of a bulletin board with blue butcher paper, art tissue, construction paper, or cellophane. Use a felt pen to draw an outline sketch of a tidal pool. Have the students make paper constructions of seashore plants and animals. As students learn about the location of organisms in a tidal pool, they can draw, paint, or pin their constructions into the appropriate background: on rocks, under rocks, among seaweeds, swimming, etc.

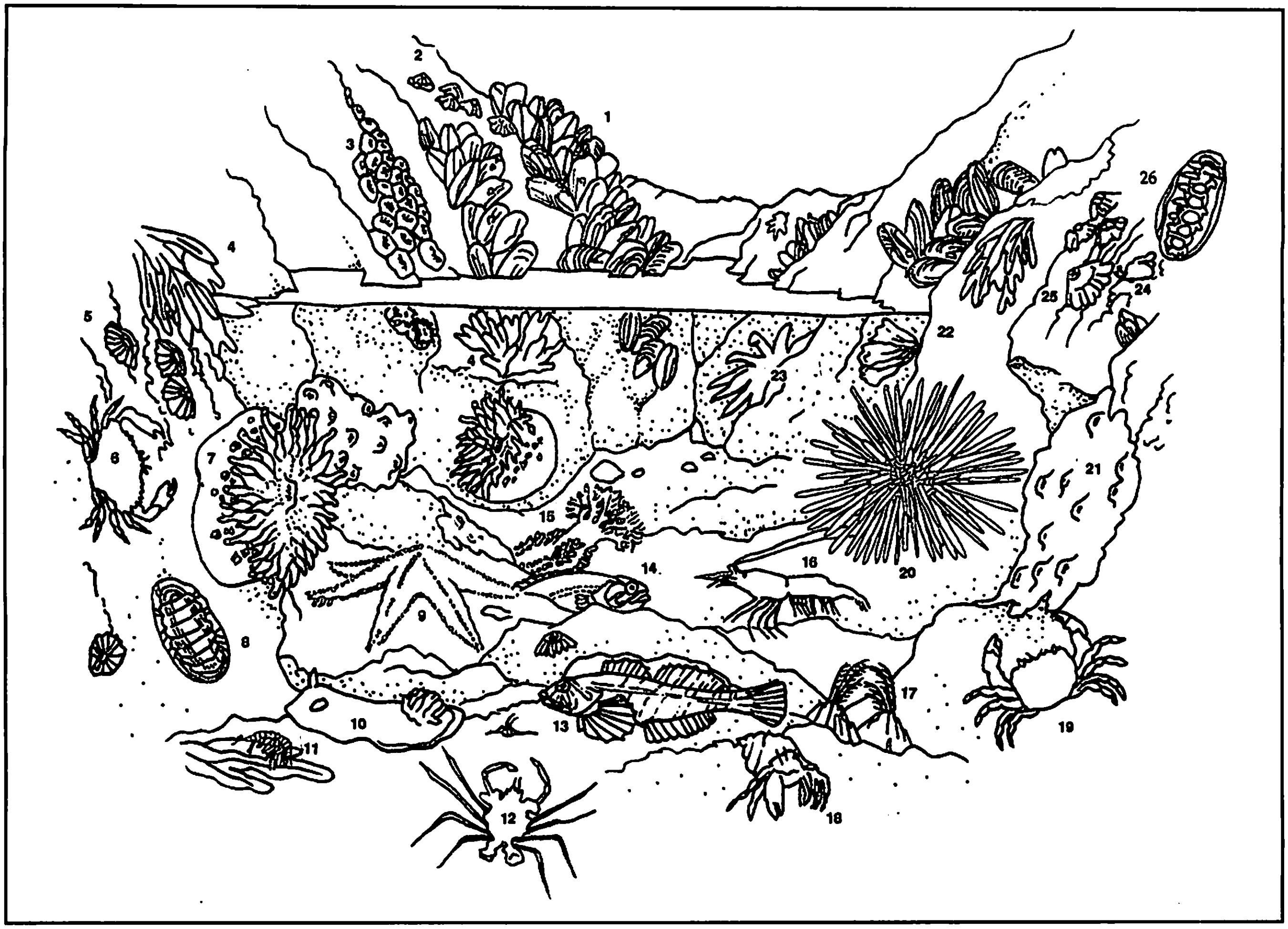
Papier-mâché Diorama

Have the students make clay or papier-mâché models of organisms in a tidal pool. Use crepe paper, construction paper, dried pieces of seaweeds, pieces of driftwood, sand, beach pebbles, etc., to make a model of a tidal pool. Use this as an opportunity to talk about animal homes (habitats.) Where in the tidal pool do organisms live: on rocks, under rocks, among seaweeds, or in the bottom sand and mud? The students can take turns placing the seaweeds and animals in their correct locations in the pool.

Tidepool Crayon Resists

Have the students draw an outline sketch of their tidal pool on butcher paper (approximately 45 cm [18 inches] by 35 cm [14 inches]). Color the drawings with wax crayons. Remind them to press the crayons hard and to fill in all the spaces. Use a wide, soft brush to paint a blue or bluish-green tempera paint wash, the consistency of milk, over the entire surface of the tidal pool. The wax crayons will resist the paint to create interesting undersea textures. Glue these onto the mural. As much as possible, the mural should represent the actual tidal pool and the organisms that live in it.





Color Key to Tidal Pool Organisms

Many tidal pool organism are camouflaged to blend in with their surroundings. Others are so brightly colored they seem unreal. Use water colors or colored pencils, and the color key below to create a realistic tidepool scene.

1. Edible Blue Mussel—bluish black.
2. Speckled Limpets—white shell speckled with brownish-black dots.
3. Pink Tipped (or Aggregate) Anemone—green body with pink tipped tentacles.
4. Rockweed—olive green or brownish green.
5. Small Acorn Barnacles—dirty white.
6. Red Rock Crab—a solid deep red or brownish-red, the pinchers tipped with black.
7. Giant Green Anemone—solid bright green body and tentacles.
8. Lined Chiton—a smooth shiny surface marked by brownish lines that zigzag across a field of gold, pink and lavender-blue or green.
9. Purple or Ochre Star—bright purple, or brownish purple or brownish orange.
10. Sea Lemon—bright yellow with speckles of black dots.
11. Amphipod—dull green or gray-brown.
12. Decorator Crab—light brownish body, attaches seaweeds to its back for camouflage.
13. Tidepool Sculpin—white and green-black body with gray or green or pink highlights that blend with the surroundings. To some degree, able to change colors.
14. High Cockscomb Blenny—olive green or dark brown with designs on the back.
15. Orange Sea Cucumber—reddish-orange or purplish brown, with bright orange or reddish tentacles.
16. Broken-back Shrimp—though the body is generally transparent it will show a slight green, gray, brown, or reddish tinge to enable it to blend in with the background.
17. Thatched Acorn Barnacle—dirty white.
18. Hairy Hermit Crab—brownish body.
19. Purple Shore Crab—reddish purple body, purple dots on claws.
20. Red Sea Urchin—bright reddish-purple.
21. Encrusting Sponge—dull green or gray; or bright purple; or bright red: each species a different color.
22. Sea Lettuce—bright green or yellowish-green.
23. Sunflower Star—bright orange or pink with a grayish-blue or grayish-purple line running down each ray.
24. Checkered Periwinkle—brownish black or bluish-black with white checkers.

Tidal Pool Populations

A population is a group of plants and animals of the same kind that live and reproduce in a particular area. Generally, small organisms have huge populations, while large organisms have small populations. For the students to see this, have them make a second chart and arrange the plants and animals in order, from those that have the largest populations to those that have the smallest populations:

TIDAL POOL NUMBER

Plant or Animal (Organism)	Number (Population)	Class Totals (Optional)
Checkered Periwinkles	109	
Limpets	21	
Hermit crabs	5	
Barnacles	56	
Mussels	19	
Shore crabs	13	
Tidepool Sculpins	11	
Sea Lettuce	15	
Rockweeds	4	

Discuss the Following Questions

- Which organisms have the largest populations? The smallest populations?
- How does the population of each kind of organism compare with its size? (Compared to large organisms, tiny organisms have huge populations to sustain their species because they are the food of countless larger organisms.)
- How might the population of each organism change with what it eats?
- Is it surprising to see so many organisms living in one tidal pool?
- Why is a tidal pool called a community?

Comparing Two Tidal Pools

Map a tidal pool high on the shore and a tidal pool low on the shore. Discuss the following questions:

1. How are the two tidal pools similar? How are they different?
2. Why is the water temperature lower in the low pool?
3. Which pool has the greatest variety of life? Why is this so?

Brain-Buster Questions

1. Does a tidal pool contain predators, scavengers, filter feeders, grazers? If so, what are they? (See "Getting Food," pages 125–130)
2. How did the seaweeds, barnacles, and mussels in the tidal pool get there? (They settled out of the plankton, attached and began to live out their adult lives.) How did the crabs, sea stars, and sea urchins get there? (They likely moved into the tidal pool as adults.) (See the chapter on "Plankton Soup," page 91, and the lesson "The Life Cycle of a Crab," page 106.)
3. What predator-prey relationships exist in a tidal pool? How could you find out?
4. Why is a tidal pool called a community?

Zonation on a Rocky Shore

1. Zonation is the arrangement of plants and animals in horizontal layers on the shore.

2. The tide creates the conditions that cause zonation.

3. Although tide zones overlap, each zone is home to a different collection of plants and animals.

4. Plants and animals are "adapted," or equipped to live in certain zones on the shore.

Understandings

The students will be able to 1) identify and describe tide zones at the seashore, 2) identify organisms in each zone, 3) collect data along a transect line, 4) construct a zonation mural, and 5) infer how organisms are adapted to live in each tide zone.

Teacher Information

Twice each day the tide rises and falls. Twice each day the seashore is covered with seawater or exposed to air or rain, and sometimes to the drying effect of the sun. The seashore is inhabited by organisms that have adapted to the stressful and varied conditions of the intertidal. The conditions impose limits on the distribution of organisms within the intertidal, resulting in characteristic vertical distribution patterns called intertidal zonation. Beaches are divided into zones or areas according to the length of time they're covered by water or exposed to air.

The Spray Zone

First and highest is the upper beach, or spray zone, an area flooded only by the highest storm waves and the ocean spray, and almost completely dry much of the time. The spray zone can be recognized by a band of black lichens covering the rocks. Hordes of little black snails called Checkered Periwinkles cover the rocks, and barnacles and species of limpets that survive under hard conditions live in the cracks and crevices.

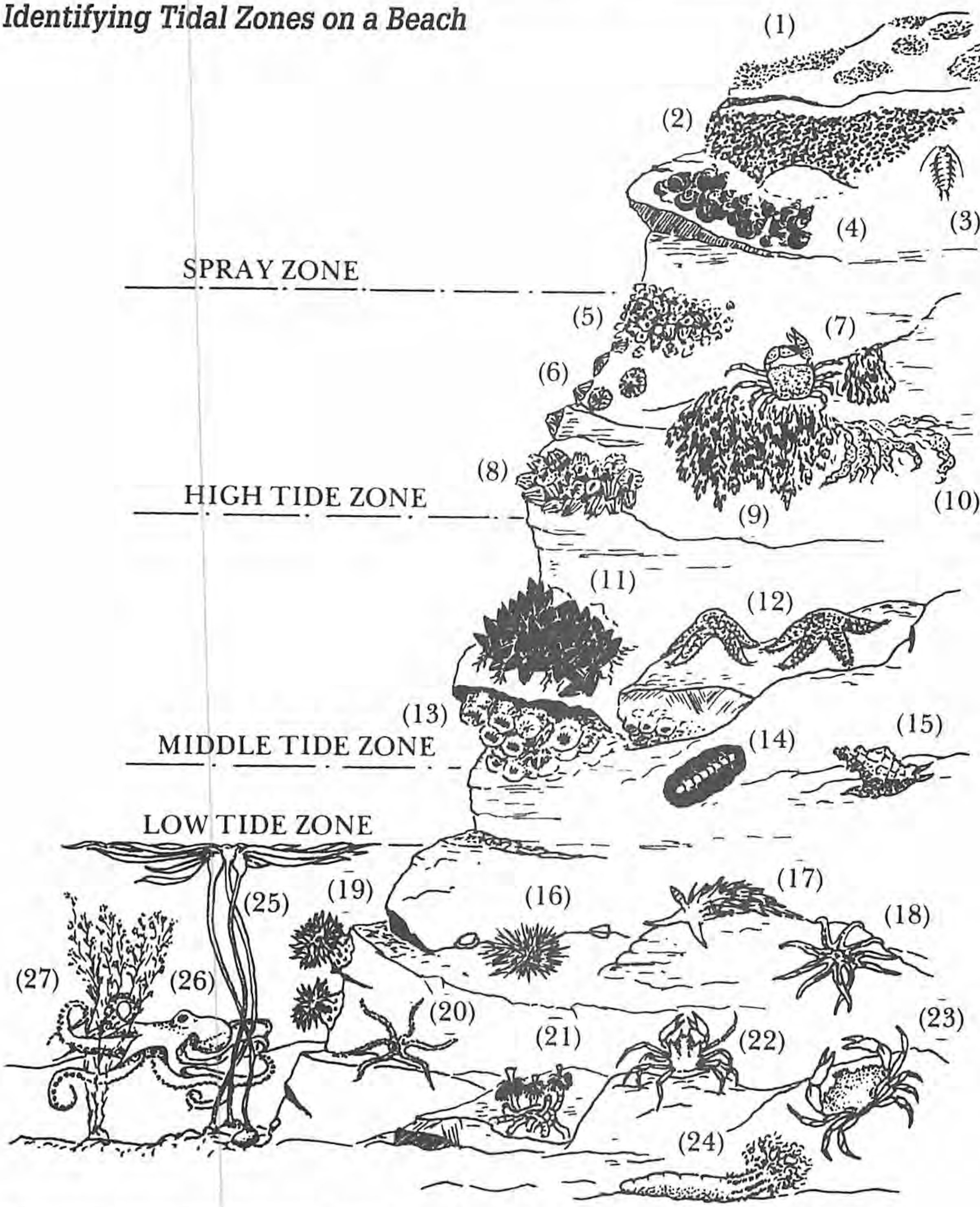
The High Tide Zone

Just below the spray zone, the high tide zone is an area normally uncovered except during high tides, and the home of animals adapted to spending long periods of time in air. This area, too, has many changes of temperature, water cover, and salt content. There is a greater variety of plants and animals here than in the spray zone. The lower part of the zone has greater numbers and larger sizes of barnacles. Scattered among the barnacles are small clumps of Edible Blue Mussels, and limpets and snails are everywhere. In the middle of the zone the Rockweeds begin to grow lush, and toward the bottom of the zone bright green clumps of Sea Lettuce mingle with the Rockweeds. Tidepool Sculpins and Hairy Hermit Crabs attract attention in tidal pools, while Purple Shore Crabs scurry under the rocks.

The Middle Tide Zone

The middle tide zone is typically covered and uncovered twice each day, and the great numbers of animals here may require the rise and fall of the tides. Temperature changes are less, because the middle

Identifying Tidal Zones on a Beach



Cross-section showing vertical zonation on a rocky shore. (1) Lichens; (2) blue-green algae; (3) Rock Louse; (4) Periwinkles; (5) small Acorn Barnacles; (6) Finger Limpets; (7) Rock Crab; (8) Common Acorn Barnacles; (9) Rockweed; (10) Sea Lettuce; (11) Blue Mussels; (12) Purple or Ochre Sea Stars; (13) Aggregate Anemones; (14) Black Chiton; (15) Wrinkled Whelk; (16) Red Sea Urchin; (17) Opalescent Nudibranch; (18) Sun Star; (19) Giant Green Sea Anemone; (20) Brittle Star; (21) Calcareous Tube Worm; (22) Kelp Crab; (23) Red Rock Crab; (24) Orange Sea Cucumber; (25) Bull Kelp; (26 Octopus; (27) Sargassum.

tide zone is covered with water much of the time. High in the zone great beds of Edible Blue Mussels clump together or share spaces with the barnacles. On the rocks just below the mussel beds are many kinds of brightly colored sea stars. By far the most abundant is the common Purple or Ochre Sea Star, as well as the Sunflower Star and Six-rayed Star. On the tops and sides of boulders are clusters of Aggregate Anemones, as well as the Black Chiton.

The Low Tide Zone

This tide zone is always covered except during the very lowest tides. A more constant area, having fewer changes in temperature, exposure, or salt content, it supports subtidal animals that move up as far as possible from deep water. This region is tremendously crowded because a greater number and variety of organisms live here than in the other tide levels. Many of the animals common to the middle tide zone live here, as well as animals that move up from levels below low tide. Every tidepool, every rock, and every cluster of seaweed becomes home to countless plants and animals because the region is very seldom exposed to waves. The sea urchin is a sure sign of the low tide zone.

Zonation is most easily observed on a vertical surface. The zonation on a rocky shore is comparatively easy to distinguish because so many plants and animals live in a narrow band, because animals generally aren't able to burrow below the surface, and because there are no trees or other obstacles blocking the view.

As the tide ebbs over a beach, the animals not attached to hard surfaces must find suitable places to hide from the drying sun and from new predators such as hungry shorebirds. Some intertidal animals, and many crabs and snails, are extremely hardy and not too particular about where they hide. As the water drops they may slide under moist rocks or into crevices, or simply become stranded on a rock or in a tidepool, but most plants and animals require more specific conditions for their survival and live in specific habitats.

That zones occur is obvious, but like everything else in nature, zones are not simple patterns. On a seashore they may vary with the tidal cycles, the speed of currents, and the degree of exposure to waves, all themselves determined by such factors as whether or not the shore is protected or exposed. Zones may also vary according to the climate and the season; for example, certain seaweeds live their entire lives in one growing season and die off in winter. Zones on a vertical rock face are close together and appear as distinct, horizontal bands, but on a rocky shore with a gentle slope the zones spread out and overlap. Nevertheless, the zones on a rocky shore look pretty much the same in England, Australia, South Africa, the United States, and Canada. When identifying zones on a beach, look for indicator seaweeds and for indicator animals such as barnacles, because these organisms are permanently attached to hard surfaces. Organisms such as crabs and sea stars are not attached and some species are capable of wide-ranging movement.

The charts at left can be used as a guide to zonation on a Pacific coast rocky shore. It should be noted that on northern Canadian shores, tide zones occur lower on the shore than they do in Oregon, and that in certain instances there may be considerable overlap between zones of certain organisms.

Zonation Mural

A mural is an excellent way to study the distribution of organisms within the intertidal, the conditions that pose limits on the distribution of organisms, and how organisms are adapted to survive in particular zones. The best way to study zonation is to observe zonation patterns on a rocky shore, collect data along a transect line, and construct a mural in the classroom from the data collected. **If time and logistics do not allow the collection of data at the seashore, a class simulation and mural are ways that zonation can be studied without going to the seashore.** Students of all ages enjoy constructing a zonation mural.

Materials

Zonation Data Sheets	Local field guides
Variously colored construction paper	Scissors, paste
Felt pens, pastel colors	Index cards

Zonation Simulation

Make a set of organism cards representing rocky shore plants and animals. For each tide zone, write the names of seashore plants and animals on index cards (if possible, paste a picture of the animal on the backside). Or, use the appropriate Pacific Coast Information Cards. Put the cards in large brown envelopes marked above beach, spray zone, high tide zone, middle tide zone, and low tide zone. Use local field guides to determine which organisms occur on the rocky shore nearest your school (see "Field Guides," page 280).

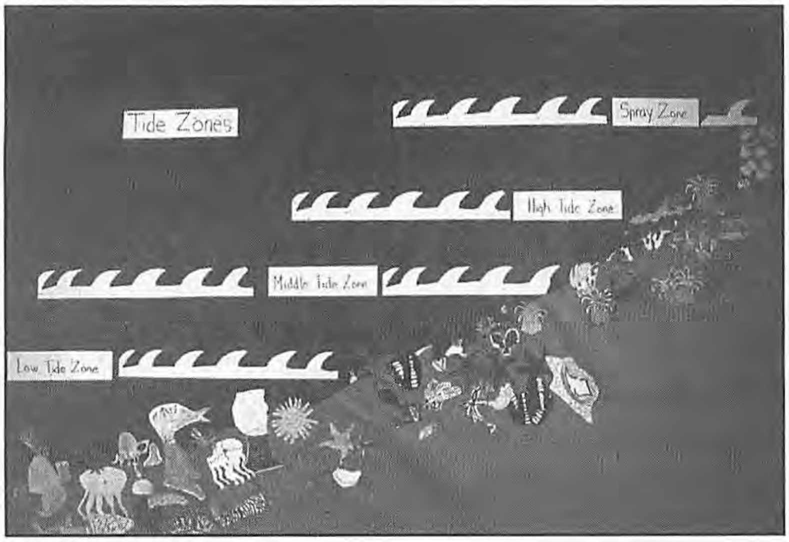
Divide the class into groups and assign each group one of the tide zone envelopes. Each group is responsible for researching the appropriate color of the organisms in its envelopes.

Encourage the students to predict what they will find. For example, in which tide zone do they expect to find:

- The greatest populations? Why?
- The greatest variety? Why?
- The greatest populations of barnacles? Crabs? Sea stars? Mussels? Checkered Periwinkles?
- The greatest variety of seaweeds? The longest seaweeds?
- The tide zone with the brightest-colored plants and animals? The dullest? Why?

Zonation Data Sheet

Use brightly colored chalk to draw a Zonation Data Sheet on the blackboard similar to the one on the next page (or use a black felt pen on a large sheet of newsprint.) After each group has researched the organisms in its envelope and tide zone, they should write the names of organisms in the appropriate column. From the data, construct a zonation mural.



Zonation mural using color paper constructions (grades 3–4).

Constructing the Mural

1. Cover the bulletin board (or wall) with butcher paper. Draw a vertical rocky shoreline. Use a felt pen to draw a broken line denoting horizontal zonation patterns. Print in large letters the names of the various tide zones. Have the students make large paintings or papier-mâché constructions of rocky shore organisms. Cut these out. The students should pin their organisms in the appropriate tide zone.

2. When the bulletin board is complete, have the students stand back and make observations and inferences of what they see, as if they were at the seashore. Engage the students in a discussion related to the following questions:

- Do color patterns appear from a distance?
- What plants and animals live in each zone? What are the dominant organisms in each zone?
- Does the size of organisms change from the spray zone to the low tide zone?
- Does the variety and number of organisms change from the spray zone to the low tide zone?
- Infer what physical factors can affect the organisms living in the different intertidal zones. Discussion should include exposure time, salinity (salt) changes, and temperature changes. Which tide zone has the most constant temperature? The greatest changes in temperature?
- Infer how different plants and animals protect themselves from drying out, temperature changes, and wave action.
- Infer what physical adaptations (structures) plants and animals have that enable them to survive in the various zones, e.g., hard shells.
- Do all plants and animals live exactly in one tidal zone and not others? Do zonation boundaries overlap?
- Discuss tide zones in terms of predator-prey relationships, and how the population of each organism changes with what it eats.
- Would an organism that lives in the spray zone be able to live in the low tide zone, and vice versa?
- Would an organism that lives on the a surf-swept rocky shore necessarily be able to survive on a protected shore? Why not?

Zonation Data Sheet

Record the names of organisms you (or your classmates) have found in each zone.

Zone	Organisms
Above beach	
Spray zone	
High tide zone	
Middle tide zone	
Low tide zone	
Open water	

Mapping Zonation on a Shore

To obtain useful information about beaches, careful measurements must be taken. In this activity students sample populations using the grid method.

Because this activity requires some familiarity with intertidal organisms, it should not be done on the first trip to the seashore. In addition to measuring and sampling techniques, analysis of the interrelatedness of beach life and environmental factors is stressed.

The Grid: A Technique for the Study of Zonation

One of the simplest methods of mapping zonation is to have each group of students mark off four square meter grids, one in the spray zone, one in the high tide zone, one in the middle tide zone, and one in the low tide zone. Do this activity during the lowest tide possible.

Materials

Local field guides	A magnetic compass (optional)
String	Field notebooks and pencils
Meter/yardstick	Clipboards (optional)

Four one-square meter grids (or coat hangers bent into squares)

Classroom Advance Organizer

1. In the classroom, tell the students that they're going to take a count of some of the animal and plant populations at the seashore in order to learn more about how animals survive in their environment. Can they define a population? (Members of the same species living in a certain area.)

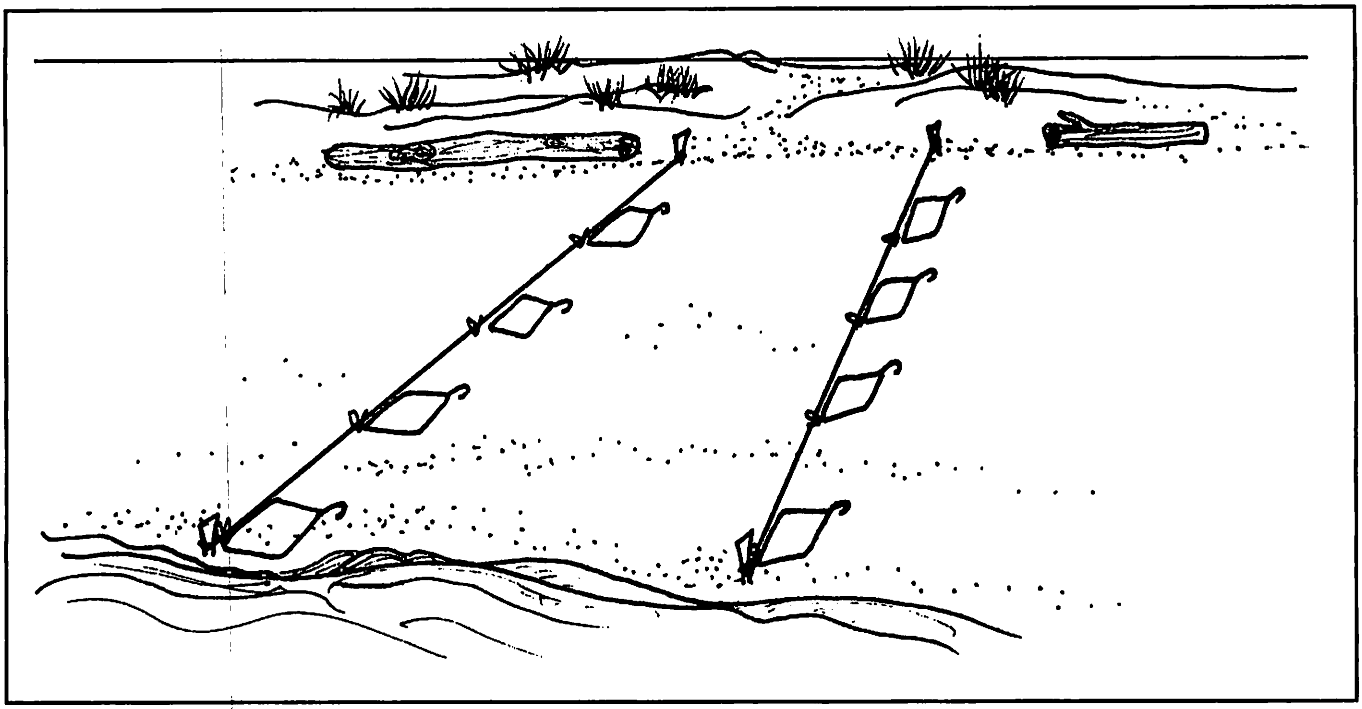
2. How could they accurately count a population at the seashore? Could they accurately count the number of barnacles on a seashore? On a large boulder? Suggestions might include counting small numbers, small areas, and estimating.

3. Brainstorm how they might record and map what plants and animals live where on a shore? Students should be able to come up with counting the plants and animals, but may need encouragement to develop a standard set area such as a circle (hula hoop), grid (square meter/yard), or square coat hanger grid to compare the different zones.

4. Who would use this information? Have students brainstorm their own ideas. (Examples might be marine biologists, other scientists, conservation groups, city planners, developers, oil companies, shoreline management agencies.)

5. Why would such information be important? (Preserving the beach, developing the site, prevention of exploitation, observing the effects of specific types of pollution over time.)

6. Before leaving the classroom, be sure that a method of data collection is clear. If possible, have students map the room or playground prior to going to the beach.



Collecting Data

1. At the seashore, locate a vertical rock face that shows a nice pattern of zonation. Ask the students to stand at a distance and observe the rock face. What patterns do they notice? Describe the patterns. Ask the students to speculate why the color patterns are arranged in horizontal layers.

2. Locate study sites; at least one in each tide zone and, if possible, one above the beach.

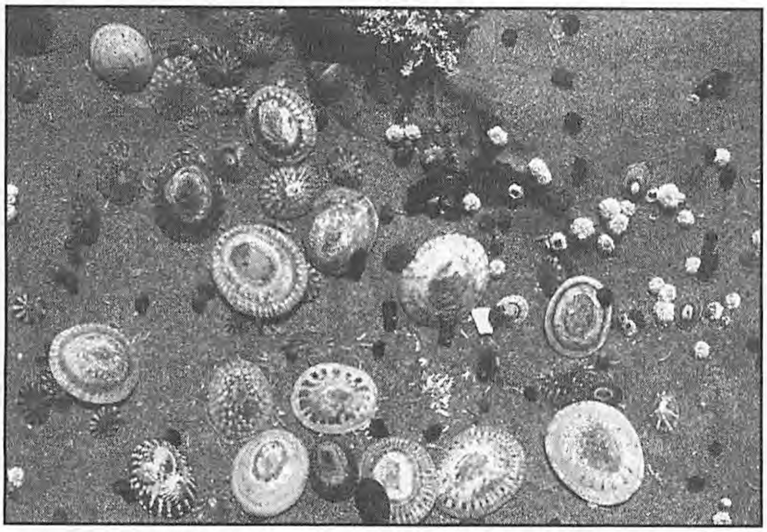
3. Divide the class into groups of four or five students. Each group should identify and count the population of each species of plant and animal in each grid (or in one of the grids) and record the information in a field notebook. One student should act as a recorder and note the plants and animals that are identified, the number of species at each station, and the station number. Another student should have an identification book and identify the plants and animals. If the identification of an organism is in doubt, the organism should be sketched and the detail noted, and the organism identified later.

4. While still at the seashore, a rough map showing any distinguishing features as well as the position of plants and animals should be drawn for each grid.

Classroom Follow-up

1. Upon returning to the classroom each group draws a map of its own grid, exactly one meter square. The class agrees upon a common legend of symbols representing plants and animals. Each group of students draws symbols on the map to represent the correct numbers of plants and animals in their grid.

2. The grids are pinned together, like a mural, across the length of the room. (An alternate method is to roll a sheet of butcher



Barnacles, periwinkles, and limpets dominate tidal pools high on the shore.

Fifth-grade students use a grid to conduct population counts of seashore plants and animals.

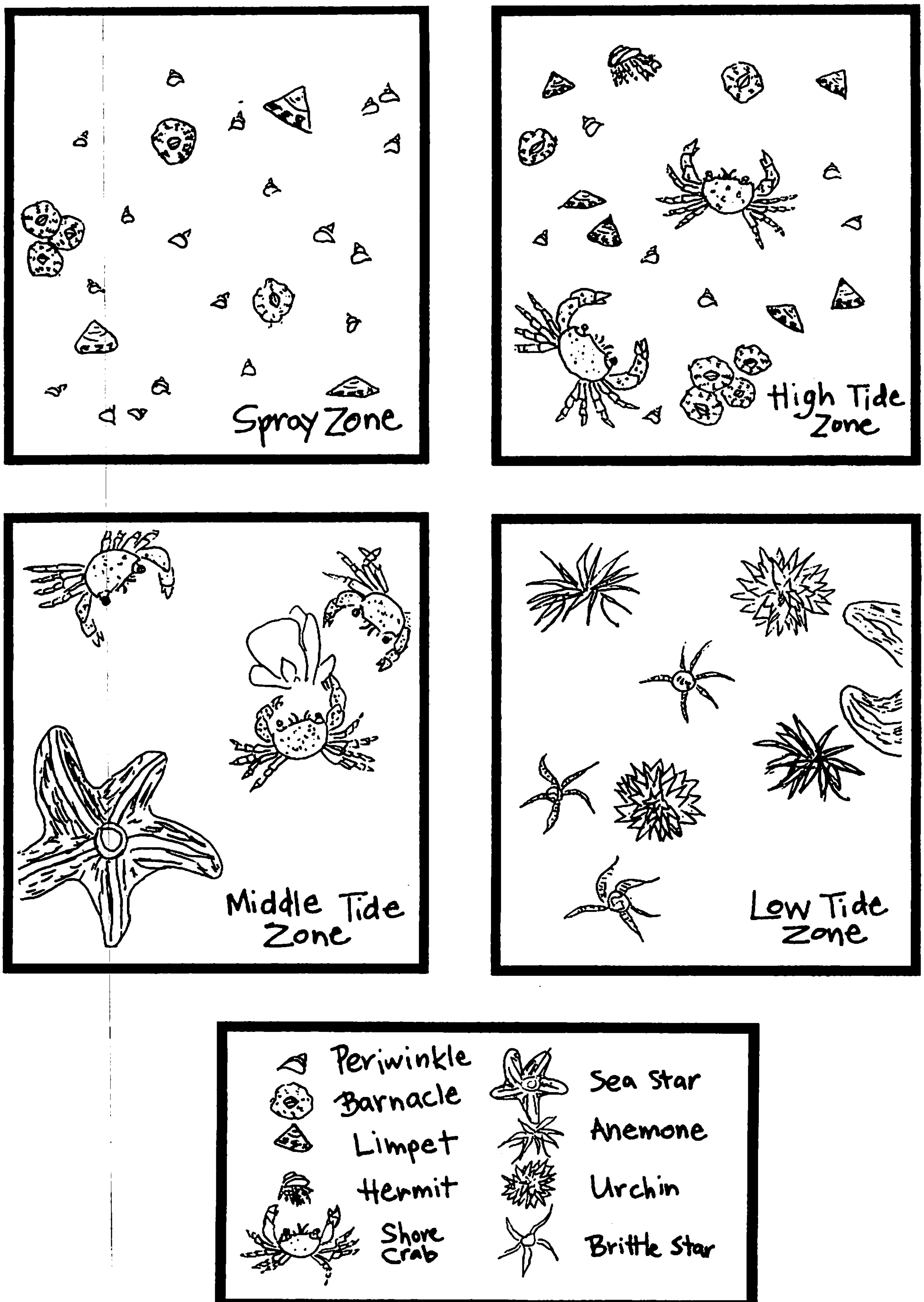
paper across the room or down the hall and have the students mark off the appropriate grids and draw them accordingly.) The completed mural is a map that shows where on the beach different plants and animals live. It can be used as a focus for observing, comparing, questioning, inferring, and interpreting data. (See questions for discussion of the Zonation Mural, page 194.)

Enrichment Activities

1. Which intertidal zone has the greatest or least number of species? Graph the intertidal zone against the species.

2. Which intertidal zone has the greatest or lowest population of a particular organism; for example, barnacles, sea urchins, or mussels? For each tide zone, graph the population of a specific organism. When the graphs are completed, each group will present its graph and explain it in terms of exposure time to air or seawater.

The Grid



Rachel Sinnott

The Transect: A Mapping Technique for the Study of Zonation

The information gathered along a transect line grid can be recorded and then used to compare one beach with another. It's a simple method of investigation that offers a greater degree of accuracy than the grid. By sampling at predetermined distances along a line, we eliminate bad counts that result from random selection of count sites. This is because in random selection there are always subjective factors: "There are more organisms here, let's make our count here," or "It looks easier to count here, let's count here." Your class or school can keep these records on file and observe your favorite beach over several years. Such a record is extremely valuable and can be helpful information for research groups involved in environmental issues.

Materials

25–50 meter length of line

Local field guides

20 coat hangers bent into squares

Magnetic compasses (optional)

Yellow flags (optional)

Procedures

1. Have the students work in groups of three or four. Each group should select an interesting area of the seashore. Try to avoid tidal pools.

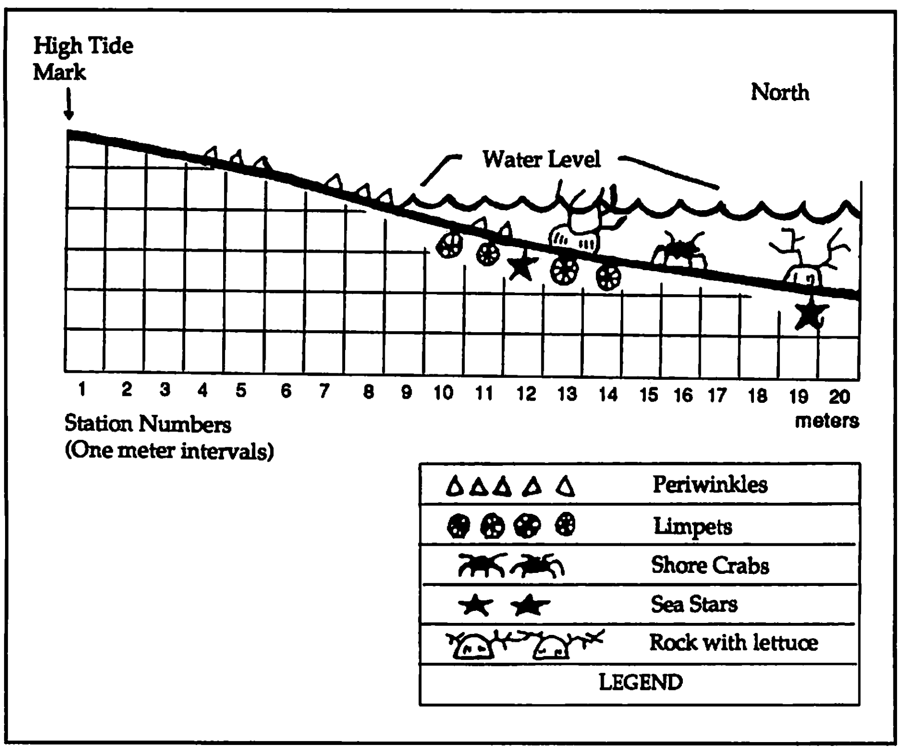
2. Use a tide table to determine the level and time of the low tide for the field study site and record them on the field data sheet.

3. Stretch a transect line out along the area to be mapped. Anchor the transect line at the top of the intervals and lay the line out as the students proceed toward the water line. The transect line is divided into stations at chosen intervals, such as every meter, by tying a knot, marking with a red felt pen, or tying plastic brightly colored plastic flags.

4. Set up stations at each interval: a hula hoop or coat hanger shaped into a square. If necessary, place flags at each interval.

5. The students should sketch a rough map of the beach. It should include any distinguish-

Beach transect



ing formations such as a large boulder, logs, the slope of the land, and the type of bottom; whether it's rocky, sandy, or muddy. The station numbers and compass direction (optional) of the transect should be included.

6. The students should write up a table of information, including the date, weather conditions, location, tide conditions, and the air and water temperatures.

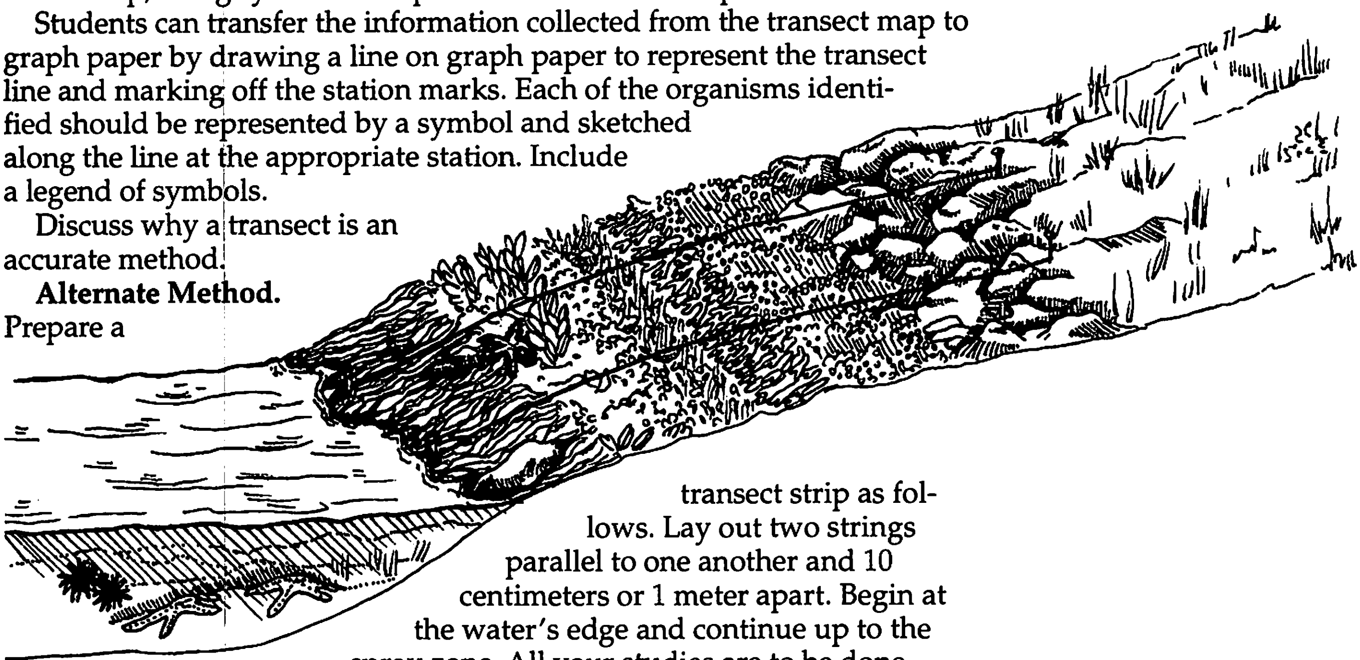
Classroom Follow-up

From the rough map drawn up at the seashore the students should draw a new map, using symbols to represent landmarks and plants and animals.

Students can transfer the information collected from the transect map to graph paper by drawing a line on graph paper to represent the transect line and marking off the station marks. Each of the organisms identified should be represented by a symbol and sketched along the line at the appropriate station. Include a legend of symbols.

Discuss why a transect is an accurate method.

Alternate Method. Prepare a transect strip as follows. Lay out two strings parallel to one another and 10 centimeters or 1 meter apart. Begin at the water's edge and continue up to the spray zone. All your studies are to be done within this transect strip. Continue as outlined above.



Computer-Based Data

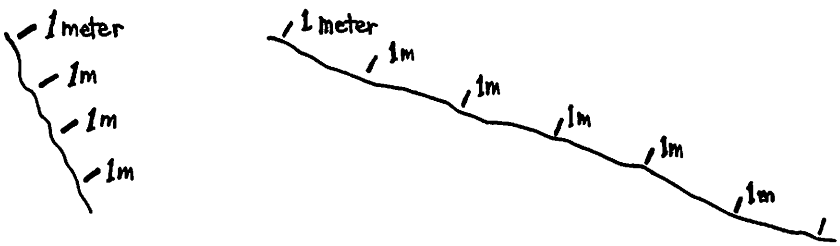
If your classroom or school is equipped with computers, you might want to store the population counts on a database system. Such information can be kept from year to year by continuing classes, and presented to biologists or conservation groups to monitor populations of organisms on a local beach.

Transect Data

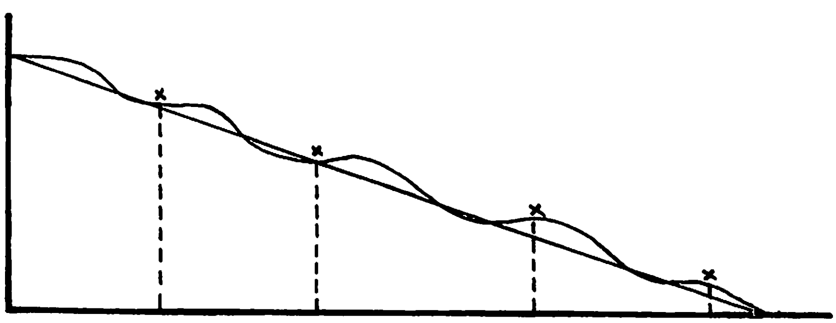
Habitat description	Organisms Common name	Latin (optional)	No. of organisms	Type of bottom

Vertical Zonation (Optional, Grade 6 and Up)

The problem with the preceding methods is that there is no way to measure vertical height above a set point. Such transects can never be compared to each other. For example, if we have two different beaches, very different results would be obtained:



To make comparisons, the slope (or vertical height) of the beach must be measured for each station. This information can be collected by one group of three students and used during the graphing of the data from different transects.



x = Stations along the transect

Materials

1 spirit level

1 "Gradient Data Sheet"

1 transect line (marked in meters)

1 clipboard

2 1 x 2-inch sticks, 1.5 meters long, divided into tenths of a meter, or simply use a tape measure on a stick.

Procedures

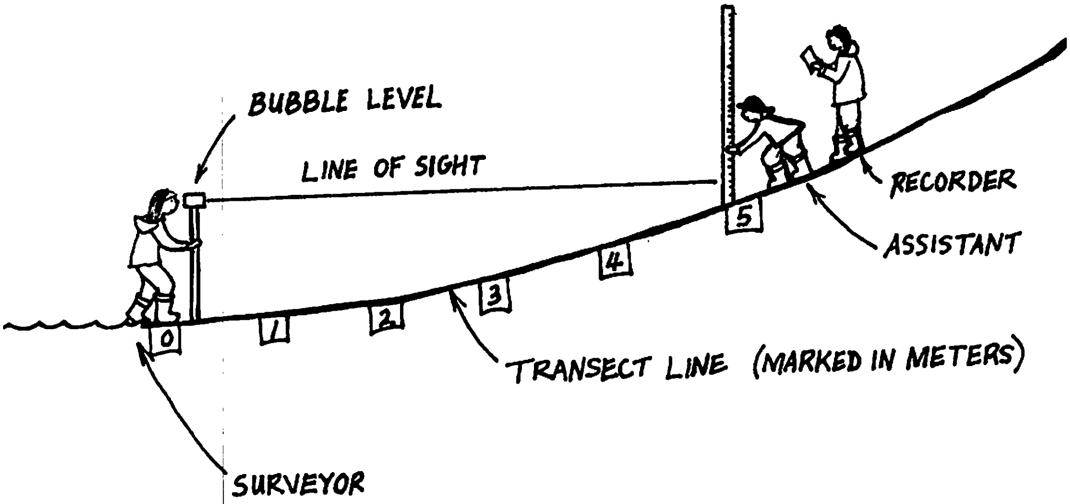
1. Stretch a transect line (rope or tape marked in meters) from the low tide zone to a location high on the shore. Set up stations equal distances along the transect line.

2. Divide the class into teams of three or four students. Each member of the team should be assigned one of the following tasks:

a. Recorder. Takes down the data on the "Gradient Data Sheet."

b. Surveyor. Holds the stick with the spirit level.

c. Assistant. Holds the stick without the spirit level.



3. Place the surveyor's stick at zero (0) on the transect line next to the water's edge. The elevation at Distance 0 is 0. This should be marked on the "Gradient Data Sheet." Note the exact time. Tide levels can be calculated or estimated using tide table data. This allows for comparison between sets of transect data done at different times of the year, or at different beaches.

4. Move the assistant's stick to each station on the transect line. The surveyor places the spirit level on top of the stick. The surveyor sights along the spirit level making sure the bubble is between the lines at the assistant's stick. The assistant moves one hand up and down his/her stick until the surveyor indicates it is directly in the line of view. The diagram below indicates how it will appear.

5. Read the elevation to the nearest tenth of a meter. This is the amount of the stick which is above the assistant's hand when it is directly in the surveyor's line of sight. The recorder reads the elevation and writes it down on the Gradient Data Sheet at the appropriate distance of that station.

6. Now the team moves to the next station along the transect line. If the beach is not too steep, the surveyor stays at 0, while the team moves up to the next station. If the beach is steep, the surveyor can move to the 1st station, but ensure to add the height of station one to the newly measured height.

7. Continue taking elevations until the team reaches the higher end of the transect line and the Gradient Data Sheet (see next page) is filled in.

Gradient Data Sheet

Team members: Recorder ______________________

Surveyor ______________________

Assistant ______________________

Date ______________________ Location ______________________

Time ______________________ Low Tide ______________________

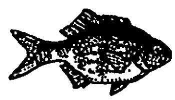
Distance from water's edge (meters)	Elevation (meters)	Time

Some Interesting Seashore Investigations with Zonation

1. Try running the same transect or grid at different times of the year, i.e., spring, summer, autumn, winter.

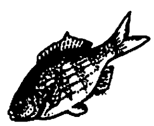
2. Compare the zonation on a rocky beach, a sandy beach, and a muddy beach.

3. Choose a large boulder that faces the open, unprotected ocean. Compare transect or grids of both the side that faces the ocean (windward view) and the side that faces the land (leeward view). What possible inferences could account for such extreme variations?



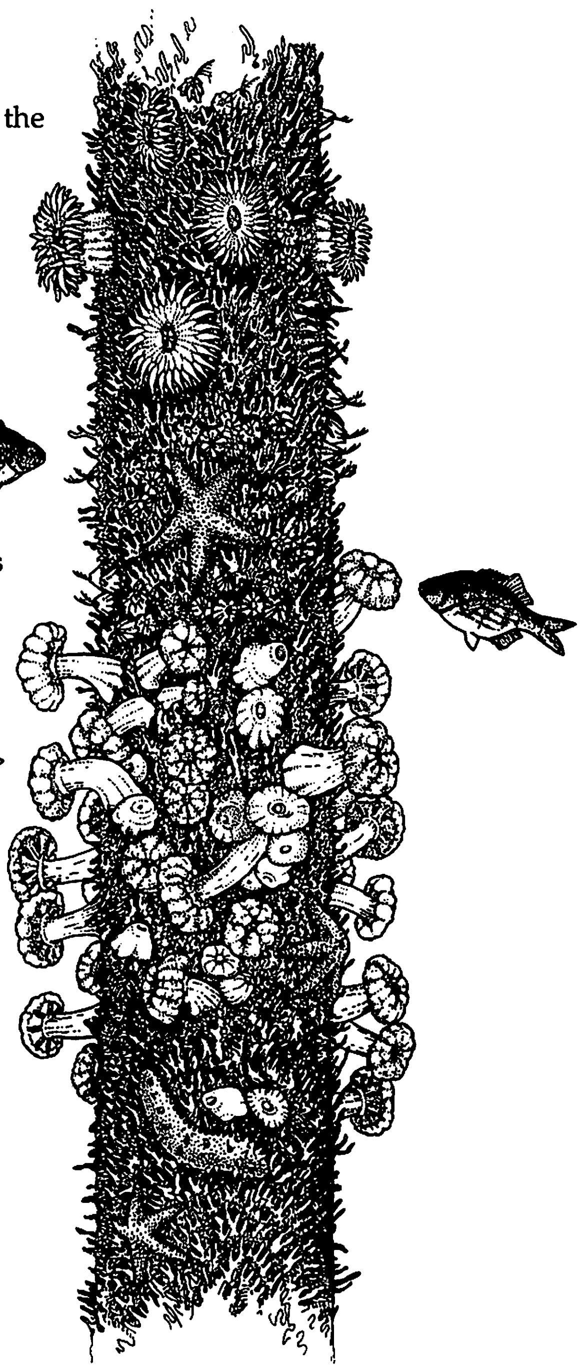
4. Dock pilings that have been placed in the middle tide zones show good examples of vertical zonation. Attach a rope to the top of the dock piling, and let it hang down the piling. Examine the animals one inch on either side of the rope. Map a dock piling. Describe the animals below your transect, still submerged in the water.

5. Compare a clean beach to a similar beach after an oil spill or similar mishap.



6. Compare transects or grids near a pulp mill, boat marina, a sewage disposal pipe, a tourist area.

7. Stream Study: Locate a freshwater stream that runs into the ocean. Conduct a horizontal zonation study of the stream. Starting in freshwater well above the high tide level, mark off grids.



A Rocky Shore is a High-Rise Building Metaphor

As a follow-up to the study of zonation, the students can explore the metaphor "A rocky shore is a high-rise building." One way to proceed is to show the students the overhead transparency of the "Rocky Shore," or have the students respond to their own rocky shore mural. Tell the students that they're going to compare a rocky shore to a high-rise building. Suggest that such comparisons are easy (even fun) to think about and allow for imaginative explanations. Tell the students that there are no incorrect responses. They are to let their creative imaginations flow. Write the following metaphor question on the blackboard.

If a rocky shore (or dock piling) were a high-rise building, what would be its:

- Foundation
- 1st floor
- 2nd floor
- 3rd floor
- 4th floor
- Top floor (penthouse)
- 1st-floor residents
- 2nd-floor residents
- 3rd-floor residents
- 4th-floor residents
- Top-floor residents
- Floor decorations
- Rooms, hallways
- Apartments
- Elevators
- Furnace
- Air conditioner
- Janitors
- Manager

Why?

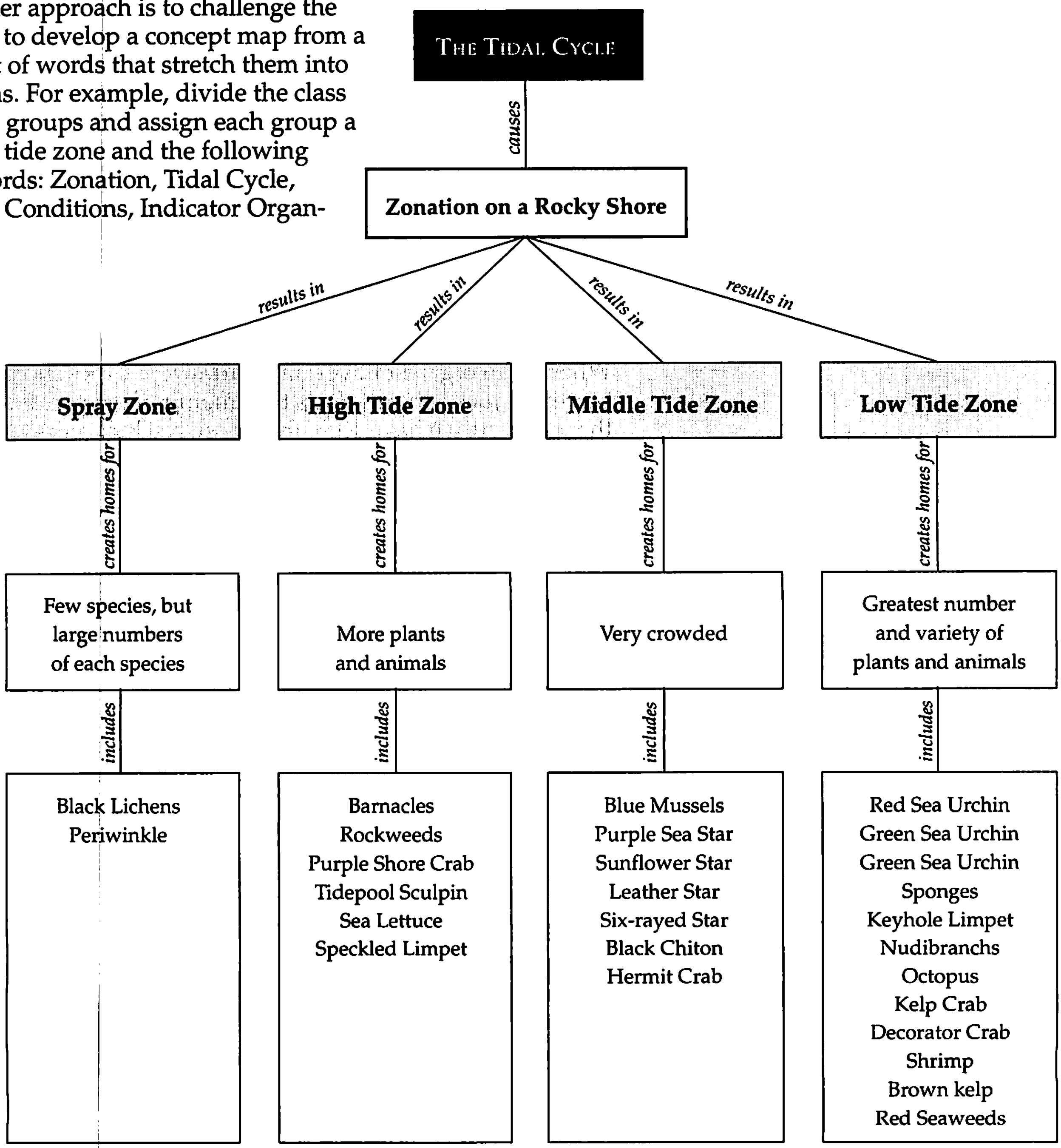
Would a resident be able to move from the 1st floor to the 4th floor? Why or why not?

Be prepared to accept a wide range of possible responses. Ask "Why?," "What?," and "When?" questions at every turn. What would be the rooms? Let's make a list of different kinds of rooms. Who would be the janitors? Why? What have you observed that leads you to that conclusion? Try to lead the students through thinking activities that allow them to "experience" and "understand" the rocky shore in new ways.

Zonation Concept Map

After the students have had several experiences with the concept of zonation, have them make a concept map of their ideas about zonation. One way to begin is to write the word "zonation" on the blackboard. Ask the students to close their eyes and recall their trip to the rocky shore, then brainstorm words and images that come to mind. The zonation mural (if constructed) is another good way to get them started. As the students talk, put their words onto 4 x 5" cards. From the words and images, challenge the students to use connecting words and phrases to arrange and rearrange the words until they tell the story of zonation. The concept map below was developed by a group of fifth-grade students.

Another approach is to challenge the students to develop a concept map from a given set of words that stretch them into new areas. For example, divide the class into four groups and assign each group a different tide zone and the following set of words: Zonation, Tidal Cycle, Limiting Conditions, Indicator Organisms.



Limiting Factors for the Rocky Shore

Concepts

1. Limiting factors influence the ability of an organism to survive; e.g., food, water, shelter, space, pollution.

2. Physical factors such as temperature, desiccation (drying out), and salinity set the upper limit of how far up the shore a particular species of plants or animal can live.

3. Competition for food and space set the lower limit of how far down the shore a particular species of plant or animal can live.

Understandings

The students will be able to 1) brainstorm limiting factors for the rocky shore, 2) identify limiting factors for each tide zone, and 3) develop a concept map for limiting factors that includes the tide zones.

Teacher Information

As we have seen, several factors affect life in the marine environment. Some of these are natural; that is, these physical factors are in the marine environment regardless of human activity. Among these are light, temperature, the salinity or salt content of the water, oxygen, the type of seashore, and the degree of wave shock.

The type of coastline affects life in the marine environment. Whether an organism lives on a surf-swept rocky shore or a protected rocky shore affects the amount of oxygen available in the water. As we have seen, the Goose Neck Barnacle and California Blue Mussels actually require the high oxygen content of a surf-swept rocky shore, and cannot survive on protected rocky shores. The type of seashore affects life in the marine environment. Whether an organism lives on a rocky shore or a sandy beach affects whether it's exposed to the drying effects of the dropping tide, or can burrow deep into sandy bottoms to keep wet. Thus, the type of habitat affects life in the marine environment.

The tide zone also affects life in the marine environment; whether the animal lives in the spray zone or the low tide zone affects the amount of time it's covered with seawater and exposed to the drying conditions of wind, air, and weather.

Procedures

1. What do human beings need to survive? Discuss the need for food, water, shelter, temperature control, clean air, protection from physical abuse, and so on.

2. Write the words "Limiting Factors for the Rocky Shore" on the blackboard. Brainstorm factors that might limit the ability of a plant or animal to survive on a rocky shore. In different words, what factors might put stresses on (or kill) plants and animals in the rocky intertidal? Write students' ideas on the blackboard.

3. Would the limiting factors be different for different locations on the shore, or for different tide zones? Why or why not?

4. Have the students stand back and observe the class mural of the rocky shore. Focus their thinking on the problems of survival in each tide zone. Write their ideas on the blackboard. Brainstorm as a class or in small groups the following questions.

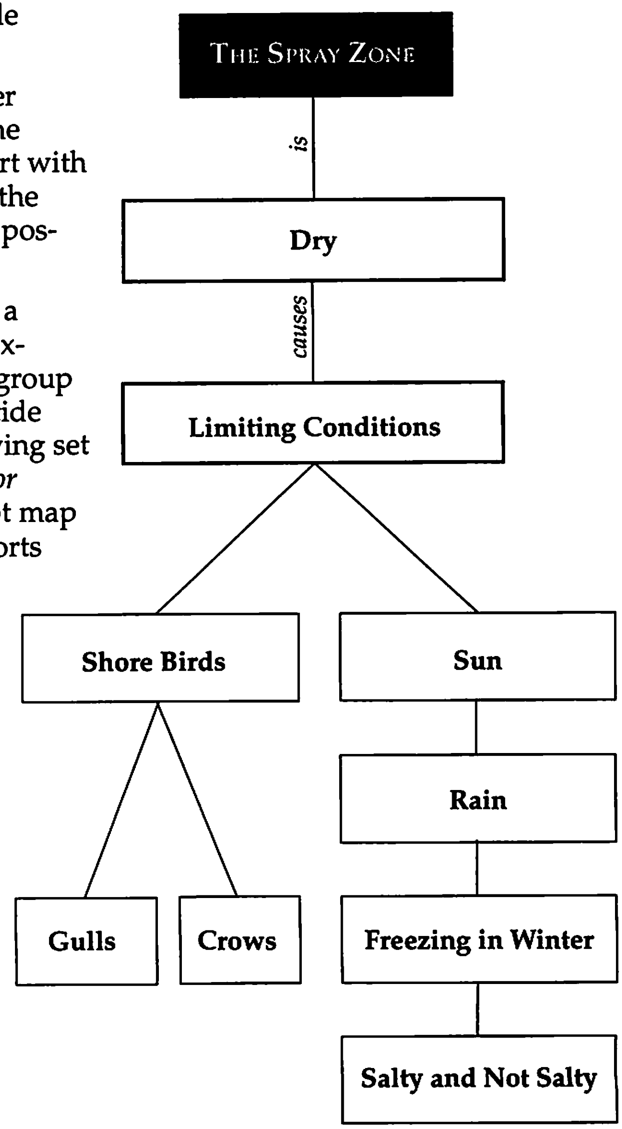
Basically, which tide zone(s) has:

- The greatest changes in temperature? (Spray zone.)
- The most constant temperature? (Low tide zone.)
- The greatest changes in salinity? (Spray zone.) The least? (Low tide zone.)
- The greatest variety of organisms? (Low tide zone.)
- The greatest population of plants and animals? (Low tide zone.)
- The greatest competition for space? (Middle and low tide zones.)
- The greatest competition for food? (Middle and low tide zones.)

5. Use a felt pen to make an outline chart on butcher paper similar to the one next page (or use the blackboard.) As the students make observations and inferences, fill in the chart with the students. For each tide zone, describe the location on the shore, the physical conditions, the limiting factors, and if possible, indicator organisms for the tide zone.

6. Challenge the students to develop a concept map from a given set of words that stretch them into new areas. For example, divide the class into four groups and assign each group a different tide zone: spray zone, high tide zone, middle tide zone, and low tide zone. Then give each group the following set of words: *Zonation, Tide Cycle, Limiting Conditions, Indicator Organisms*. They might use felt pens and put their concept map onto a large piece of butcher paper. After each group reports back to the class, they might think about similarities and differences between the maps. The concept map for the spray zone at left was developed by a group of sixth-grade students.

7. Would the natural factors that limit the distribution of organisms on a rocky shore be the same on a sandy beach? A mud flat? (No—many of the physical and biological factors would be different.)



Limiting Factors on a Rocky Shore

Zone	Location	Physical Conditions	Limiting Factors	*Indicator Organisms for the Rocky Shore
Spray Zone	From the highest reach of spray and storm waves to the average of all high tides	• Almost completely dry • Extreme temperature ranges • Extreme salinity changes • Sparsely populated by animals • Can be exposed to extreme storms, wind, and surf	Drying out	• Sparsely populated by plants and animals • *Black Lichens • *Periwinkles
High Tide Zone	Normally uncovered except during extreme high tides	• Great deal of changes in temperature, water, and salt content • Can be exposed to a great deal of surf pounding	Drying out	• Great numbers of barnacles, limpets, and snails • Frequently called the "barnacle zone" • *Common Acorn Barnacle *Sea Lettuce *Rockweeds
Middle Tide Zone	Typically covered and uncovered twice each day	• Changes in temperature and salt content are less because of longer periods covered with water • Plants and animals have accustomed themselves to, and may require, the rhythm of the tides	Competition for food Competition for space	• Mussel beds • *Blue Mussel *Purple or Ochre Sea Star *Rockweeds *Sea Sac
Low Tide Zone	Always covered except during the very lowest tides	• The most constant region • Few changes in temperature, exposure, or salt content • The greatest variety of species • The most heavily populated by plants and animals	Competition for food Competition for space	• Very crowded • Most plants and animals are unable to exist higher up than this zone • *Any of the sea urchins *Giant Green Sea Anemone *Brown Kelp

Adaptations of Rocky Shore Animals

Concepts

1. Marine plants and animals must have special adaptations to survive in particular habitats.

2. Structural adaptations include body parts or structures that help an organism survive; e.g., heavy shells or durable coverings; wide, muscular foot; streamlined shape; strong attachment devices.

3. Behavioral adaptations include hiding under rocks, speed, and aggression.

Understandings

The students will be able to 1) brainstorm adaptations of rocky shore organisms, 2) classify adaptations as behavioral or structural, 3) identify physical characteristics of different habitats, 4) identify adaptations of the on-rock habitat, and 5) sketch adaptations of rocky shore organisms.

Materials

The following Pacific Coast Information Cards:

Common Acorn Barnacle
Sea Sac
Wrinkled Whelk
Tidepool Sculpin
Northern Abalone
Aggregate Sea Anemone
Black Chiton
Checkered Periwinkle
Common Purple or Ochre Sea Star
Rockweed
Speckled Limpet
Red Sea Urchin
Bay Mussel

Transparency: "Adaptations of Organisms That Live on Rocks"

Teacher Information

Although the seashore is a harsh environment, all plants and animals are protected in a great variety of ways. An adaptation is how the plant or animal is specially equipped to survive in its environment. Some adaptations are behavioral; e.g., a crab that crawls under a rock to escape predators and the drying sun. Some adaptations are structural; e.g., the large, rootlike holdfast that attaches kelp to rocks.

Life on the Rocks

Animals that live on rocks have thick shells to lessen water loss and wave shock, strong attachment devices, and cone-shaped or streamlined bodies to allow the waves to rush over them.

The Checkered Periwinkle has adapted well to the high tide region. Its shell is thick to lessen water loss, and the opening to the shell is small—which also decreases water loss. It has a little trap door called an "operculum," which closes when the snail retreats to create a moist chamber when the tide goes out. It's so well adapted that it can stand exposure to the air for over a month. In fact, Checkered Periwinkles have been known to survive out of seawater for up to 200 days.

Barnacles have thick shells to lessen water loss. Their five cover plates let air in through an opening that is small enough to prevent serious water loss. As adults, they're firmly cemented to rocks, and their pointed, streamlined shapes allow water to flow over them.

Limpets create a powerful suction with their wide, muscular foot. Their cone-shaped shells allow heavy surf to rush over them. When the tide goes out, the suction seals the moisture inside the shell-house.

Mussels have hard, streamlined shells that create a moist chamber inside when the tide is out. Strong, plastic-like byssal threads anchor the animal to the rock.

Rockweeds have a strong rootlike structure called a holdfast that anchors them to rocks. Bull Kelp and Giant Kelp have massive tangled holdfasts which anchor them firmly to the rocks.

Purple or Ochre Sea Stars and sea urchins have hundreds of tube feet that create a powerful suction. Sea urchins use their long, sharp spines to dig into crevices. Sea anemones have a powerful disc that holds onto rocks. The saclike covering that envelops their body is a durable, plastic-like material that protects the animal from abrasive sand and from drying out.

Mussels, barnacles, and Aggregate Anemones frequently cluster together. This overlapping helps to reduce water loss, and creates a firm attachment to the rock.

Procedures

1. Review the types of habitats and the physical characteristics of rocky shore habitats. Emphasize the concept that physical conditions can vary greatly within the distance of a few centimeters; e.g., on rocks, underneath rocks, in crevices, in tidal pools, among seaweeds, and even in sand or mud.

2. Lead a discussion that encourages students to think about the problems of survival on a rocky shore. Brainstorm in small groups the following questions:

- At high tide, or when in seawater, what are all the hazards of living on a rocky shore? (Wave shock, marine predators, being swept out to sea by the outgoing currents, being pinned under rocks or logs moved by currents.)
- At low tide, or when out of seawater, what are all the hazards of living on a rocky shore? (Desiccation or drying out, freezing in winter, changes in salinity, shore predators.)

3. Review the concept of adaptation—how organisms are specially equipped to survive in particular habitats. Brainstorm answers to the following questions:

- When the tide goes out, how can rocky shore organisms keep from being swept out to sea? Or, when storms occur, how can they keep from being swept away by strong currents and heavy surf? Discuss barnacles, mussels, limpets, chitons, sea stars, sea urchins, seaweeds.

- How many different ways do rocky shore plants and animals attach to rocks? Discuss barnacles, mussels, limpets, chitons, sea stars, sea urchins, seaweeds.
- At low tide, or when out of seawater, how do rocky shore animals keep from drying out? How do they maintain moisture, or find wet hiding places? How do they survive temperature changes? Discuss barnacles, mussels, limpets, snails, sea stars, sea anemones, crabs, Tidepool Sculpins, seaweeds.
- What happens when an animal becomes pinned down by a rock moved by currents? Do any rocky shore animals have special adaptations that would help them survive being pinned down by a rock or predator? Discuss sea stars and crabs.

4. Tell the students that there are two kinds of adaptations: "behavioral" adaptations and "structural" adaptations. Write these words on the blackboard. What is an example of a behavior that would help a Purple Shore Crab to survive? (Hiding under a rock at low tide.) What is an example of a structure or body part that would help an animal survive? (The crab's hard outer shell, its pincers and claws.)

5. Divide the class into groups of two or three. Each group should use the Pacific Coast Information Cards to discuss one organism in detail, whether the organism's habitat is on rocks or under rocks, the characteristics of the habitat, and how the organism is equipped to survive the conditions of its habitat. They should attempt to identify the adaptations as behavioral or structural. As each group reports back to the class, you fill in the "special adaptations" section on the chart (see next page).

6. Engage the students in a discussion about adaptation to a specific type of habitat. Use the transparency "Adaptation of Organisms that Live on Rocks" to discuss adaptations of plants and animals that are permanently attached to rocks.

7. Summarize the discussion. Review the importance of leaving organisms in their own particular habitat because each plant and each animal is specially adapted to survive in its own habitat.

Enrichment Activities

1. Students could sketch one organism and tell how the organism is specially adapted to survive on a rocky shore. What special structures does it have? How do these special structures or behaviors help it to survive? Students could make a clay model emphasizing how a rocky shore animal is adapted to its habitat.

2. Summarize the discussion. Discuss possible metaphors as simple comparisons; e.g., the tube feet of sea stars are like bathroom plungers, a barnacle attaches to rocks like cement, a mussel's byssus threads are like ropes anchoring it down. The masses of Rockweeds create a seaweed curtain. (See "Community Metaphors," pages 85–90)

Rocky Shore Adaptations

Name of Animal	Structural Adaptation	Behavioral Adaptation
Common Acorn Barnacle	Hard, moisture-filled shell; five cover plates; cement attachment; pointed and streamlined	Withdraws into its shell
Purple Shore Crab	Hard, protective shell; flattened wedge shape; can regenerate legs, pincers	Hides under rocks, in crevices, and in tidepools
Limpets, chitons, abalones	Hard, protective shell; wide, muscular foot creates a powerful suction, keeps moisture in; low and streamlined	Hides in crevices, under seaweeds, in tidepools
Tidepool Sculpin	Has ability to change its colors to suit its surroundings; walking fins; big, sharp teeth	Slips into tidepools, swims out to sea with outgoing tide, hides under rocks in tidepool

Rocky Shore Adaptations

On Rocks: Exposed to Sun, Rain, Wind, Weather at Low Tide

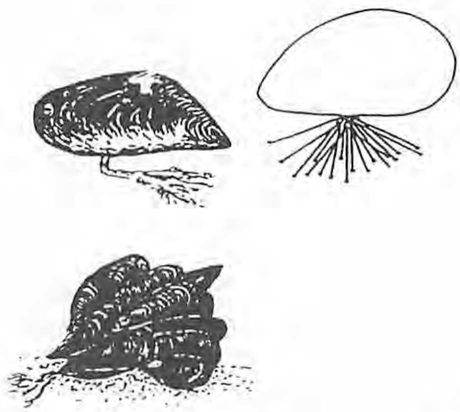
Name of Organism	Adaptations To Habitat
Common Acorn Barnacle	Hard, moisture-filled shell-house; five cover plates; cement attachment; streamlined
Edible Blue Mussel	Hard, moisture-filled shell-house; hard byssus thread "ropes" anchor the mussel to rocks; clustering to keep wetness in; streamlined shape
Limpet, chitons, abalone	Hard, moisture-filled shell-house; wide, muscular foot creates a powerful suction; low, streamlined to let water surge over it
Sea Urchins	Hard, moisture-filled shell-house; tube feet and long, sharp spines to dig into crevices; regenerates spines
Purple or Ochre Sea Star	Hard, spiny body; tube feet create suction cups; able to regenerates arms
Checkered Periwinkle, Wrinkled Whelk	Hard shell house; operculum for a trap door to seal moisture in; seals itself to rocks with mucus; moves to a suitable environment
Rockweed, Bull Kelp	Rootlike holdfast; thick, moisture-filled fronds to keep wetness in; gas-filled bladder buoys plant toward surface
Aggregate Sea Anemone	Muscular disc for attachment; strong, plastic-like outer covering; clustering to keep wetness in
Sea Sac	Water-filled saclike structure; strong attachment or holdfast

Adaptations of Rocky Shore Organisms

Sketch of Organism	Type of Habitat	Adaptation to Habitat

Adaptations of Organisms that Live on Rocks

(A) Thick, protective shells
(B) Attachment devices
(C) Streamlined
(D) Regenerate body parts
(E) Moisture-filled shell or sac
(F) Clustering



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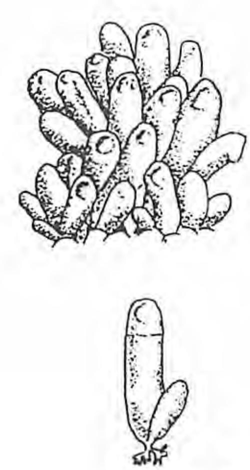

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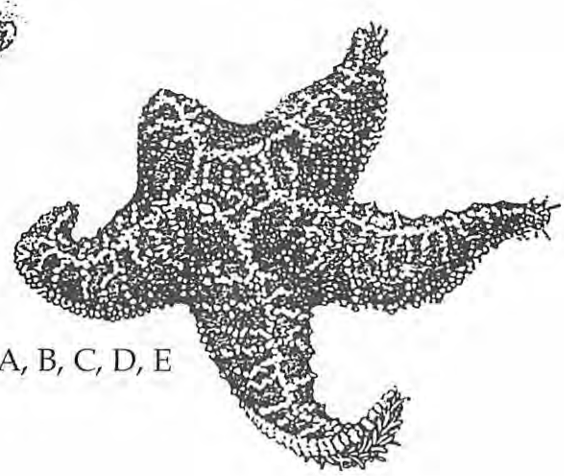

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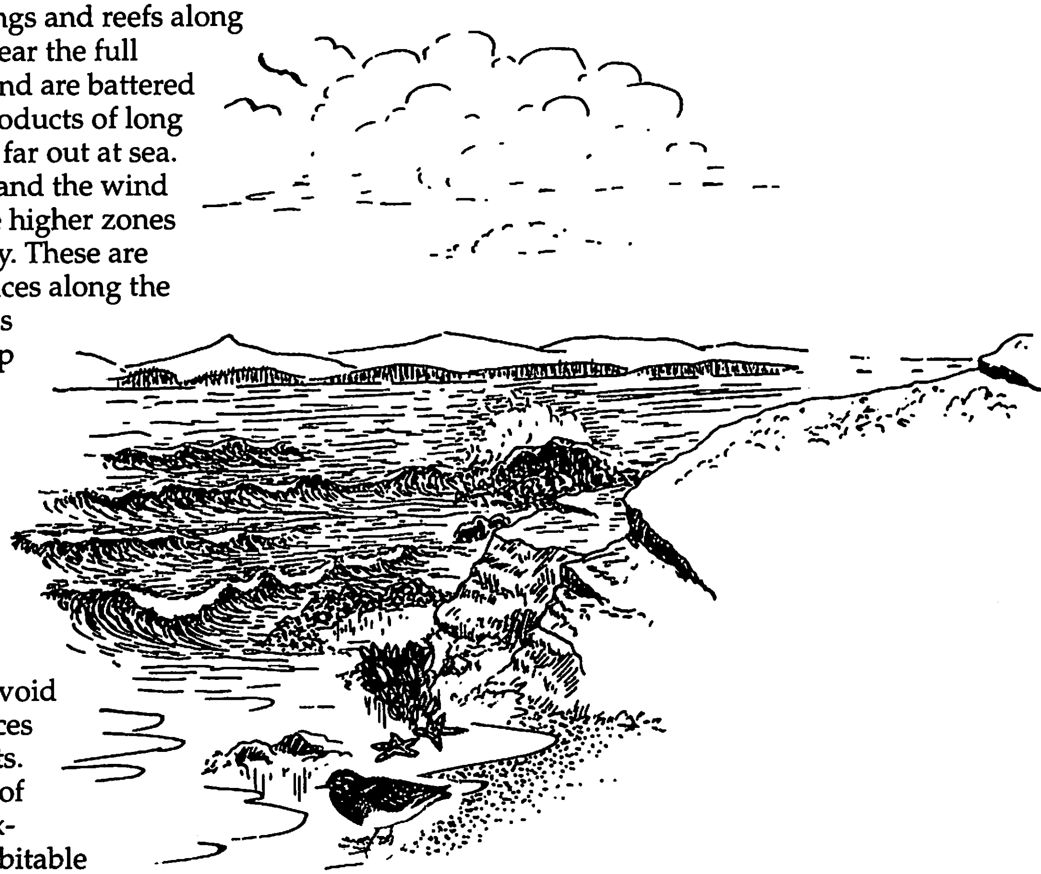
The Surf-Swept Rocky Shore



The rocky outcroppings and reefs along the unprotected coast bear the full brunt of storms at sea and are battered by great waves—the products of long ocean swells generated far out at sea. The force of the waves and the wind is so great that even the higher zones are drenched with spray. These are the most dangerous places along the open coast. Large waves can unexpectedly sweep a person to sudden death. When exploring the seashore with students, you should know an exposed area—or at least observe it for awhile from a safe vantage point before venturing out—and you should avoid dangerous-looking places altogether with students.

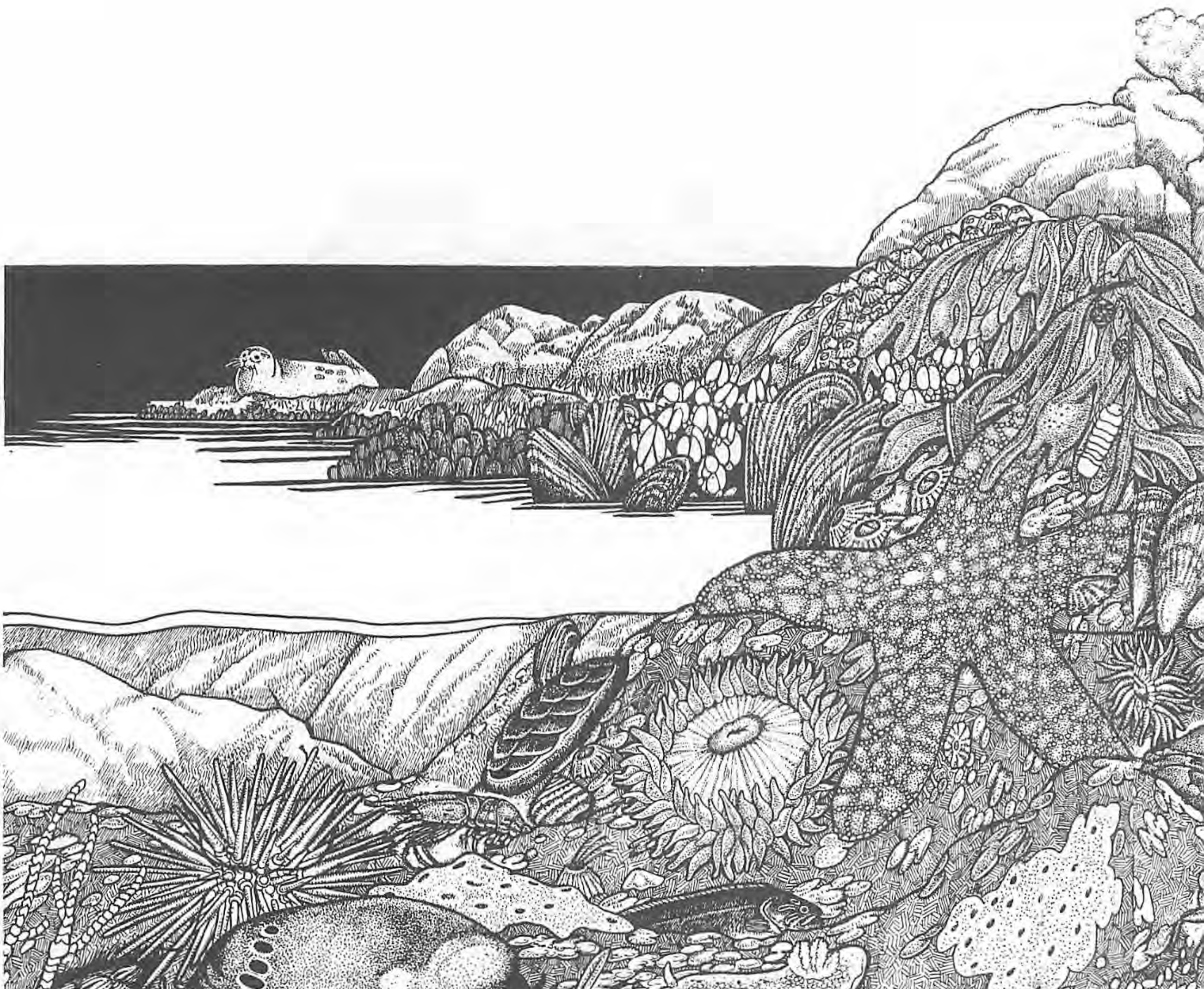
Although the action of the waves makes the exposed coastline uninhabitable to many creatures, it does not much decrease the quantity of organisms. Indeed, by bringing in a rich store of nutrients and food, and by making it difficult for predators and competitors, waves may greatly benefit those that can put up with the harsh conditions. Though by no means as rich in animals as partially protected shores, the open coast supports a distinctive and characteristic assemblage of animals that either require surf or have learned to tolerate it. Nonetheless, a certain amount of adjustment is necessary, and the importance of wave shock here is revealed in the structure and life style of both animals and plants.

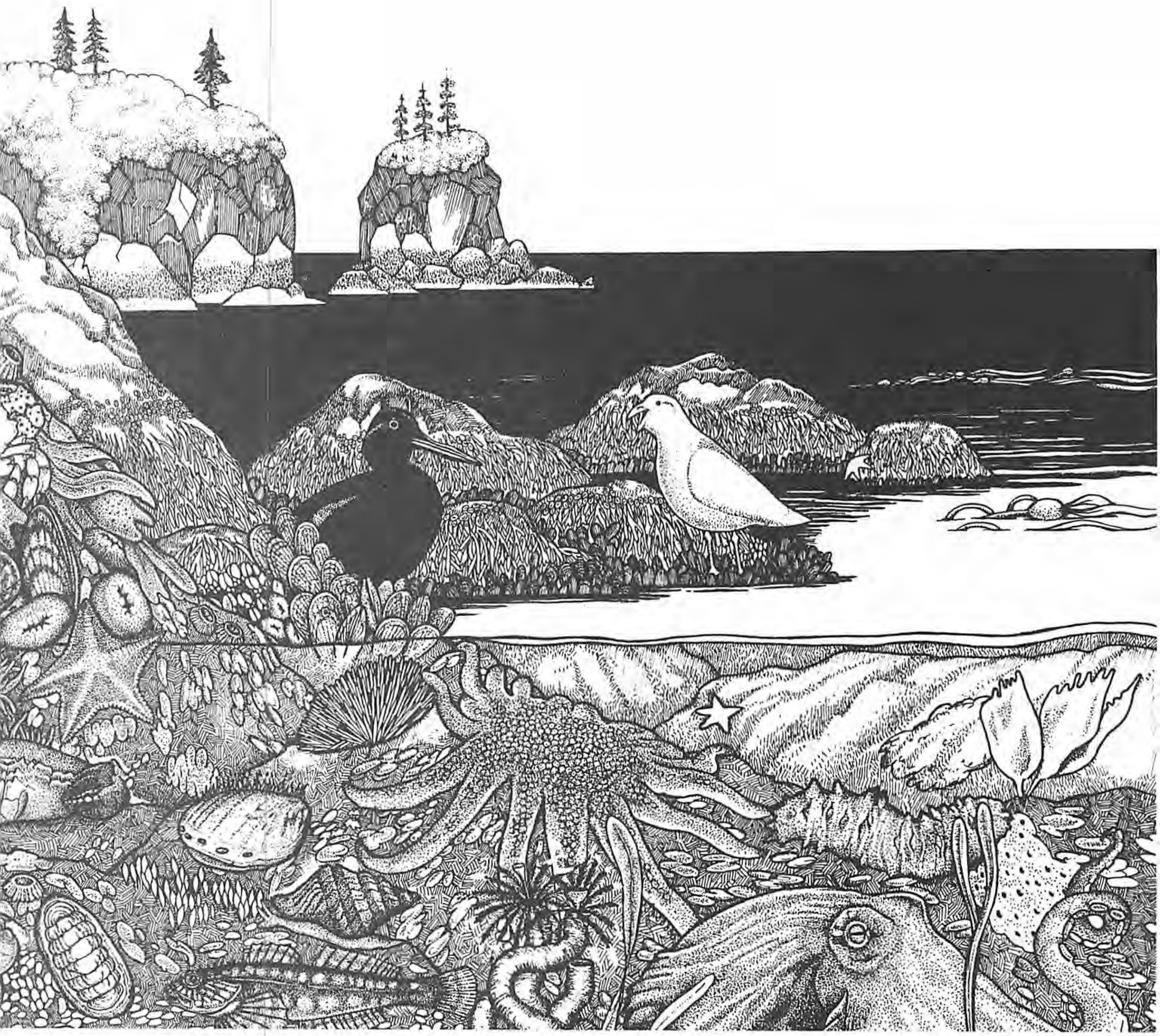
Procedures

1. Recall the names of rocky shore animals and seaweeds identified on your field trip. Write these on the blackboard.

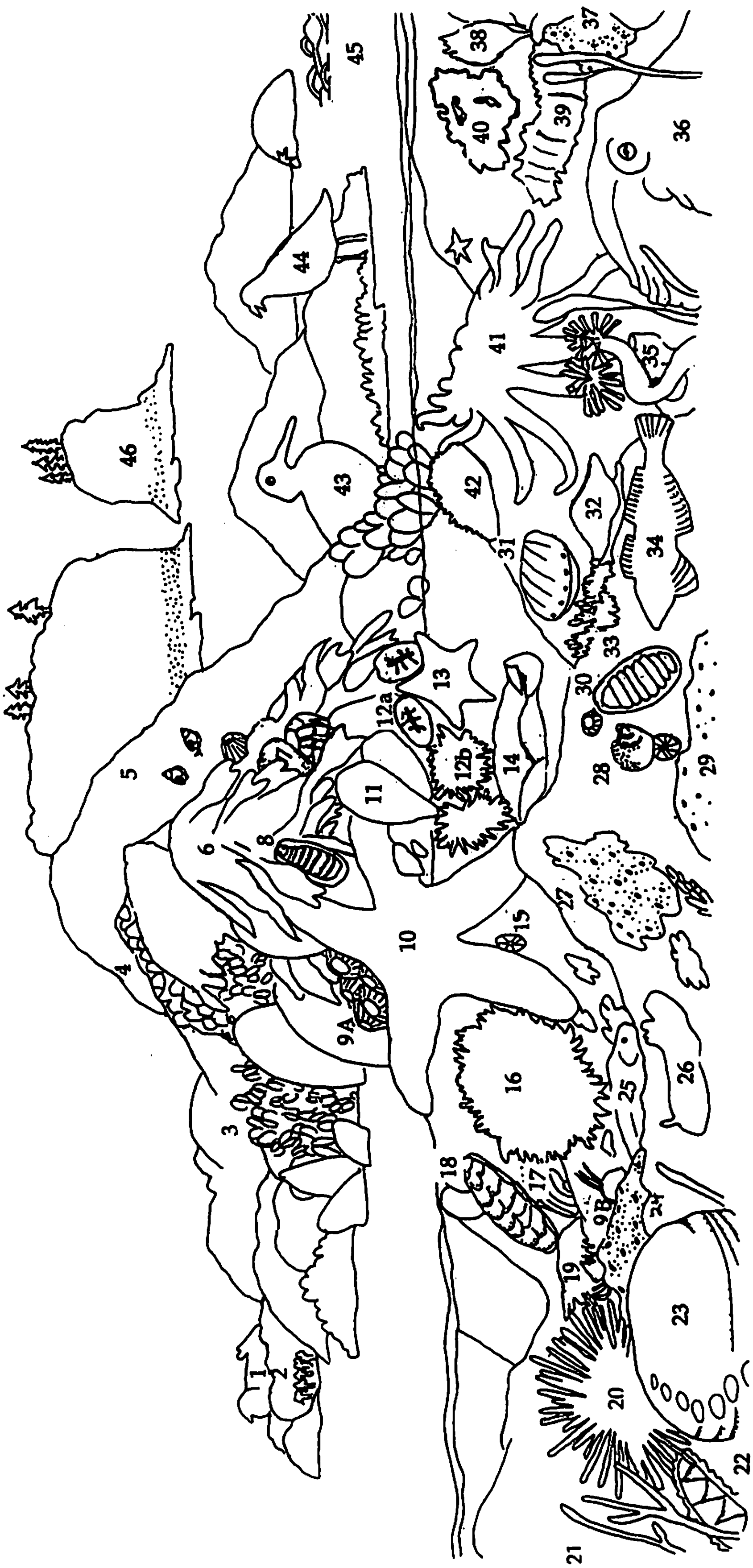
2. Make photocopies of the "Surf-Swept Rocky Shore" handout, pages 218–219, and color key. Use water colors or colored pencils and the color key to create a realistic rocky shore scene. Engage the students in a discussion emphasizing the great variety and numbers of rocky shore organisms.

3. From the students' observations at the seashore, and by identifying predator-prey relationships illustrated in the photocopies of "the rocky shore," challenge the students to construct a food web for the rocky shore. (See answer key, page 220–221.)





Rocky Shore Key



Color Key to the Rocky Shore

1. Harbour Seal—tannish gray-brown with dark spots above
2. Sea Palm—olive green
3. Goose Neck Barnacle—white cover plates with bluish-black necks
4. Small Acorn Barnacle—white or light gray
5. Checkered Periwinkle—dark bluish-gray or black
6. Rockweed—olive green
7. Purple Shore Crab—reddish or reddish-purple, purple dots on pinchers
8. Rockweed Isopod—olive green

9a/b Thatched Acorn Barnacle—white or light grey

10. Purple or Ochre Star—bright purple, bright orange, or brownish orange
11. California Blue Mussel—shell is dark blue, brown, and black

12a/b Pink-tipped Anemone (closed up)—greenish with pink-to-purple-tipped tentacles

13. Leather Star—a mottled green-gray and brownish-red upper surface
14. Red Rock Crab—a deep red to dark reddish brown, with black-tipped claws
15. Finger Limpet—brown colored shell with fingerlike white patches
16. Giant Green Anemone—bright green
17. Rock Whelk—usually white shell with variously colored yellow, orange, brown, or black lines
18. Black Chiton—white plates on a black background
19. Broken-back Shrimp—olive green, or reddish brown
20. Red Sea Urchin—bight red
21. Graceful Coral Seaweed—bright pink or pinkish purple
22. Mossy Chiton—dark brown or bluish-black cover plates with mossy green or brown bristles
23. Northern Abalone—dark reddish-brown or reddish-black shell
24. Encrusting Green Sponge—dull mossy green
25. High Cockscomb Blenny—a combination of browns, blacks, grays, and greens with designs or stripes running the length of the body
26. Sea Lemon (Nudibranch)—bright yellow
27. Encrusting Purple Sponge—dark purple
28. Hairy Hermit Crab—a dark brown body with white or blue band around the base of the legs
29. Encrusting Golden Sponge—dull yellow
30. Lined Chiton—variously colored with brown lines zigzagging across a field of yellow, pink, and lavender blue or green
31. Pink Scallop—broad pink and white bands radiating from center
32. Wrinkled Whelk—shells may be white, yellow, orange, brown or grey
33. Wrinkled Whelk eggs (sea oats)—shell may be white, yellow, orange, brown, or gray, or a combination of colors. Large clusters of yellow egg cases in summer.
34. Tidepool Sculpin—variously colored black, brown, or green along with some white
35. Calcareous Tube Worms—white tubes, bright red tentacles
36. Pacific Octopus—yellow eyes, body may be reddish or brownish with fine black lines, the color changeable
37. Encrusting Red Sponge—bright red
38. Sea Lettuce—bright emerald green
39. Giant California Sea Cucumber—reddish-brown or orangish-brown skin
40. Rockcrust Seaweed—reddish-pink or pinkish-purple
41. Sunflower Star—bright pink, purple, or orange
42. Purple Sea Urchin—bright purple
43. Oyster Catcher—jet black feathers, pink legs and feet, bright red bell, golden eyes
44. Glaucus Gull—white head, pale gray mantle, yellowish bill with a red spot, flesh colored legs
45. Bull Kelp—olive brown
46. Black Lichens—black

Adaptations of Surf-Dwelling Rocky Shore Organisms

Concepts

1. Surf-dwelling organisms must have special adaptations in order to survive.

2. Surf-dwelling adaptations include: thick shells, strong attachments, clustering, flattened or streamlined shapes, and living in protective depressions.

Sea Palm

Understandings

The students will be able to 1) identify surf-swept rocky shores and protected shores, 2) describe adaptations of surf-dwelling organisms, 3) name "indicator organisms," and 4) invent an adaptation for a surf-dwelling organisms.

Materials

The following Pacific Coast Information Cards:

California Blue Mussel	Sea Palm
Northern Abalone	Gooseneck Barnacle
Purple Sea Urchin	Bull Kelp
Black Chiton	Purple or Ochre Star

Transparency: "Adaptations of Surf-Dwelling Rocky Shore Organisms"

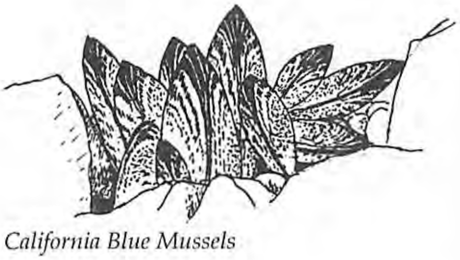
Gooseneck Barnacle

Teacher Information

Waves on surf-swept outer coastlines are important in determining the collections of shore populations. Waves not only exert crushing forces on rocky shore organisms, but also scour rocks and living organisms with sand and shifting sediments such as sand and cobble.

Seaweeds such as the striking Sea Palm can tolerate heavy surf conditions by developing large and rugged holdfasts which anchor them firmly to rock surfaces; by growing in clusters of their own kind; and by developing tough, rubbery stems which whip back and forth with the surf, much like a rubber hose.

Some organisms such as the California Blue Mussel and the Gooseneck Barnacle actually require the high oxygen conditions created by heavy surf. These mussels and barnacles often grow in close association, forming a distinct community of the outer coast shore. Compared to the bay mussel of more protected shores, the California Blue Mussel has much thicker shells and is much larger in size. Its strong byssus threads firmly anchor it to the rocks. Like the Sea Palm, the Gooseneck Barnacle has a long, rubbery stem which whips back and forth with the surf. The mussel and the Gooseneck Barnacle cluster together in depressions, their heavy mass creating further stability against wave action.



California Blue Mussels

The Purple Sea Urchin, unlike the Red Urchin or the Green Urchin, favors rough water and creates its own unique micro-habitat in stone by gradually wearing down the rock over the years to create a hollow in which it can safely weather even the most pounding surf. Only the abrasive action of the long, sharp spines forms the hollow. So effective is this mode of protection that one is convinced that the urchin had sealed itself into a self-created prison for life. Food for the imprisoned urchin appears to be mostly drift seaweeds, captured by the tube feet.

Chitons, limpets, and abalone are specially adapted to survive the pounding surf by their low, flattened bodies and streamlined shapes. These organisms also have large, fleshy, muscular feet, which create a powerful suction to anchor them to the rocks.

The wide-ranging Purple or Ochre Star remarkably clings to wave-swept rocky shores just below the mussel beds. This tenacious sea star sports a tough, slimy body and is quite capable of creating a surprisingly powerful grip with its hundreds of sucking tube feet.

Procedures

1. Show the students a picture of a surf-swept rocky shore. Ask the students whether this would be a safe place to explore tidal pools. Why would this not be a safe place to explore? (Unpredictably high waves, powerful waves, shifting boulders, shifting logs, being swept out to sea.) Brainstorm signs of a surf-swept rocky shore. Tell the students that today they're going to learn how to identify a surf-swept shore and that this knowledge might someday save someone's life.

2. Brainstorm problems of survival for surf-dwelling organisms on a rocky shore. (High waves, strong powerful waves, shifting boulders, abrasive sand and gravel, shifting logs, being swept out to sea.) Emphasize that surf-dwelling organisms must survive many of the problems that could easily kill people. In addition, these hardy organisms must survive the abrasive action of moving sand and gravel.

3. Collect pictures of rocky shores. Compare pictures of wind-swept trees on exposed rocky shores, and trees on protected rocky shores. Windswept trees are often short and stubby and appear to have a rather severe "hair cut" that slants upward from the open ocean.

4. Ask the following question: Imagine yourself looking into a tidal pool on a surf-swept rocky shore. You kneel down to get a closer look at the beautiful seaweeds and brightly colored sea stars. Suddenly you look up and see that a huge wave is about to wash over you. What would you do? Would you run? Why or why not? What else might you do? Lead the students to realize that if the wave is too close, and they attempt to run, the wave would simply wash them into the sea. Sometimes the best thing to do is to crouch down and make yourself as small and as low as possible, like a barnacle or sea star. Attempt to hold onto or straddle a rock, or even seaweeds. Let the wave simply

wash over you. Then run for safety. Stress the fact that they should NEVER explore near a surf-swept shore without a knowledgeable adult, and then ONLY WITH GREAT CAUTION!

5. Some people believe that every seventh wave is the largest, and that those in between are safer. Is this true? Discuss the fact that waves on an exposed shoreline are highly unpredictable. Sometimes several high waves follow in succession. They should never turn their back to the sea unless they're very familiar with the wave action of the area.

6. Brainstorm ways that rocky shore animals could survive on a surf-swept shore. (Being small, streamlined, heavy, etc.) Emphasize that some rocky shore animals are better equipped to survive heavy surf than other rocky shore animals. Think of rocky shore animals that are specially adapted to survive heavy surf.

7. Ask selected students to read the Pacific Coast Information Cards listed above. They should look for ways these organisms are specially equipped to survive heavy surf. Project the overhead transparency, "Adaptations of Surf-Dwelling Rocky Shore Organisms." Ask the class to infer how the organisms survive in heavy surf.

8. Tell the students that Sea Palms, Gooseneck Barnacles, and Purple Sea Urchins are considered to be "indicator organisms," that is, they're specially suited for living in the violent surf-swept world of exposed shores. **Students should avoid shores with these organisms.**

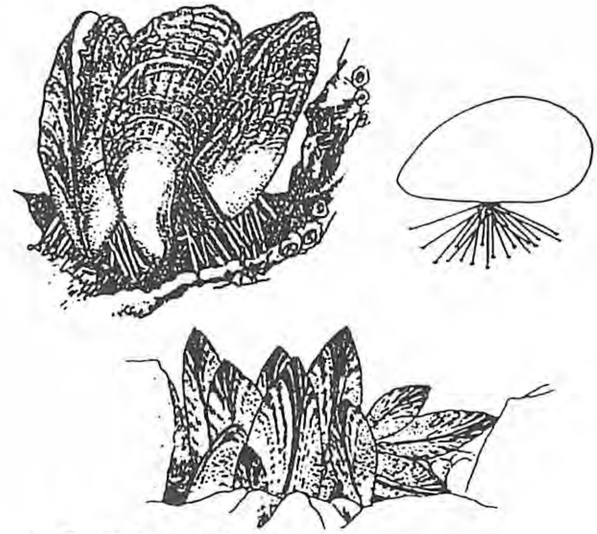
Enrichment Activities

1. Invent adaptations for surf-dwelling rocky shore organisms.

2. Invent a plant or animal specially equipped to survive the surf-swept rocky shore. Draw a picture of the organism. Give the organism a name. Tell how the organism is adapted for life in heavy surf.

Adaptations of Surf-Dwelling Rocky Shore Organisms

(A) Thick shells
(B) Strong attachment devices
(C) Clustering together
(D) Flattened or streamlined
(E) Flexible, rubbery stems
(F) Protective depressions
(G) Large size



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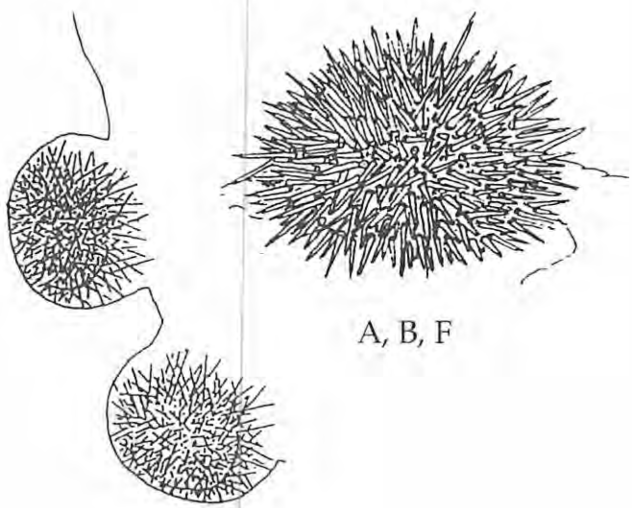

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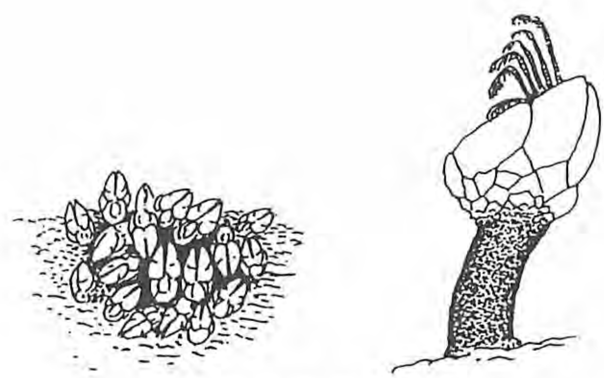

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Chapter 7: The Cobblestone Beach

1. Cobblestone beaches protected by inlets and bays have little wave action.

2. On the Pacific coastline, glaciers retreated 10,000 years ago, leaving behind cobblestone beaches along the Inside Passage of Alaska and British Columbia, and south along the Puget Sound in Washington.

Understandings

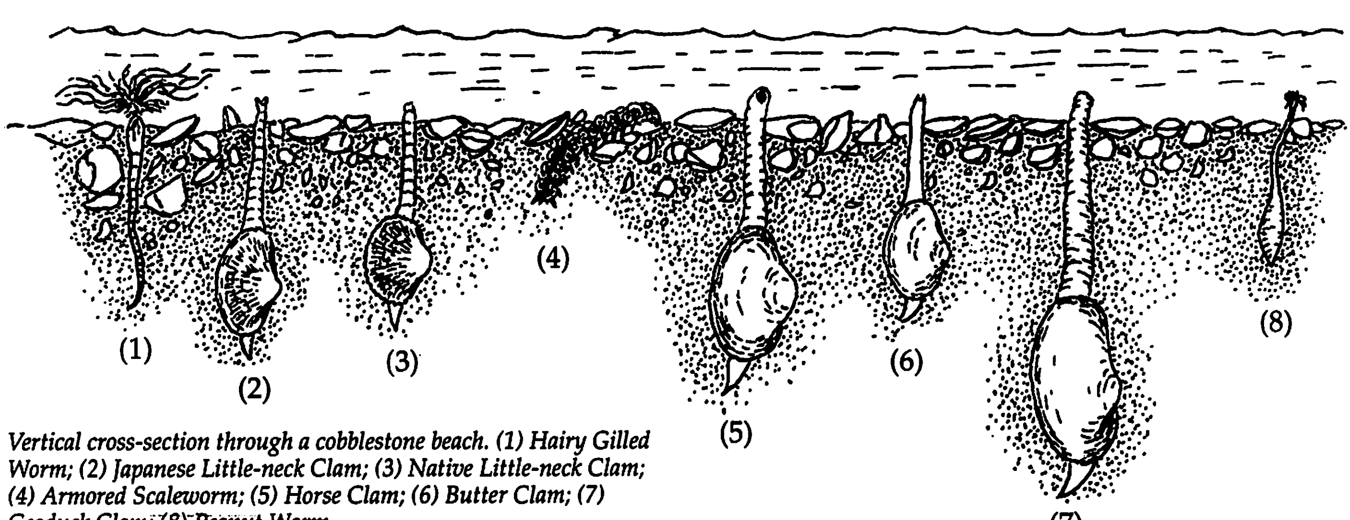
The students will be able to 1) map the location of cobblestone beaches along the Pacific coastline, 2) distinguish between boulders, cobblestones, gravel, sand, and mud particles; 3) infer the hazards of a cobblestone beach, and 4) infer how organisms are adapted to live on a cobblestone beach.

Materials

Transparency: "The Cobblestone Beach"

The following Pacific Coast Information Cards:

Brittle Star	Porcelain Crab
Purple Shore Crab	Northern Cling Fish
High Cockscomb Blenny	Calcareous Tube Worm
Horse Clam	Armored Scaleworm
Pea Crab	Orange Sea Cucumber
Butter Clam	Hairy Gilled Worm
Clam	Flat Worm



Vertical cross-section through a cobblestone beach. (1) Hairy Gilled Worm; (2) Japanese Little-neck Clam; (3) Native Little-neck Clam; (4) Armored Scaleworm; (5) Horse Clam; (6) Butter Clam; (7) Geoduck Clam; (8) Peanut Worm.

Teacher Information

Cobblestone beaches, protected by inlets and bays, have little wave action. These beaches are very different from those of the outer coast: the cobblestones are smooth and round and much larger, often between 10 to 30 cm in diameter. Often a stream deposits loose gravel mixed with sand and mud, and because the wave action isn't enough to carry the mixture out to sea, mixed sand and mud provides a stable bottom for plants and animals. On some beaches the tops of cobblestones teem with life, but the abrasive action of sand moved by water polishes the sides and bottom edges clean.

Don't confuse protected cobblestone beaches with those gravel beaches on rocky headlands on the outer coast. On the outer coast the strong wave action continuously tumbles stones until they become pulverized gravel, pebbles, and sand. Those beaches on the outer coast are a wasteland: few, if any, animals can survive the harsh, abrasive action of constantly tumbling rocks.

Many plants and animals living here are associated with rocky shores, particularly in the higher zones where the rocks are covered with Checkered Periwinkles, barnacles, mussels, and limpets. Beneath the cobblestones and boulders the shore crabs hide, and the little clingfish and blennies slither into holes and crevices when the tide drops. There are no sculpins here because the sand and mud and gravel mixture makes too loose a bottom to hold permanent pools of water. But under the cobblestones that very mixture provides a loose, coarse bottom for such animals as clams and worms that can burrow easily. Some cobblestone beaches have so many clams and are so strewn with empty clam shells that they're known as "shell beaches."

In most bays, the combination of cobblestone, gravel, sand, and mud changes so gradually that particular conditions tend to overlap. So don't be surprised to find plants and animals common on rocky shores, muddy flats, or even sandy beaches.

Living Under Rocks

Animals that live under rocks tend to have flattened bodies, hard shells, or protective shields. Should an animal such as a crab or sea star become pinned down by a shifting rock moved by currents and lose an arm or a leg, it may well crawl away and regenerate the lost limb. The Porcelain Crab and Brittle Star are specially adapted to live under rocks and are particularly quick at shedding an arm or leg. The under-rock habitat also protects an assortment of strange-looking worms; for example, the Armored Scale Worm with its overlapping scales that shield the worm in an abrasive gravel environment. In between the cobbles look for the bright orange tentacles of the Orange Sea Cucumber, whose tough, leathery body and ability to contract when annoyed protect it from predators and abrasive sand.

Living in Mixed Gravel, Mud, and Sand

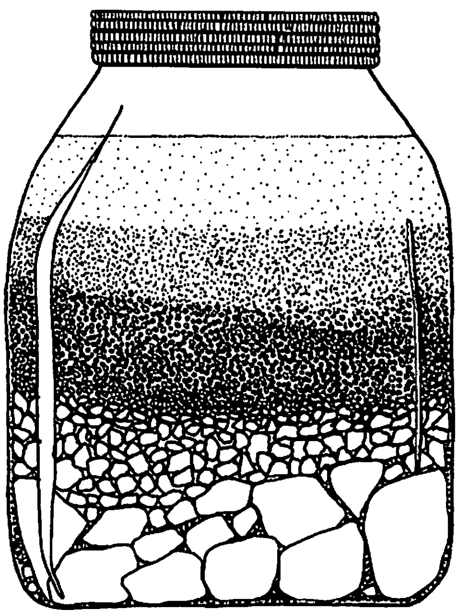
Under the cobblestones where mud, sand, or gravel, and pieces of broken shell mix together, look for such animals as clams and worm that can burrow easily. The Hairy Gilled Worm builds its own "home" from fragments of shell and stone and other debris. It cements hard particles together with a sticky mucus to form a protective tubelike house.

Clams that live on cobblestone beaches are characterized by thick heavy, shells that protect the soft animal inside from the abrasive action of sand and gravel moved by water. Should you find a Horse Clam, open one up and look inside. Almost every one will have a pair of soft-bodied Pea Crabs living inside. By living inside the clam, the Pea Crabs have a protected "home" and food from the seawater brought in through the clam's siphon.

Procedures

1. Ask: Has anyone been to a cobblestone beach? What was it like? Where was it?

2. Show pictures of cobblestone beaches. Brainstorm the source of so many cobblestones. (Discuss how glaciers transported cobblestones along the Alaska Panhandle and Inside Passage of British Columbia, and Puget Sound.)



3. Collect sand, mud, and beach pebbles in a mason jar. Add some water and a lid. Shake the jar vigorously. The grains will float around and filter to the bottom. They well sort by size and weight. Discuss the following:

- Does the water get clear quickly...slowly...at all?
- Describe the layers of mud, sand, and gravel.
- Which size is on the bottom...in the middle...on top? Why?
- Is wet sand heavier than dry sand? Why?
- Relate this to how sand is brought in and taken out by the tide.
- Relate this to how mud accumulates in protected bays where waves don't carry the mud and finer sand grains out to sea.

4. Imagine yourself an organism living in mixed mud, sand, and gravel. What would be problems of survival? How would you get your food? Could you move easily to get your food? Discuss the problems of abrasive sand and moving through such a habitat.

5. Pass out the activity sheet, "Adaptations of Cobble Beach Animals." List animals and their adaptations. Refer also to "Adaptations of Animals that Live on Rocks" and "Adaptations of Animals that Live Under Rocks." How is it possible that all of these habitats and organisms could occur on a cobblestone beach?

6. Has anyone dug clams? What kind of clams? (If they dug Razor Clams, they would have been on an exposed, surf-swept sandy beach. If they dug Horse Clams, Littleneck Clams, or Cockle Clams, they would have been on a cobblestone beach or a mixed sand, mud, and gravel beach.)

7. How is a Horse Clam adapted for living in such an environment? Discuss the heavy shells for protection from abrasive

sand and gravel, and the long leathery siphons that go up to the surface to collect plankton when the tide is in.

8. Can a Horse Clam burrow deeper if you try to dig it out or hold onto its siphons? (No. Clams that live on cobblestone beaches can burrow only to the length of their siphons because their shells are too large and heavy to burrow up and down through mixed mud, gravel, and sand. When the tide goes out, or when the clam is disturbed, it pulls its siphon back down into its shell.)

Under Rocks: Protected from Sun, Weather, Predators

Name of Organism	Adaptations to Habitat
Purple Shore Crab	Hard, protective shell; flattened; wedge-shaped; can lose and regenerate legs
Brittle Star	Flat, writhing body for moving under rocks; easily loses and grows back brittle-like legs
Northern Cling Fish	Can slither under rocks; sucker-like fins cling to underside of rock
High Cockscomb Blenny	Elongated, snakelike body easily slithers under rocks; moves to suitable environment
Calcareous Tube Worm	Hard, calcareous "tube-house" protects from abrasive sand; cemented to rock
Flat Worm	Elongated, flat, muscular body easily slithers under and holds onto rocks

Living Under and Between Cobbles in Mixed Gravel, Sand, and Mud

Name of Organism	Adaptations to Habitat
Armored Scale Worm	Hard, protective shields; flattened; can regenerate scales
Hairy Gilled Worm	Cements shell and stone fragments together to create its own home
Orange Sea Cucumber	Long, leathery body; tube feet attach to rocks, holding it firmly; contracts
Butter Clam	Thick, heavy, protective shells; burrowing, anchoring foot
Horse Clam	Thick, heavy, protective shells; burrowing, anchoring foot
Pea Crab	Lives inside another animal for protection

Adaptations of Animals That Live Under Rocks

(A) Flattened bodies

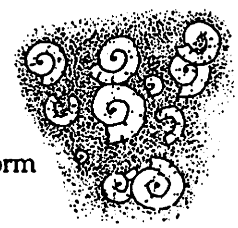
(B) Hard shells or protective coverings

(C) Regenerate body parts

(D) Slithering

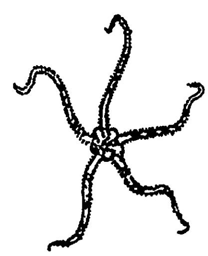
(E) Moisture-filled shell-house

(F) Strong attachment devices

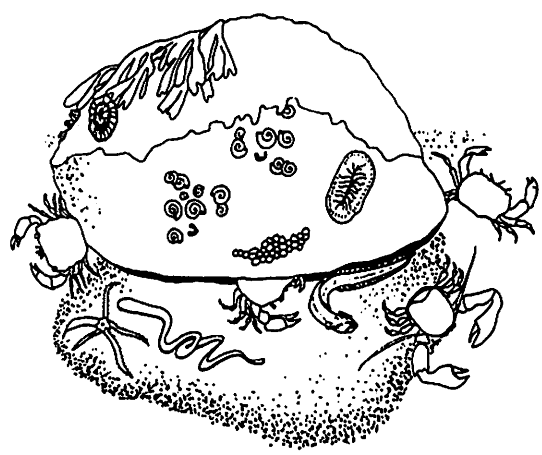


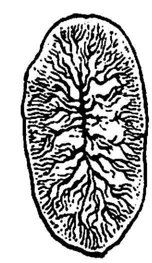
Tiny Tube Worm
A, B, F

Purple Shore Crab
A, B, C, E

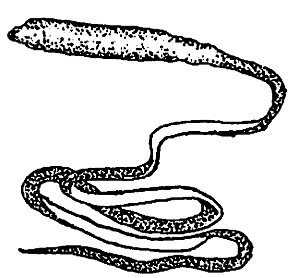


Daisy Brittle Star
A, B, C, D

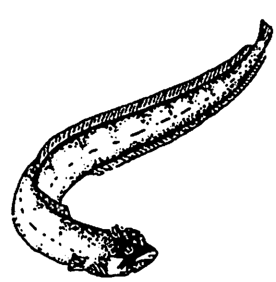




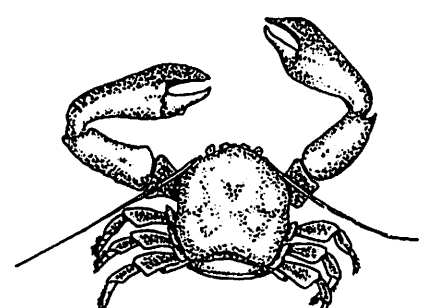
Flatworm
A, C, D



Green Nemertean
A, C, D



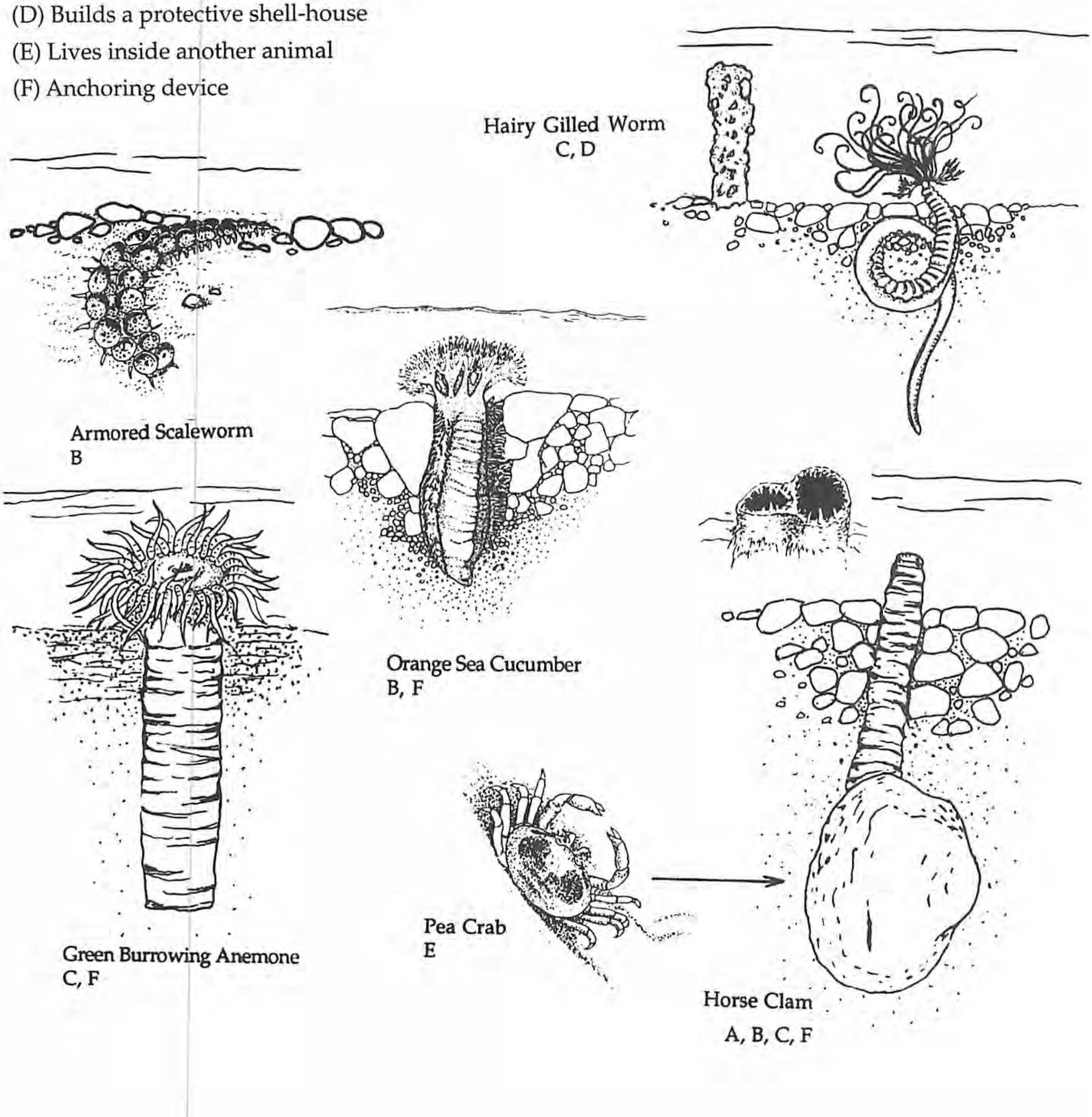
High Cockscomb Blennie
A, D



Porcelain Crab
A, B, C, E

Adaptations of Animals Living in Mixed Sand, Gravel, and Mud

(A) Very thick shells
(B) Protective shields or leathery skin
(C) Tubes or siphons to the surface
(D) Builds a protective shell-house
(E) Lives inside another animal
(F) Anchoring device



Teacher's Note

To dig for clams, look for holes at the surface; when the tide drops, the clams withdraw their siphons. Use a three-pronged, long-handled fork or shovel. Small clams will re-bury themselves, but may not survive large amounts of gravel being turned over. Large clams are unable to re-bury themselves and may not survive even when reburied. Check for and follow the legal limits set for each species. Many clam beds are rapidly becoming depleted because of unthinking diggers. As a general rule when digging clams for observation, take the first clam of each species, then carefully re-bury the clams to the depth of their siphons. Small clams should be left at the surface with only a small amount of sand covering them.

Enrichment Activities

1. Beaches vary enormously. To investigate the effect of the type of seashore on each animal, you'll need to observe whether the beach is mud, sand, gravel, cobble, or some combination. Later you can compare your population couts with other samples taken on different types of seashores, and during different seasons. The "Beach Environment Data Sheet" next page, can be used to collect data and record observations at different locations on the shore. Use the Classification Table below to classiby beach rock sizes. (For this investigation you'll need coat hangers bent into square frames.)

2. A stream bed is a great way to demonstrate a range of beach processes.To make a simple stream bed:

- Fill a small bucket with sand, mud, gravel, and beach pebbles.
- Dump the contents into one end of a large tray or stream table.
- Elevate that end using a brick or books.
- Pour a stream of water from a hose connected to a faucet, or using a sprinkling can with a 2-hole pour spout, begin to gently wash the sand and grael. Avoid flooding the far end of the tray.
- Ask the students to predict what will happen. From their observations, infer why the gravel, sand, and mud sort out with the smaller particles traveling downslope the farthest. (The larger sizes require more energy to travel the same distance as the smaller sizes.

Classification Table for Beach Rock Size

Boulder Beach	This beach is made of rocks of a large size. While some rocks may be small, the majority of rocks here are larger than 265 mm (10 inches).
Cobble Beach	The majority of rocks on this beach are between 135 and 265 mm (5–10 inches). The average size is about that of a grapefruit.
Gravel	A gravel beach is made of rocks ranging from tiny pebbles >5 cm (1/4 inch) to rocks of about 2.5 inches.
Sand	The best beaches for sunbathing and for walking. Sand is made of tiny particles of rocks smaller than 2 mm or .08 inches.
Mud Flat	The rock particles here are fine and are less than .0039 mm(.00015 inch). The spaces between particles hold a lot of water, making the sediments like an ooze.

Beach Environment Data Sheet

Beach: ______________________________

Name: ______________________________

Station number: ______________________________

Date: ______________________________

Beaches vary enormously. To investigate the effect of the type of seashore on each animal, you'll need to observe whether the beach is mud, sand, gravel, cobble, or some combination. Later you can compare your population counts with other samples taken on different types of seashores, and during different seasons. (For this investigation you'll need coat hangers bent into square frames.)

1. In your field notebook, make a detailed drawing of what is in your frame. Include pieces of shells, sand, gravel, etc. Include any living organisms. Make a key with symbols.

2. Describe the sediment (type of bottom) by size and amount. Describe only what is located within your frame.

Fine sand	*all*	*most*	*some*	*none*
Coarse sand	*all*	*most*	*some*	*none*
Gravel	*all*	*most*	*some*	*none*
Cobble	*all*	*most*	*some*	*none*

3. Now look outside of your frame. How would you describe the sediment? ______________________________

____

4. Is your frame exposed to the sun or is it in the shade? ______________________________

____

5. Describe the tide and wave action. ______________________________

____

Measure the *largest* stone in your frame. Use centimeters.

Length cm. ____________________ Width cm. ____________________

Measure the *smallest* stone in your frame. Use centimeters.

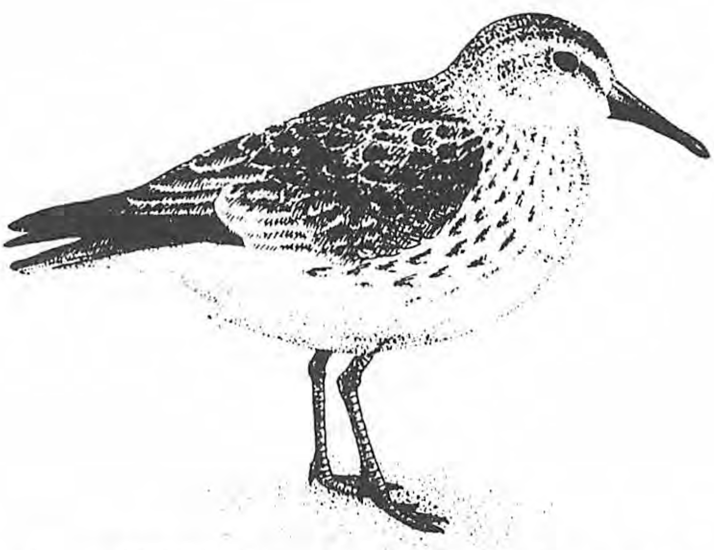
Length cm. ____________________ Width cm. ____________________

Make a count of:

Shells or shell pieces ____________ Pieces of seaweed ____________

Pieces of litter ____________ Parts of sea creatures ____________

Other things? Name them. Count them.



A group of delightful Western Sandpipers, no larger than sparrows, run along the tide line in stops and starts. Popularly called "peeps," when alarmed they take flight in great flocks, filling the air with a chorus of soft peepings. Then, after a few turns, they settle down again to the same spot and resume their feeding.

Chapter 8: Sandy Shores

The sandy shore, in contrast to the rocky shore, appears barren of life. But life does exist here. Most of the organisms, however, live beneath the surface. Like rocky shore organisms, these organisms have adapted to the hard conditions that accompany the changing water levels.

Wave action is one of the most important factors governing life on a sandy shore. Every wave on a sandy shore lifts and moves quantities of sand. Successive waves, changing tides, and passing seasons continually change the beach. Much of the sand is carried away and deposited offshore as sand bars. In winter, strong waves create steep-sloped beaches of coarse sand; in summer, gentle waves produce broad, flat areas of fine sand.

This chapter describes exposed and protected sandy beaches, and how on some protected sandy beaches eelgrass beds help stabilize the bottom and prevent the sediments from being carried away. The eelgrass beds provide food and shelter for large communities of fish, crabs, snails, worms, clams, isopods, and amphipods.

In this chapter, students will gain an understanding of the following concepts:

- Exposed sandy beach
- Eelgrass bed
- Protected sandy beach
- Sand dune
- Zonation
- Abrasive
- Camouflage
- Survival
- Behavioral adaptation
- Structural adaptation
- Interacting
- Burrowing
- Sand bar
- Community
- Limiting factors

Eelgrass bed

A surf-swept sandy beach (Pacific Coast).

The Surf-Swept Sandy Beach

Concepts

1. Sandy beaches are in a constant state of change and motion.

2. Animals on exposed sandy beaches must protect themselves from shifting, abrasive sand and heavy surf.

Understandings

The students will be able to 1) identify surf-swept sandy beaches and protected sandy beaches, 2) locate surf-swept and protected sandy beaches on a map, 3) identify plants and animals on an exposed sandy beach, and 4) describe limiting factors on an exposed sandy beach.

Materials

Field guides

The following Pacific Coast Information Cards:

Glaucus-winged Gull	Moon Snail
Western Sandpiper	Razor Clam
Beach Hopper	Sand Dollar
Sand Sole	Mole Crab
Purple Olive Snail	Sand Worm

Overhead transparencies:

"Sandy Beach Adaptations"

"Zonation on an Exposed Sandy Beach"

Teacher Information

Waves on surf-swept outer coastlines are important in determining the collections of shore populations. Waves not only exert crushing forces on rocky shore organisms, but also scour rocks and living organisms with sand and shifting sediments such as gravel and beach pebbles.

If you have ever walked along a sandy beach after a violent storm, you probably noticed much debris. Floating objects, seaweeds, small shells, and dead and dying animals are cast ashore. This is an ideal time to look for glass floats and beautiful shells, but violent storms make life difficult for organisms. Only specialized animals can live in this turbulent world.

Exposed sandy beaches are in a constant state of change and motion. Shifting sand offers no firm attachment sites, so large marine plants are unable to keep a foothold. Many animals such as shrimp are free-moving and able to reestablish themselves when the sand stops shifting. Large sandy beach animals are either visitors (birds and fishes), or burrowers (clams, snails, worms, and Beach Hoppers), able to dig beneath the sand for protection. Sand protects burrowing animals. It hides them from the drying sun at low tide and buffers them from extremes in temperature and salinity, as well as protects them from the moving sand.

Procedures

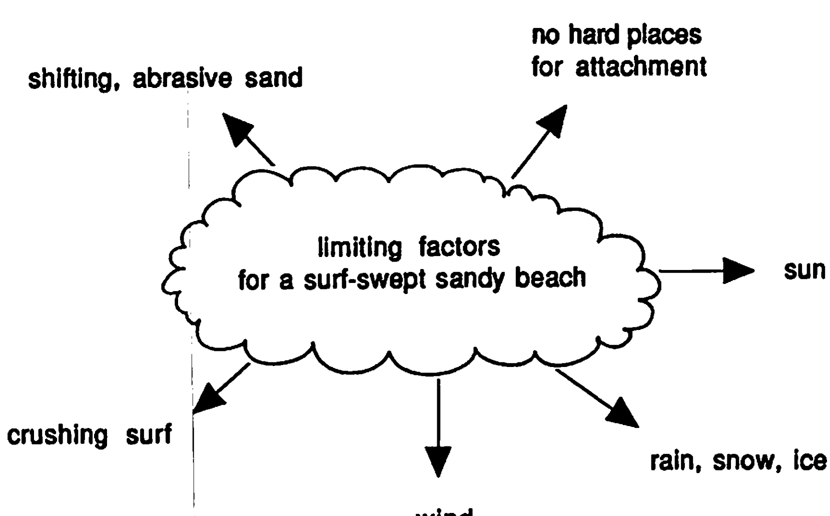
1. Have pictures of the ocean and sandy beaches displayed around the classroom. If possible, include surf-swept sandy beaches and protected sandy beaches. Spend some time sharing experiences about the ocean and sandy beaches. Who has been to a sandy beach? Where was it? Did it have high waves crashing to shore, or were the waves small or nonexistent? Try to locate regional surf-swept sandy beaches and protected sandy beaches on a map.

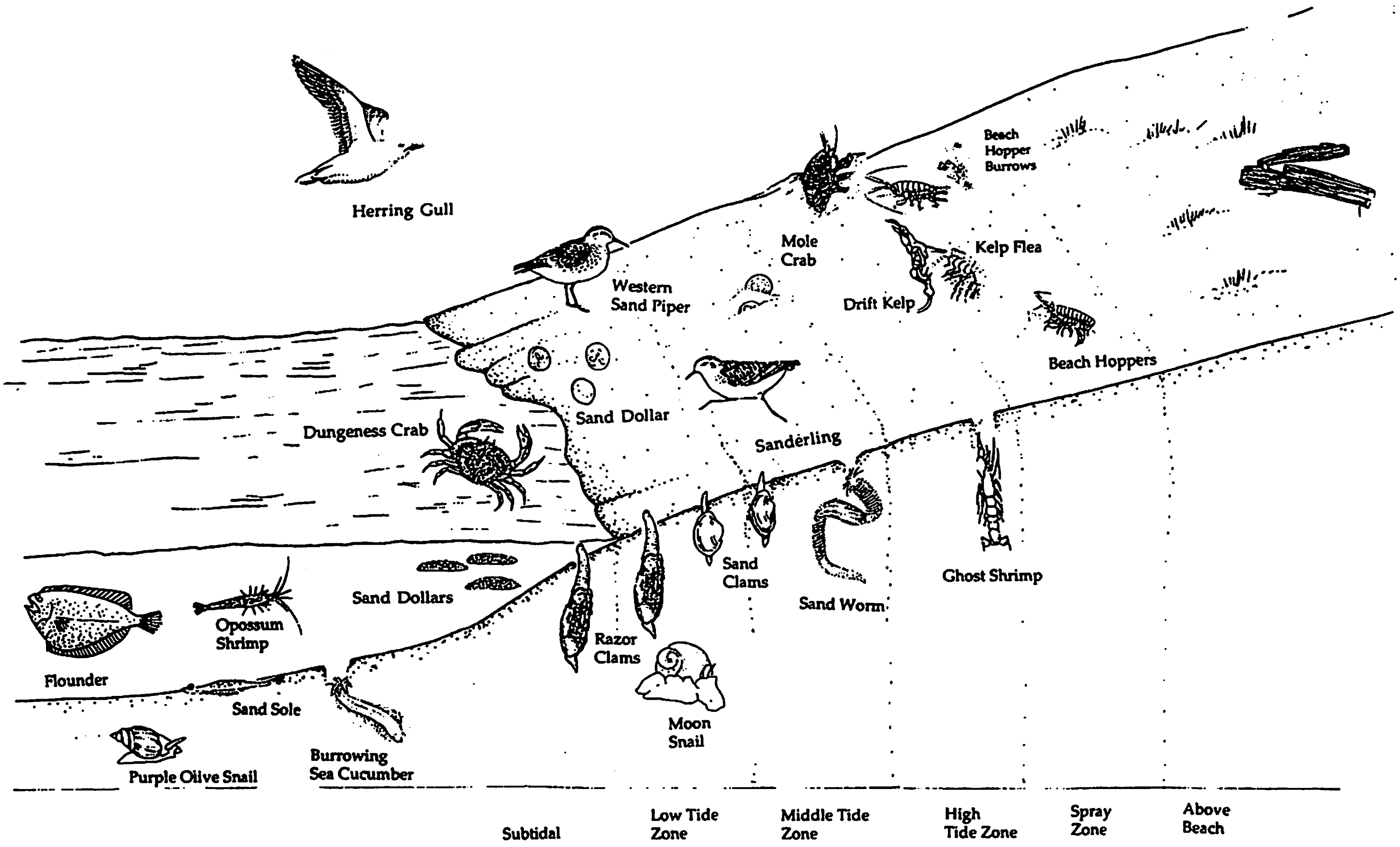
2. Where does sand come from? Probe the students' thinking as to what sand is, where it comes from, what it's made of, where it occurs in large amounts, how it changes. Has anyone ever tried to build a sand castle, dig a hole, etc. on a sandy beach? Discuss the properties of sand and water. Attempt to develop the concept that a sandy beach, especially on an exposed coastline, is a relatively unstable and constantly moving environment. Unlike a rocky shore, there are no hard surfaces and few places for plants and animals to attach.

3. Has anyone been to an exposed sandy beach? What plants and animals did you see? Was there evidence of plants and animals? Why do they think so few plants and animals appear to live there?

4. Do many seaweeds survive on a surf-swept sandy beach? (No.) Why not? (There are no hard places for attachment.)

5. Write the words "limiting factors" on the blackboard. Brainstorm factors that might limit the distribution of organisms on a surf-swept sandy beach.





Zonation on an Exposed Sandy Beach

6. Discuss the abrasive properties of sand. What would it be like to live in a sand-filled world? Discuss the problems of protection from abrasion, moving sand, and water loss. Bring several samples of sand to school. Use sandpaper to demonstrate the properties of sand.

7. If few animals live at the surface of a sandy beach, where on the beach might they live? Discuss the fact that on an exposed sandy beach there are few types of habitats: on sand, burrowing in sand, or swimming in the water. How might this contribute to few types of species?

8. Which type of seashore is more productive, a rocky shore or a sandy beach? (A rocky shore.) Why? (Compared to a sandy beach, a rocky shore is a more stable environment and has many more types of habitats: on rocks, under rocks, in tidal pools, among seaweeds.)

9. Project the transparency "Zonation on a Sandy Beach." Engage the students in a discussion about problems of survival in the spray zone compared to the low tide zone and in the subtidal. In other words, what factors might put limits on the ability of organisms to survive in the various zones?

Sand Study

Sand of different types is readily available at the beach, and most students enjoy handling sand. Such activities also help students become aware of their immediate environment, and to appreciate how difficult it is for plants and animals to survive in an abrasive and shifting sandy beach environment.

Observing Sand at the Seashore

- Walk from the high tide line to the low tide line. Observe how the size of sand grains changes. Which size would more likely occur on a surf-swept beach? (Coarse sand.) Which size would likely occur on more sheltered beaches? (Fine sand.)
- Try to determine possible agents of transportation (wind, streams, glaciers, waves, offshore currents).
- Try to match the color of the sand with rocks in the environment above the beach, beach cliffs, upstream.
- Observe a beach through the seasons; spring, summer, fall, winter. How does the slope of the beach change? How does the size of sand grains change? Photograph the same beach during each season. Compare photographs.

Observations with a Magnifying Lens or Microscope

Collect samples of beach sand from different types of beaches: white coral sand, black lava sand, sand with pieces of agate, etc. Exchange samples of sand with a friend.

- Describe the color of individual sand grains. How many colors are present? Which color dominates? What shapes do you see? Classify samples of sand by color: transparent, white, gray, pink, green, etc. Research in the library possible sand composition: quartz, feldspar, magnetite, shells of organisms (calcium carbonate), etc.
- Classify samples of sand into coarse sand, medium sand, fine sand, very fine sand.
- Collect pieces of polished beach agates, pebbles, and sand. Observe with hand lenses and microscopes. Research their composition.

Adaptations of Surf-Dwelling Sandy Beach Organisms

Concepts

1. Surf-dwelling organisms must have special adaptations in order to survive.

2. Surf-swept sandy beach adaptations include speed, streamlined shapes, thin shells, weight belts, swimming with the surf, and burrowing.

Understandings

The students will be able to 1) describe adaptations of surf-dwelling organisms, 2) classify adaptations as structural or behavioral, 3) construct a map or mural of an exposed sandy beach, and 4) invent adaptations for surf-dwelling organisms.

Materials

Transparency: "Adaptations of Surf-Dwelling Sandy Beach Organisms"

Teacher Information

Waves on surf-swept outer coastlines are important in determining the collections of shore populations. Waves not only exert crushing forces on rocky shore organisms, but also scour rocks and living organisms with sand and shifting sediments such as gravel and pebbles.

Animals on exposed sandy beaches on the outer coast must protect themselves from shifting sand and heavy surf. Many are rapid movers; some dig or burrow into the sand; and most, such as shrimp, are free-moving and able to reestablish themselves when the sand stops shifting. Typically, several species of transparent shrimp swim back and forth with the waves in shallow water; while Sand Soles and other flatfish dart here and there on the bottom beyond the breaking surf. At the tide line, groups of sandpipers and sanderlings sprint along in stops and starts searching for snails, worms, and tiny crustaceans.

Many inhabitants burrow beneath the sand for protection; there are even microscopic animals living between the sand grains. Sand protects burrowing animals. It hides them from the drying sun at low tide and buffers them from extremes in temperature and salinity.

In the spray zone, hordes of large Beach Hoppers burrow under the sand and move down the slope with the tide. At the low tide zone, the thin, knife-shaped Razor Clam burrows rapidly in the surf and extends its siphon to filter plankton. Sand Dollars typically burrow part way into the sediment in deep water beyond the surf. Frequently, heavy iron oxide sand grains make up a large part of the material taken up by the animal. This "weight belt" may serve to hold the Sand Dollar steady in shifting sand.

Though burrowing animals are relatively safe from wave action and from drying out, their huge numbers attract a variety of opportunistic predators. When the tide goes out, gulls and sandpipers probe and dig along the shore in search of food, but when the beach is submerged it becomes a hunting ground for flatfish that move in from deep water to gobble up small clams, crabs, and crustaceans. Many predatory burrowers follow the clams below the surface into their own world, including predator sea snails such as the giant-sized Moon Snail and a variety of carnivorous worms which eat any animal they can manage, dead or alive.

Procedures

1. Show the students pictures of surf-swept sandy beaches and protected sandy beaches.

2. Brainstorm problems of survival for organisms on surf-swept sandy shores. (High waves; strong, powerful waves; strong currents; abrasive sand and gravel; moving, unstable bottom.) In addition, these hardy organisms must survive the abrasive action of moving sand and gravel.

3. Where is life generally found on a sandy shore? (Most organisms burrow beneath the sand.) Why? (Sand protects burrowing animals from surf; moving, abrasive sand; and temperature and salinity changes at low tide.)

4. Do many seaweeds live on a sandy beach? (No.) Why not? (No hard surfaces for attachment.)

5. Show the transparency, "Adaptations of Surf-Swept Sandy Beach Organisms."

For each sandy beach organism, describe adaptations for protection from beating surf and abrasive sand. For example, consider the Razor Clam. How is the Razor Clam adapted for digging rapidly? (Consider its muscular, wedge-shaped foot and thin, streamlined, razor-shaped shell.) How is the Moon Snail adapted for burrowing? (Consider its large, wedge-shaped, fleshy foot.)

6. Classify sandy beach adaptations into "structural" or "behavioral" adaptations.

7. Name organisms that commonly visit the sandy shore when the tide is out. (Gulls, sandpipers, sanderlings, flatfish, etc.) For each organism describe adaptations for food gathering. Name animals that feed on other sandy beach organisms when the tide is high. Ask the students to read the information on the back side of the Pacific Coast Information Cards listed above.

8. Discuss the fact that on an exposed sandy beach, many of the organisms such as crustaceans are very tiny and live between the sand grains.

Invent an Imaginary Surf-Dwelling Organism

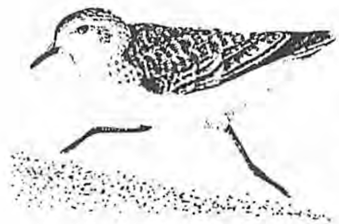
Brainstorm adaptations for surf-dwelling organisms. Be creative. Consider both behavioral adaptations and structural adaptations. Then invent a plant or animal specially equipped to survive the surf-swept rocky shore or the surf-swept sandy beach. Draw a picture of the organism. Give the organism a name. Tell how the organism is adapted for life in heavy surf.

Sandy Beach Mural

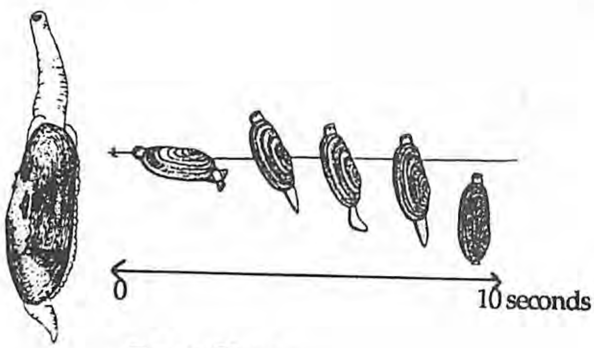
Cover the bulletin board (or wall) with construction paper. Draw the profile of a sandy beach exposed to heavy surf. Use a felt pen to draw in a few distinguishing features such as the horizon line, high tide zone, low tide zone, beating surf, tide line, beached logs, etc. Have the students make large paintings or papier-mâché constructions of sandy beach organisms. Cut these out. The students should pin their organisms in the appropriate places on the mural. Consult various local field guides to identify additional sandy beach organisms. Include paintings or paper constructions of these animals on the mural.

Adaptations of Surf-Dwelling Sandy Beach Animals

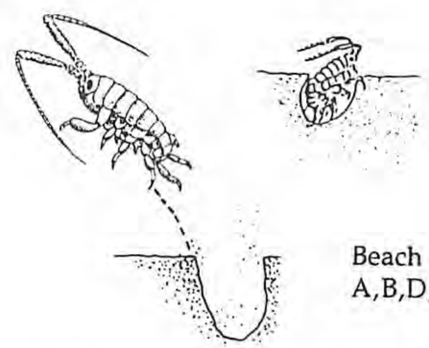
(A) Swift moving
(B) Thin shells
(C) Streamlined and/or flattened
(D) Burrows under surf
(E) Moves with the surf
(F) Lives beyond the surf
(G) Tubes open to the surface
(H) Weight belt
(I) Anchoring device



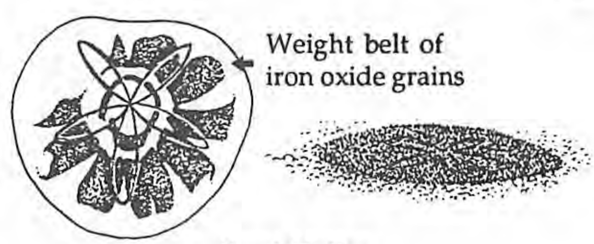
Sanderling
A,D



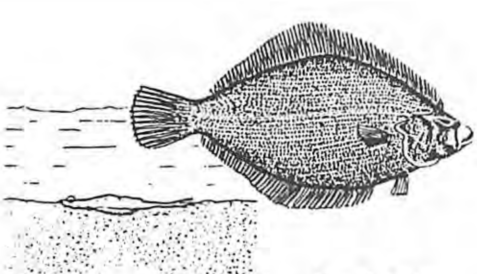
Razor Clam
A,B,C,F,G,I



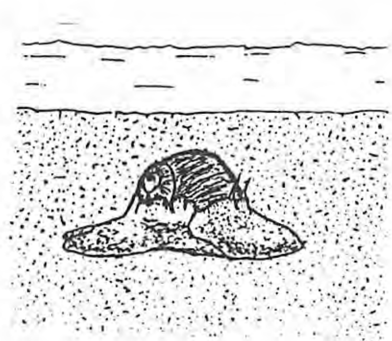
Beach Hopper
A,B,D,E



Sand Dollar
B,C,F,H



Sand Sole
C,F



Moon Snail
D,I

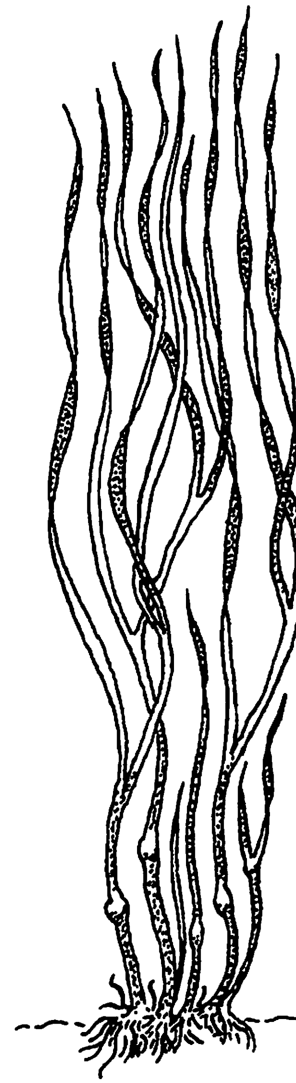
The Protected Sandy Beach

Concepts

1. Protected sandy beaches occur where offshore islands, deep bays, or inlets provide protection from surf.

2. Eelgrass beds help stabilize the bottom.

3. Eelgrass beds provide food, shelter, and attachment sites for a community of interacting plants and animals.



Eelgrass

Understandings

The students will be able to: 1) describe the characteristics of a protected sandy beach, 2) identify organisms that live on a protected shore, 3) draw an eelgrass organism in an eelgrass bed emphasizing how it is adapted to its habitat, and 4) explain why an eelgrass bed is called a "community."

Materials

Transparency: "Eelgrass Bed"

The following Pacific Coast Information Cards:

Eelgrass	Black Brant
Sand Dollar	Sand Sole
Moon Snail	Pipefish
Dungeness Crab	Sand Worm
Plant Plankton	Animal Plankton

Teacher Information

Sandy beaches in protected areas frequently become mixed with fine mud, and have a richer assortment of microscopic animals and a greater variety and number of larger inhabitants than exposed sandy beaches. Cockles, sand clams, and tellens move slowly through the sand, most living deep below the surface, and the adults barely able to move. Tube-dwelling worms glue sand grains together to form homes so fragile that they would be destroyed on the surf-swept outer coast.

On some protected beaches where sand mixes with mud, eelgrass beds stabilize the bottom and prevent the sediments from being carried away. Eelgrass is a flowering plant adapted to relatively shallow water along the shore. The long, thin, bright green, grasslike blades are 50 cm or more in length. The thick root structures take hold in sandy bottoms and help stabilize the bottom sediments. The root structures and tangled blades provide shelter and sites of attachment for large communities of amphipods, isopods, snails, nudibranchs, crabs, and fish. The well-camouflaged Pipefish swim to and fro looking for food, or hang vertically, blending beautifully among the stems and fronds. The beds are rich in food supplies, such as diatoms, decaying plant and animal matter, and the eelgrass leaves themselves. The large Dungeness or Edible Crab marches briskly along or hides beneath the surface of the sand, only a pair of antennae and eyes protruding. At low tide, where protective eelgrass beds or depressions in the sand hold a little water, a variety of small fish—Sand Soles, Staghorn Sculpins, and the juveniles of a large assortment of flatfish—dart off in all directions.

Though burrowing animals are relatively safe from wave action and from drying out, their huge numbers attract a variety of opportunistic predators. When the tide goes out, gulls, sandpipers, and sanderlings probe and dig along the shore, but when the beach is submerged it becomes a hunting ground for flatfish which move in from deep water to gobble up small clams, snails, and crustaceans. Hungry sea stars, notably the Pink Star, the sun star, the Purple or Ochre Star, and the Sunflower Star, range widely and creep onto sandy beaches to prey on clams at the surface. Here too, many predatory burrowers follow the clams below the surface into their own world, including the giant-sized Moon Snail and a variety of carnivorous worms, which eat any animal they can manage, dead or alive.

Pipefish

Procedures

1. Ask the students to describe the characteristics of a protected sandy beach.

2. Where do protected sandy beaches occur? Locate local protected sandy beaches on a map. Explain why these beaches are protected. (Look for islands, inlets, and deep bays.)

3. Who has been to a protected sandy beach? What plants and animals did you see?

4. What effect do eelgrass beds have on a sandy beach? (The roots stabilize the bottom.)

5. Use the overhead transparency, "Eelgrass Bed," to identify organisms that live in an eelgrass bed. What animals live in and among the eelgrass? What organisms live on the stems and leaves? The holdfasts? What animals bury themselves in the sand? What animals swim from leaf to leaf?

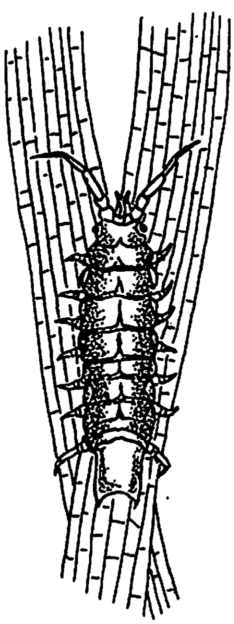
6. Look for examples of camouflage. (The green color and size of the Eelgrass Isopod. A Dungeness Crab buried in the sand with only its eyes protruding. A Sand Sole changing color. A Pipefish mimicking the eelgrass stems and frond.)

7. Why is an eelgrass bed (as well as a Rockweed bed) frequently called a "nursery" for seashore plants and animals? (The roots and leaves provide food and shelter for a great variety of juvenile snails, crustaceans, nudibranchs, and fishes.)

8. Brainstorm why so many animals live in an eelgrass bed. (The beds are rich in food supplies and provide protection from predators and from drying out at low tide.)

9. At low tide, what shore predators hunt for edible items to eat? (Gulls, Great Blue Herons, Black Brants, crows, raccoons.) What would they eat?

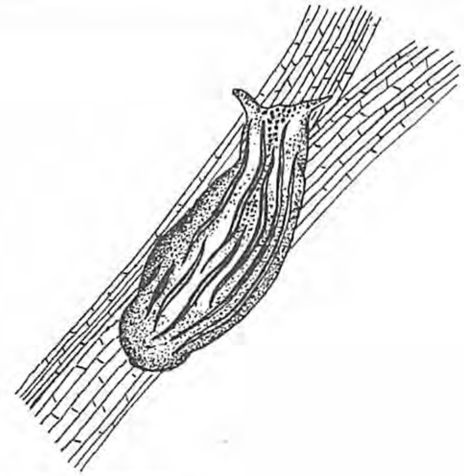
10. Why is an eelgrass bed called a "community"? (The organisms depend on one another for food, shelter, and survival.)



Eelgrass Isopod

Explore an Eelgrass Bed

If possible, visit an eelgrass bed during the spring and summer months, when the beds achieve their greatest growth and support the largest variety of plants and animals.



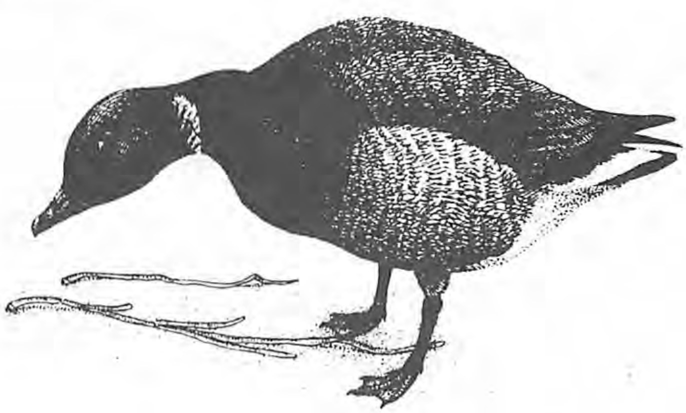
Green Sea Slug

- Teach the students to take time and sort through the leaves and stems to see various species of seaweeds, amphipods, isopods, snails, nudibranchs, and shrimp which sit on the leaves. Why do so many plants and animals live in eelgrass beds?
- Pull an eelgrass plant up from the bottom, root and all. Notice the strong, root structures. Discuss how the roots stabilize the sand. Compared to the shifting sand of the surf-swept sandy beach, how does an eelgrass bed provide a stable and protected environment?
- Use large dip nets or a seine net to capture a variety of well-camouflaged fish that inhabit the eelgrass bed. Observe these in plastic bags filled with seawater and let them go.
- Look carefully on the eelgrass leaves for ribbonlike or tire-shaped egg cases. These are usually the eggs of snails or nudibranchs.
- Notice the richness of life in the eelgrass beds. Does this diversity occur even a few centimeters outside the eelgrass bed in plain sand? Why not? (Eelgrass provides protection.)
- What colors do they see? What patterns? What animals? Do they see examples of camouflage?

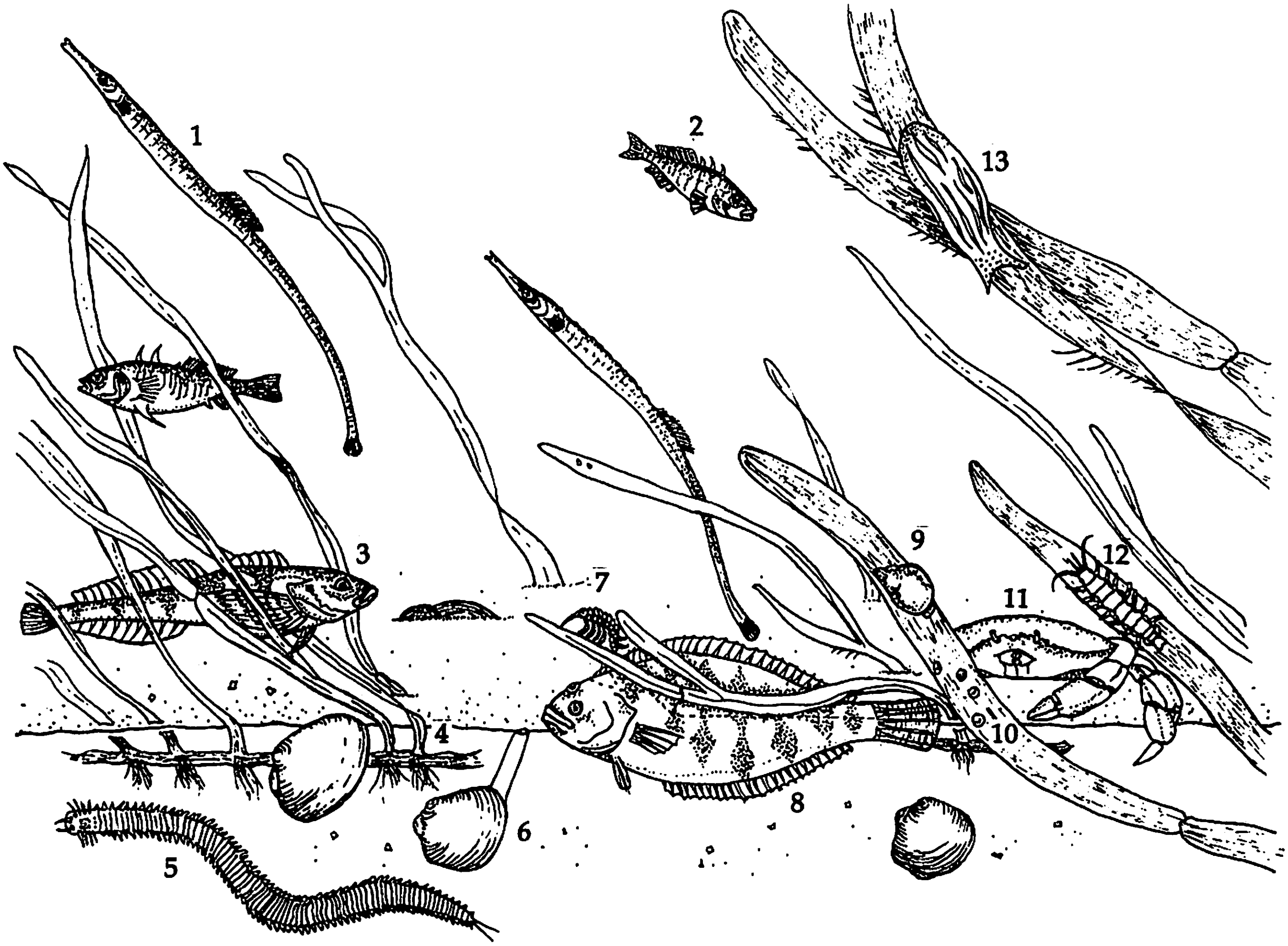
Enrichment Activities

1. Draw an eelgrass animal. Emphasize how the animal is well camouflaged to live in its habitat.

2. Construct an eelgrass food web.



On protected sandy beaches and at the lower levels of salt marshes, where beds of bright green eelgrass glisten in the sun, Black Brandts dine on succulent roots and stems.



Color Key to Eelgrass Bed Organisms

Many eelgrass organisms are camouflaged to blend in with their surroundings. Use water colors, colored pencils or pastels and the color key below to create an eelgrass community emphasizing how organisms blend into their surroundings.

1. Bay Pipefish— the color may vary from pale green to dark green or brown.
2. Stickleback—variable color, silvery green to bluish black.
3. Tidepool Sculpin—white and green-black body with gray, green, pink or brown highlights that blend with the surroundings.
4. Eelgrass—bright green stems and blades, pale green or white roots.
5. Sandworm—tan colored body with iridescent blues, greens, and sometimes reddish tones.
6. Sand Clam—chalky white or grayish white.
7. Amphipod—dull green or gray-brown.
8. Sand Sole—usually tan colored, using its natural camouflage to blend in with the sandy bottom.
9. Lacuna Snail—light brown shell with lighter bands.
10. Lacuna egg cases—dull yellowish white or yellow.
11. Dungeness Crab—tan or light brownish orange, sometimes with a purplish or orange tinge.
12. Eelgrass Isopod—the same bright green color as the stems and fronds of eelgrass.
13. Green Nudibranch—the same bright green color as the stems and fronds of eelgrass.

Chapter 9: Saltwater Wetlands

A wetland is simply any shallow land area that tends to be regularly wet or flooded. Wetlands include estuaries, freshwater and saltwater marshes, mud flats, wet meadows, swamps, bogs, lagoons, and prairie potholes.

All wetlands provide special habitats to plants, animals, humans, and the total environment. The great productivity of both plant and animal life make them a virtual food factory for herbivores, omnivores, and carnivores. Wetlands provide special breeding and rearing places for countless numbers and species of animals.

The importance of marsh grasses and other vegetation cannot be overlooked. Marsh grasses provide shade and cover during the summer and insulation from the freezing cold of winter. During spring floods, plants slow down water flow and allow excess water to drain off gradually. Healthy wetlands act as sponges, absorbing excess water and preventing floods and erosion. In dry periods, wetlands hold precious moisture after open bodies of water have disappeared. Through photosynthesis plants add oxygen to the system and keep nutrient levels from reaching toxic levels.

Common to all estuaries is the increase in salinity from river entrance to open ocean.

Wetlands are also filtering systems that have the unique ability to purify the environment. For example, some wetlands can trap and neutralize sewage waste; others, especially along shorelines, allow silt to settle and promote the decomposition of many toxic substances.

Wetlands are among the most productive ecosystems in the world. As remarkable as these systems are, they have their limits. Pollution, industrial waste, and draining are affecting the productivity of these areas. Their destruction and abuse have devastating effects on wildlife, humans, and the overall health of the environment.

The estuary, salt marsh, and mud flat together make up one of the most productive of all ecosystems. They contain an abundant and diverse community of organisms. They also provide a nursery for many shore birds, marine fishes, and many other marine and freshwater organisms.

In this chapter, students will gain an understanding of the following concepts:

High marsh	Decomposition	Mud flat
Edge effect	Low marsh	Bacteria
Salt marsh	Salt wedge	Salinity
Hydrogen sulfide	Estuary	Detritus
Productivity	Evaporation	Nutrients
Succession	Wetland	Ecosystems

Estuaries

Concepts

1. An estuary is a place where the waters of all rivers and streams eventually drain into the ocean.

2. Normally, bays are estuaries.

3. In estuaries, freshwater and saltwater mix in a circular action because of the salt wedge effect. In turn, this causes nutrients to circulate.

4. Although estuaries produce large populations of specialized organisms, the variety of organisms is small because it's difficult to live in a habitat that is sometimes freshwater and sometimes saltwater.

Understandings

The students will be able to 1) describe the characteristics of an estuary, 2) locate estuaries on a map, 3) infer how salinity varies in an estuary, 4) draw a food chain for an estuary, and 5) conduct a salt wedge experiment.

Materials

Transparencies: "An Estuary Food Web"

"Salt Wedge"

"Salinity Varies in the Estuary"

"Crab in a Salt Wedge"

Teacher Information

An estuary is an important environment between the land and the sea. It's a place where the waters of all rivers and streams eventually drain into the ocean. Estuaries vary in size, shape, water flow, and salinity. But common to all types is the increase in salinity from river entrance to open ocean.

Along the Pacific Coast there are many different types of estuaries. Some estuaries have developed behind barrier beaches, some are glacier gouged, and many of the northern Pacific are located in majestic fjords where the rivers are contained by steep rocky slopes.

Despite some very apparent differences, some characteristics appear to be common to estuaries: freshwater at the river end, saltwater at the ocean end, and a mixing system between them. In most estuaries the salinity ranges from 30 to 35 parts of salt per thousand parts of water at the ocean end to zero salinity at the river end.

Salinity also varies with depth in the estuary. The salty seawater, being denser, sinks. It flows in along the bottom in what is frequently known as a salt wedge. Meanwhile, the fresher, less dense water flows out on the surface. The salt wedge moves back and forth with the daily rhythm of the tides. It moves up the estuary on the rising tide, then recedes as the tide falls. This means that organisms that stay in one place must survive dramatic fluctuations in salinity.

Rivers flowing into estuaries carry with them erosion products and detritus, which tend to settle out as the current slows in the estuary. As they near the bottom, these sediments tend to be carried inland with nutrients carried in from the ocean; this creates a kind of nutrient trap that makes estuaries highly productive ecosystems. At the same time the constant input of sediments from the river outflow contributes to the creation of a delta extending into the sea. Unfortunately, this deposition of solid materials also traps contaminants such as pesticides, sewage, heavy metals, and toxins. Increasing densities of human populations and industry along coasts can produce far-reaching, permanent detrimental effects on the biological production of estuaries.

The food web in estuaries includes two distinct populations of producers: the plant plankton and rooted aquatic plants at the edge of the estuary, and the abundant plant plankton in the water column. The zooplankton include the larvae of most of the organisms that live in the estuary. Bottom-dwelling species range from worms through a variety of snails, crustaceans, and shellfish such as clams and oysters. Many feed by various filtering processes, an effective way of trapping the nutrients flowing through the estuary.

Fish such as stickleback are basically freshwater, but can tolerate comparatively high levels of salinity. During their juvenile stages, salmon rely on estuaries for protection from predators. The estuary also provides a rich food supply while fry or smolt adapt to the change from fresh to saltwater. Then when the salmon return to spawn, they use the estuary again to adapt to freshwater. Thus, salmon congregate in estuaries at the mouths of rivers to gather strength for the spawning run. Open ocean fish such as herring and perch migrate into estuaries as adults to feed on the abundant food available there.

These varied patterns of estuaries constantly change as each species follows its seasonal and reproductive sequence.

Procedures

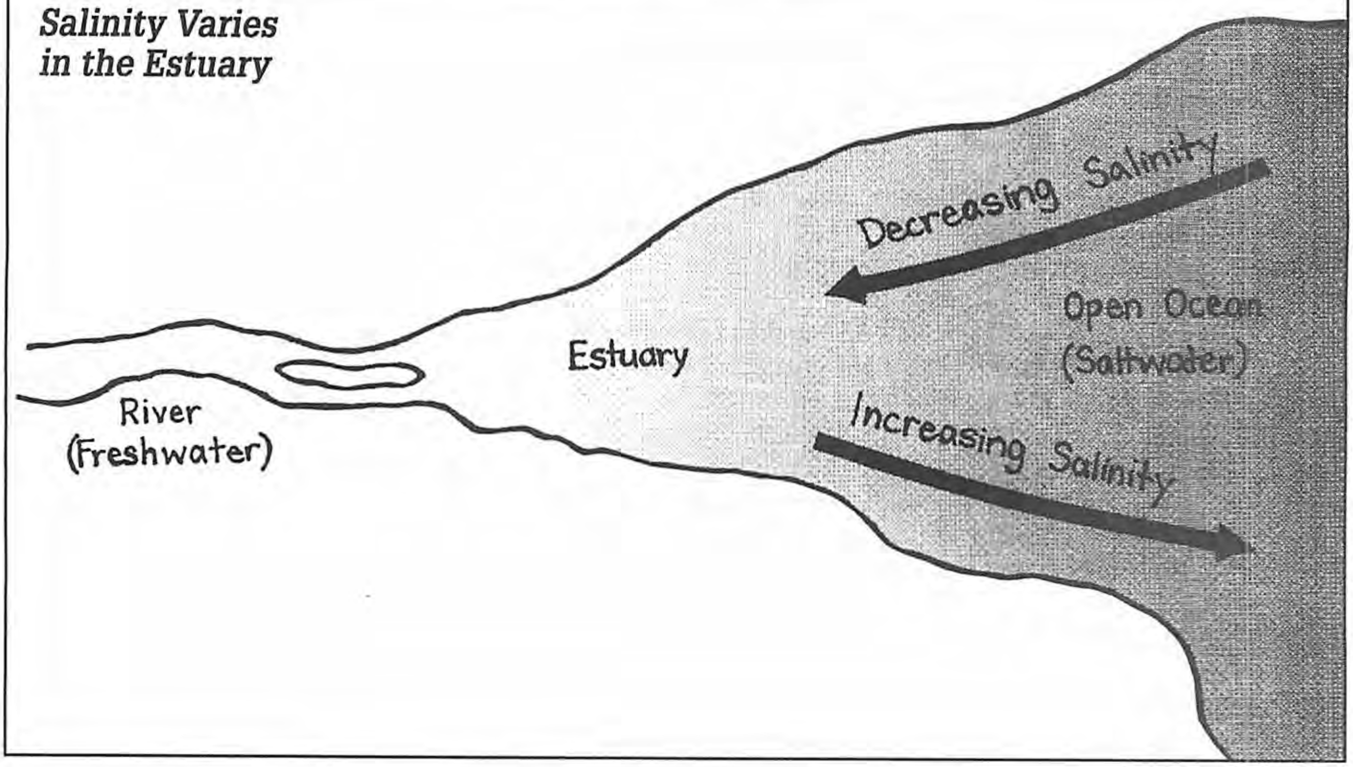
1. Write the word "Wetlands" on the blackboard. What are wetlands? Ask the students to brainstorm what they know about wetlands.

2. Locate estuaries on a coastal map. Look for incoming freshwater streams. What can the students infer about an estuary?

3. Who has been to an estuary? What plants and animals did they see? Discuss the importance of estuaries as a habitat for wetland plants and animals.

4. Discuss the differences between freshwater and saltwater. Would the water at the upper end of the estuary be fresher or saltier than the water at the lower end (the river mouth)? (Fresher.) Why? (The upper end is a freshwater stream.)

Salinity Varies in the Estuary



5. Place an egg in a glass half filled with freshwater. Ask the students to suggest ways to make the egg float. Infer what would happen to the egg if you poured salt into the container. Observe what happens. Why did the egg float? (Saltwater is heavier or more dense than freshwater. It held the egg up.) Is it easier for a person to float in saltwater or freshwater? (Saltwater.) Why? (Saltwater is heavier or more dense than freshwater. It holds you up.)

6. Project the transparency, "Salt Wedge."

Discuss the following questions:

- Why does the freshwater ride over the saltwater? (The saltwater is heavier or more dense than the freshwater.)
- What happens to nutrients carried down river? (They become trapped at the line where the saltwater and freshwater meet.)
- What happens to pollutants carried down river? (Pollutants also get trapped.)
- In an estuary, where is the highest salinity—top or bottom? (Bottom.)

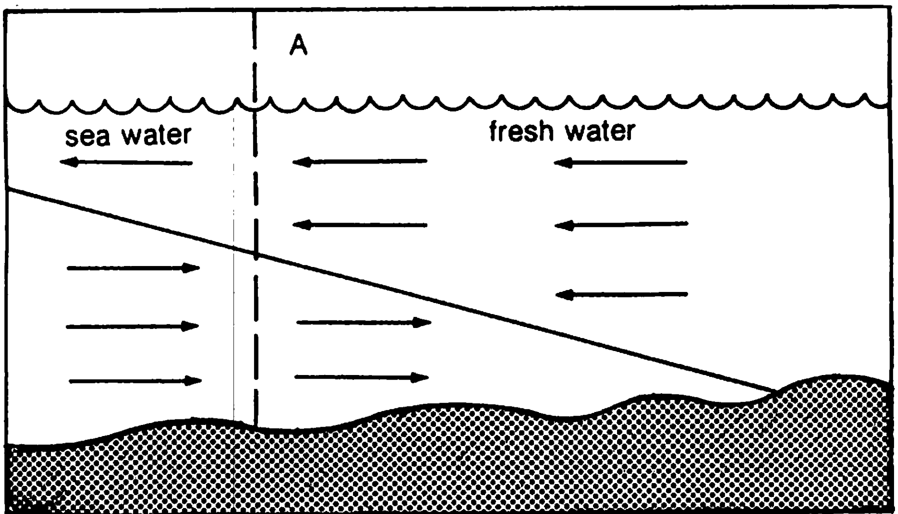
7. Project the transparency: "Crab in a Salt Wedge."

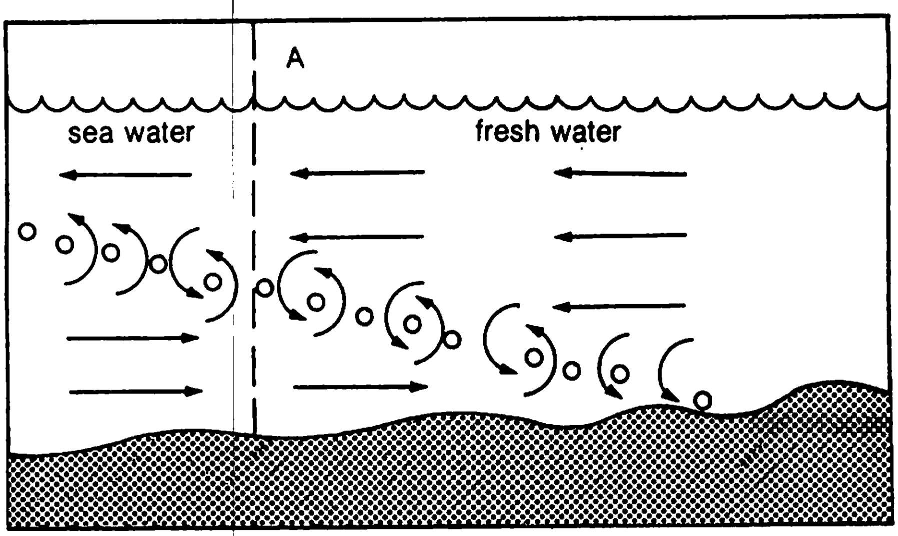
The salt wedge in a typical estuary moves in and out with the tide. At high tide the crab is covered by water with a salinity of 35 0/00. At low tide it is covered by water with a low salinity, between 5 0/00 and 15 0/00.

Discuss the following questions:

- At high tide, is the crab covered with water that is saltier or fresher? Explain.

Salt Wedge





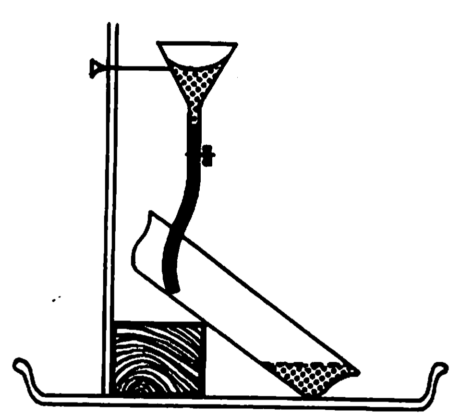
- At low tide, is the crab covered with water that is saltier or fresher? Explain.

Discuss how nutrients and pollutants carried down river in the freshwater or brought in by the sea tend to get trapped between fresh and saltwater because of the opposing currents. The trapped nutrients produce a rich place for plants and animals to live.

Demonstrating a Salt Wedge (Optional)

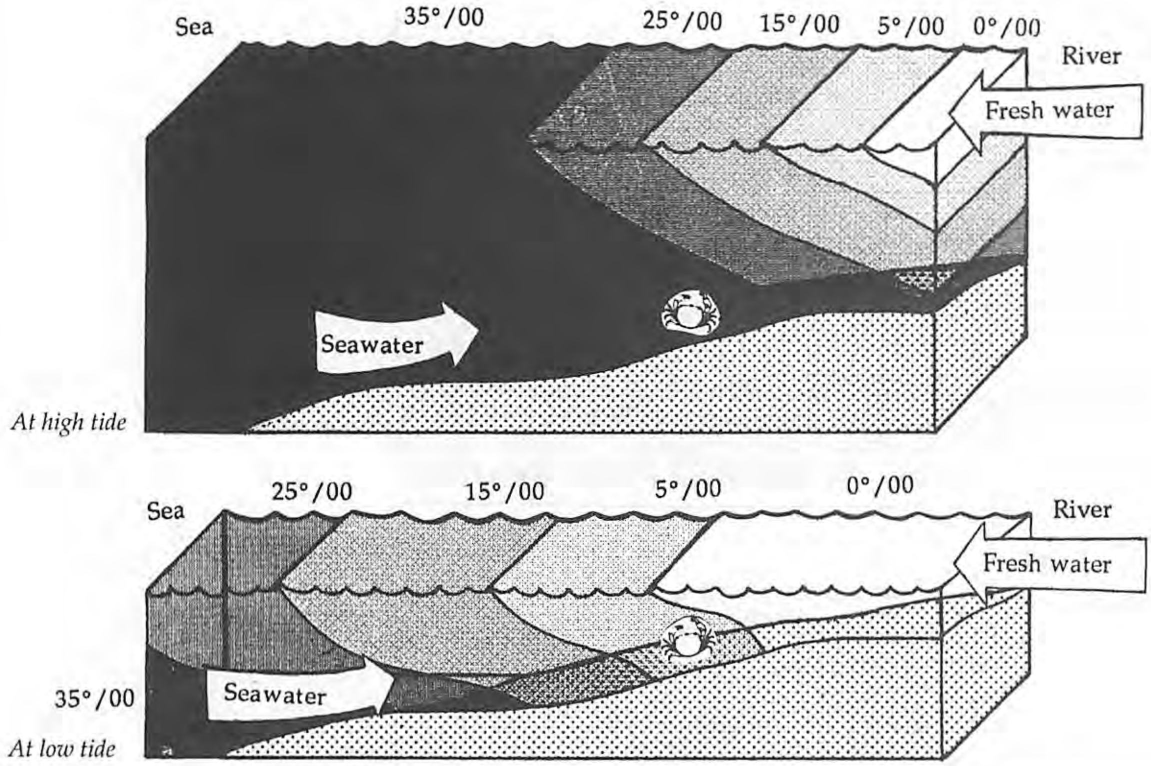
1. Set up the salt wedge apparatus as follows: Place the glass baking pan in the large tray. Place the block of wood under one end of the pan so the dish is elevated to a 45° angle. Arrange the funnel with the hose attached and the clamp shut. The hose should touch the bottom of the pan.

2. Tell the students that you are going to demonstrate what happens when the water from a river meets the ocean. Ask them to observe closely.



Salt wedge apparatus

Crab in a Salt Wedge



3. Gently pour the freshwater at room temperature into the glass baking pan and allow it to settle. Then add the blue dye to the cold saltwater. With the clamp on the hose still closed, pour the saltwater into the funnel. Slowly release the clamp so the saltwater gently flows into the pan.

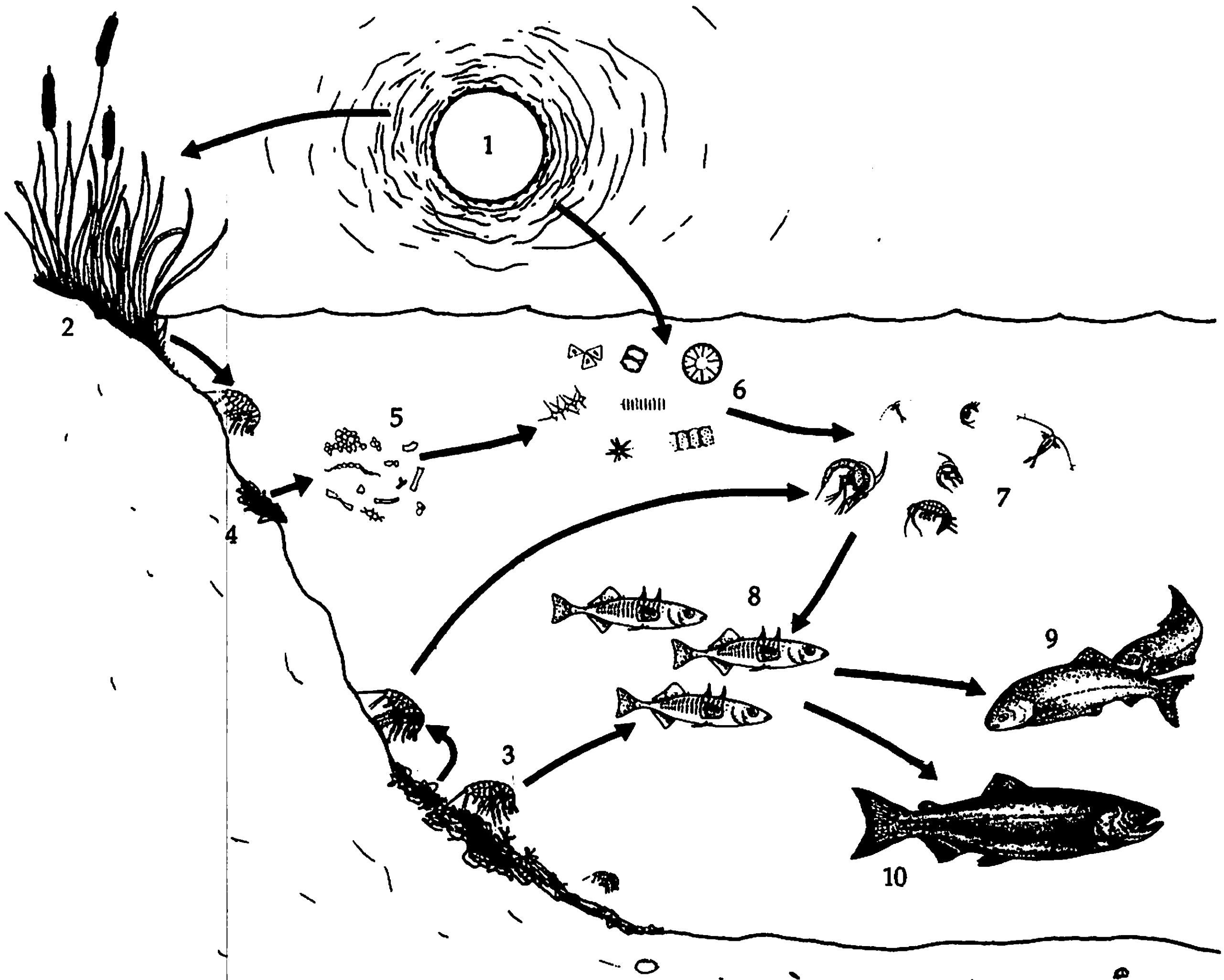
4. Ask the following questions:

- What did they observe? (The clear freshwater floats on top of the blue saltwater.)
- Why? (The freshwater is lighter and less dense than the saltwater.)
- Where might this happen? (At the mouths of river, anywhere where fresh and saltwater meet.)

5. Now gently stir the water. What did they observe? (The water mixes.) How would this mixing happen? (Currents, winds, the twice daily ebb and flow of tides.)

Project the transparency, "The Estuary Food Web." Place sticky papers over the food chain arrows. Ask the students to suggest reasons why salmon would congregate in estuaries. Ask them to infer whether or not they think a great variety of plants and animals live in an estuary. (Although estuaries produce large populations of organisms and therefore a rich food supply, the variety of plants and animals is small because it's difficult to live where home is sometimes freshwater and sometimes saltwater.) Ask the students to draw a food web, using arrows to show the direction of food energy flow from the prey to the predator.

The Estuary Food Web



(1) Sun; (2) cattails; (3) amphipods; (4) detritus; (5) bacteria; (6) plant plankton; (7) animal plankton; (8) Stickleback; (9) immature Chinook; (10) adult Chinook.

Salt Marshes

Concepts

1. Marshes are broad, wet areas where grasses dominate.

2. Estuaries and marshes serve as nurseries, feeding places, and shelter for a wide variety of wetland animals.

3. The number of species of plants and animals present is often greater at an environmental boundary, where land meets the sea, freshwater meets saltwater, or air meets a water-filled environment. Biologists call this phenomenon the "edge effect."

Pickleweed

Understandings

The students will 1) identify plants and animals that live in marshes, 2) construct a mural of a salt marsh, 3) construct a food web for a salt marsh, 4) brainstorm the importance of estuaries and salt marshes, 5) research how human populations and industries can damage estuaries.

Materials

Field guides

Photocopies of "The Salt Marsh"

Teacher Information

Marshes are low-lying, nearly flat marine wetlands that form a unique habitat for wildlife. When they are located along the margins of ponds, streams, or rivers, they are freshwater marshes. When they occur on ocean coasts or along the banks of estuaries, they are saltwater marshes. Saltwater marshes are the nurseries of the sea. They are the most productive land on earth, producing three times more than the best wheat lands.

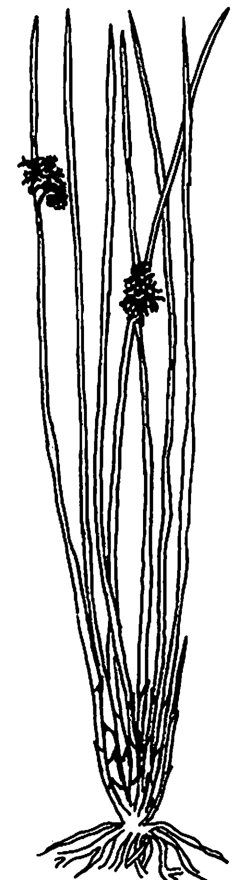
Biologically, marshes are transitional between wet and dry areas, and they are very productive in terms of the plants and animals they can produce. The main producer for this important ecosystem is the salt marsh grasses. The collection of organisms in salt marshes is often more complex and diverse because of the mixture of both fresh and saltwater.

With time, decaying plant materials and sediments accumulate, depleting the oxygen supply and increasing the accumulation of hydrogen sulfide in the mud. This gives salt marshes a characteristic rotten-egg odor.

Marshes can be huge, with hectares of grasses dominating resembling a flat pasture. They occur in a variety of climates ranging from temperate to arctic. In temperate regions, salt marshes are one of the most productive ecosystems on earth, producing up to two times as much plant food as the most fertile agricultural lands. In arctic and subarctic coastal marshes in British Columbia and Alaska, vegetation is sparse and species diversity is low.

The salt marsh is continuously changing. During high tide, dense vegetation slows down water movement. This causes deposition of mud and silt contained in the water. With time, decaying plant material and sediment accumulate. These in turn elevate the marsh, making it no longer intertidal. Other plants invade the habitat, and a new type of community eventually develops.

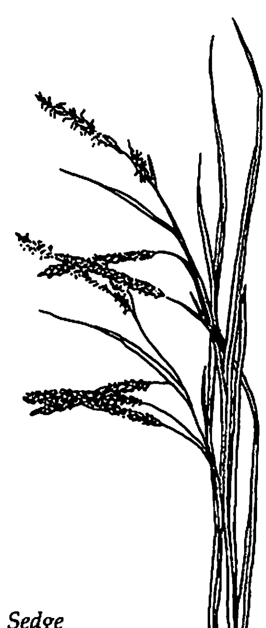
Freshwater flooding and tidal cycles can cause wide changes in salinity. Evaporation increases the salinity of the water. It can also leave heavy salt deposits in the mud. Freshwater runoff during the spring helps to reduce salinity. The tidal cycles also cause wide ranges in temperatures in the marsh. Thus, salt marsh organisms must be able to withstand wide-ranging temperatures, variations in salinity, limited oxygen, and tidal cycles. The oxygen supply in the water is generally sufficient. However, it is absent in mud. Bacterial decomposition in the mud quickly depletes the oxygen. A byproduct of bacterial decomposition without oxygen is hydrogen sulfide, which accumulates in the mud. This gives marshes a characteristic rotten-egg odor.



Rush

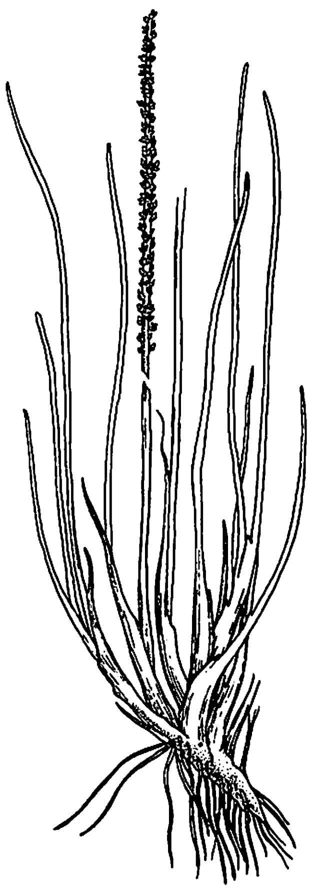
Cattails, horsetails, rushes, sedges, buttercups, asters, and many types of grasses are most likely to live at the upper level of tidal influences, where tidal inundations occur only a few times a year. Salt marsh grasses actually thrive in the nutrient-rich waters where saltwater from the ocean mixes with freshwater from the land. Saltgrass and arrow grass are the most prominent salt-tolerant grasses and plants able to tolerate salt spray along the edge of the marsh. Pickleweed and sometimes eelgrass forms thick growths at the edge of the lower marsh. A salt marsh is always producing new grass as old grass dies. Bacteria promote the decay of the marsh grass, which in turn produces detritus. Snails, crustaceans, and some fishes feed on decomposed marsh grasses. These detritus eaters serve as food for crabs, birds, and fishes; including blennies, soles, sculpins, smelt, salmon, and flounder. Filter feeders such as clams, mussels, barnacles, and oysters feed on the rich planktonic waters.

Salt marshes are necessary as nurseries, feeding places, and shelter for a wide variety of wetland animals. They are important spawning areas for salmon, and countless birds depend on them for food and nesting sites. Ducks that use them are the Canada Goose, Snow Goose, Mallard, Northern Pintail, Bufflehead, American Widgeon, Greater Scaup, Common Loon, and American Coot. Other common aquatic birds include the Bald Eagle, Great Blue Heron, Osprey, Killdeer, Spotted Sandpiper, Kingfisher, Dunlin, Plover, Crow, Barn Sparrow, Fly Catcher, and gulls. Raccoons, mink, and river otters are common predators that feed on nearly everything present. Grasshoppers, frogs and toads, salamanders, dragonflies, water striders, and crayfish flourish in the freshwater wetlands above the salt marsh.



Sedge

Procedures



Arrow Grass

1. Show the students the transparency, "The Salt Marsh." Brainstorm what the students think a salt marsh is. Record all their ideas. Use the key to identify organisms and locate the ocean, river, high marsh, and low marsh.

2. If possible, locate a salt marsh on a map. Look for incoming freshwater streams. What can the students infer about salt marshes from a map?

3. Discuss the salt marsh in terms of the plants and animals that live there. Also, discuss the importance of the salt marsh as a habitat for a wide variety of wetland animals. What characteristics of the salt marsh make it a good place for providing nurseries, feeding places, and shelter for wetland animals? Discuss the importance of salt marsh grasses for food and shelter.

4. Brainstorm limiting factors for the salt marsh. (Extreme changes in temperature, salinity, oxygen.)

5. If salt marsh organisms must be adapted to withstand extreme changes, what makes it such a productive ecosystem? (Rich nutrients, decaying plants, shelter, plankton.)

6. Write the term "edge effect" on the blackboard. Ask the students to identify the characteristics of the salt marsh that fit the definition: (a boundary between the ocean and the land, between air and water, between freshwater and saltwater).

7. Draw a feeding web for the salt marsh. Give the students photocopies of "Food Web for a Salt Marsh," page 263; only use white out to delete the arrows. Give students photocopies of the Teacher Information for "Salt Marshes." Challenge the students to identify marsh plants and animals and draw arrows to show the direction of food energy flow. Discuss the role of decomposition and detritus in the marsh food web.

Enrichment Activities

1. Visit an estuary and/or salt marsh equipped with cameras, binoculars, and field guides. While there, do sensory awareness activities. The students should sit quietly and describe everything perceived by their senses. Record man-made and natural objects. Make photographic essays of all their discoveries.

Saltgrass

2. If possible, dig a hole in the salt marsh sediments. Smell the bottom sediments. What does it smell like? (Rotten eggs.) (The smell comes from the presence of hydrogen sulfide, a byproduct of bacterial decomposition in the presence of oxygen.)

3. Construct a mural or model of a salt marsh. Use the Pacific Coast Information Cards and local field guides to identify organisms for your area. Construct a local food web by placing arrows in appropriate places. Or, connect each plant and animal with yarn.

4. Salt marshes, mud flats, and estuaries are important wetland ecosystems, yet they are disappearing rapidly. Find out what is happening to these ecosystems near you. What is being done to preserve these important systems?

5. Write letters to editors and local and federal governments expressing feelings and concerns about wetlands. Design a brochure to teach about their local wetlands.

Wetland Metaphors

Concepts

1. Wetlands provide food, shelter, safety, and breeding places for a variety of wetland organisms.

2. Wetlands absorb excess water and prevent flooding and erosion.

3. Wetlands can trap and filter out toxins and impurities from the water.

Understandings

The students will be able to 1) describe the characteristics of wetlands, 2) infer connections between wetlands and metaphorical objects, and 3) design a metaphorical poster depicting the ecology of wetlands.

Materials

Egg beater	Electric fan
Sponge	Curtains
Blanket	Soap
Coffee filter	Jewel
House key	Blanket
Umbrella	Strainer/sieve
Mouse trap	Cradle
Thermos bottle	Environmentally friendly soap
High-fiber cereal	

Teacher Information

Many abstract concepts such as habitat, adaptation, food energy flow, interconnected, system, decomposition, recycle, and ecosystem can be explored through metaphors. A metaphor represents a concept or idea through another concept or idea. "A salt marsh is a nursery" works because the nursery is literally a metaphor for the abstract concepts of birth, nourishing, growth, life cycle, and reproduction. "The salt marsh is a blanket" works because marsh grasses and plants provide protection from sun, rain, and freezing cold. The "sponge" metaphor works because healthy wetlands literally act as a sponge that absorbs excess water and prevents floods and erosion. In dry periods, wetlands hold precious moisture after open bodies of water have disappeared. "The salt marsh is a filter" works because wetlands are literally filtering systems that have the unique ability to purify the environment. For example, some wetlands can trap and decompose sewage waste; others, especially along shorelines, allow silt to settle and promote the neutralizing of many toxic substances. Through photosynthesis, plants add oxygen to the system and through growth keep nutrients from reaching toxic levels.

The chart on the next page helps make connections between abstract marine ecology concepts and concrete metaphorical objects.

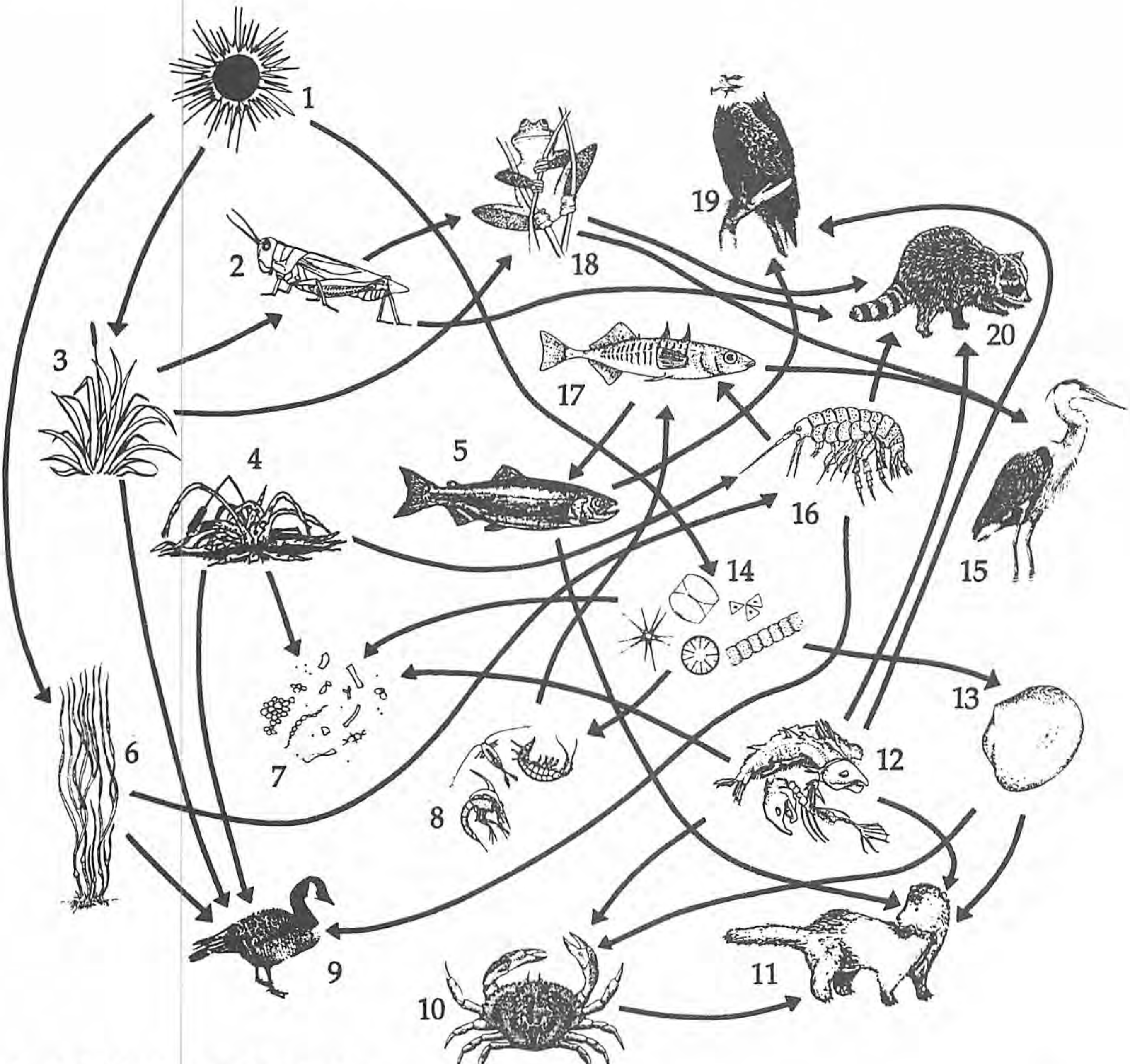
Metaphorical Comparison	Metaphorical Object	Metaphorical Function
Sun	Electric heater	Produces energy, heat
Wind	Electric fan	Circulates air, oxygen, CO^2
Marsh grasses	Blanket/Thermos bottle	Provides cover, protection
Water currents	Egg beater	Mixes nutrients, oxygen
Freshwater or saltwater	Can of vegetable beef soup	Plant Plankton
Marsh vegetation	Cradle, baby blanket	Acts as a nursery for young
Wetland bottom	Sponge	Retains moisture
Wetland plants and animals	High-fiber cereal	Provides food and nutrients
Marsh vegetation	Umbrella	Protects from sun and storms
Wetlands	Sieve or strainer Mouse trap	Strains or traps large silt and debris from water
Wetlands	Coffee filter	Filters out fine silt and debris
Wetland vegetation	Compost	Decomposes materials
Wetlands	Detergent	Cleanses impurities, toxins
Wetlands	Jewel/gift	Is precious, invaluable

1. Review the characteristics and basic ecological activities of estuaries. Brainstorm different types of wetlands. What characteristics do all wetlands have in common?

2. Write the following chart on the blackboard:

Characteristics of sponges	Characteristics of Wetlands
Have lots of holes of various sizes	
Can be any shape	
Absorbs water	
Can retain water for long periods	
Can be wrung out and loose water	
Can clean up dirt and grime	
Can deposit dirt and grime elsewhere	
Can be worn out and destroyed	

3. Ask the students to brainstorm words that describe sponges. Accept all their responses. Then ask the students to brainstorm ways that wetlands could be viewed as having the characteristics of a sponge. List these under "Characteristics of Sponges." Then ask the students to decide whether the characteristics of a sponge are similar to the characteristics of a wetland. Place two ** in the right-hand column if there is a very strong similarity. Place one * in the right-hand column if there is some similarity. Place an X in the right-hand column if there is no similarity. Try this same activity for the "wetland is a nursery" metaphor.



Food Web for a Salt Marsh

(1) Sun; (2) grasshopper; (3) bullrush (4) decaying bullrush; (5) Chinook salmon; (6) Eelgrass; (7) bacteria; (8) animal plankton; (9) Canada Goose; (10) Dungeness or Edible Crab; (11) mink; (12) decaying salmon; (13) Sand Clam; (14) diatoms; (15) Great Blue Heron; (16) amphipod; (17) Stickleback; (18) frog; (19) Bald Eagle; (20) raccoon.

4. Now, divide the class into five or six groups. Give each group a mystery box of metaphoric objects. Each group should brainstorm how the object could represent what a wetland is or does.

5. You might want to photocopy the "Teacher Information" for wetlands for each group of students. The students could read the information and make connections between the information sheets and the box of objects.

6. Announce that in 15 minutes you will want someone from each group to report back to the class how the objects could represent life in an estuary. Invite the students to share what they imagined.

7. Brainstorm all the ways that wetlands can be viewed as a special "gift" or "jewel." Encourage the students to appreciate the value of wetlands.

Enrichment Activity

Ask the students to design a metaphorical wetland poster: the wetland as a jewel, a sponge, a nursery, etc. The posters should illustrate the ecology of wetlands and encourage people to care for the preservation of wetland habitats and organisms.

This lesson is adapted with permission from Project Wild.

The Mud Flat

Concepts

1. All true mud flats are subject to the rise and fall of the tides.

2. Life in a mud flat is extremely difficult because of the few hard surfaces to serve as places of attachment, and the great problems of breathing, moving, and food gathering.

3. Compared to a rocky shore, mud flats support few species, but large populations of highly specialized animals.

Understandings

The students will be able to 1) determine which plants and animals live on a mud flat, 2) construct a map or mural of a mud flat, 3) identify limiting factors on a mud flat.

Materials

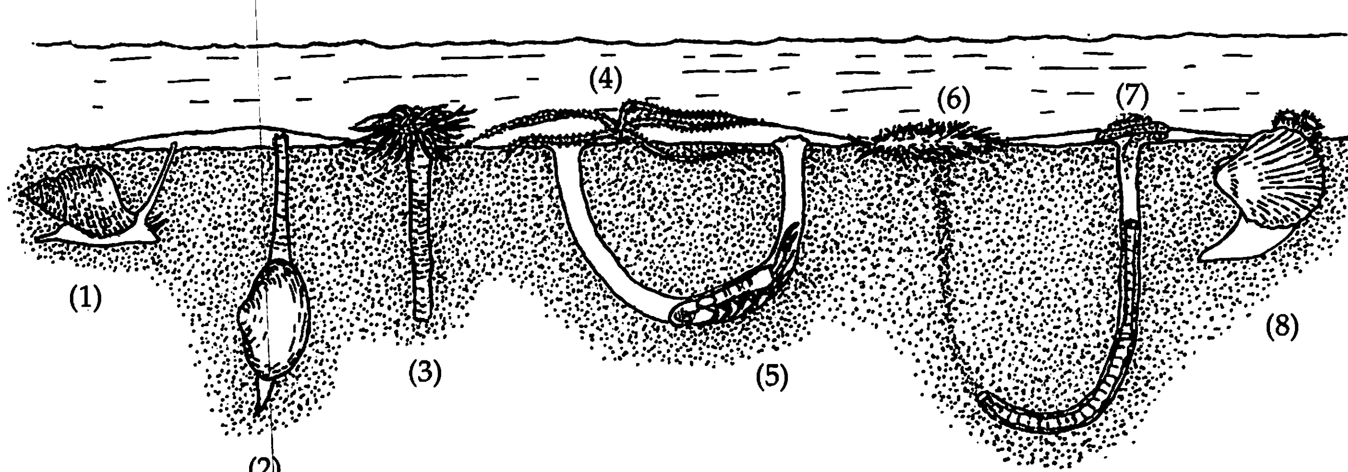
Field guides

Transparencies: "The Mud Flat" and "Adaptations of Mud Flat Animals"

Teacher Information

Mud flats occur where a river or stream enters a shallow bay or inland channel and deposits muddy sand, and because mud mixes with sand or gravel any combination is possible. Some are very firm and hard-packed, while others are like soup. But mud flats exist only on the most protected shores because strong currents or wave action would carry the mud and sandy sediments out to sea. All true mud flats are, however, subject to the rise and fall of the tides.

As the tide goes out, the mud flat looks disappointing: plants and animals aren't nearly so obvious or so spectacular as the colorful collection on a rocky shore. Mud flat animals, though, are just as intriguing and may be just as abundant, but are



Vertical cross-section through a mud flat. (1) Black Dog Whelk; (2) Mud Clam; (3) Tube-dwelling Naemone; (4) Brittle Stare; (5) Mud Shrimp; (6) Sea Mouse; (7) Lugworm; (8) Cockle Clam.

simply living underground and out of sight—at least while the tide is out.

Tidal waters prevent mud flats from completely drying up. However, water temperature fluctuates considerably during the tidal cycle. In the summer, the sun heats the mud flats during low tides. Cooler water is brought in with the incoming tides. In the winter the reverse is true.

Mud flats support large populations of highly specialized animals, including many clams and snails, a few crustaceans, and whole armies of worms. Evidence? The little piles of sand and mud around the openings to burrows, coiled fecal castings of worms, countless rambling slime trails, and empty clam shells. The surface teems with many kinds of microscopic organisms, including diatoms, and hordes of tiny crustaceans including amphipods and isopods. Mud flats also often produce thick planktonic blooms, which provide food for countless filter feeders.

For most rocky shore and sandy beach organisms, life in a mud flat would be extremely difficult because of the few hard surfaces available for attachment, and the great problems involved in breathing, moving, and food gathering. There are no sea urchins and few sea stars here, though sea stars do move down from rocky outcrops to prey upon clams and oysters. There are few animals here that breathe through the surface of their skins, and many fish and crabs cannot survive here because mud clogs their gills. On the other hand, animals that burrow under the surface are safe: wave action does not bother them, the blanket of mud protects them from extremes of temperatures, and they're in little danger of becoming dry when the tide goes out. Basically, animals living on a mud flat live in only two habitats: either on the surface or in shallow burrows beneath it. Though zones do occur, they are difficult to observe because so many of the animals live below the sediments.

Procedures

1. Ask the students the following questions: Has anyone visited a mud flat? What was it like? Have you ever walked in thick mud with boots on? What was it like to walk in the mud? Why is it so difficult to walk in mud?

2. Fill a quart jar with mud and water. Put a lid on the jar and shake it. Observe what happens to the particles of mud. When the tide comes in and goes out, how might the presence of mud particles in the water affect plants and animals living in a mud flat? Put mud and sand of various consistencies in pie plates and allow the students to observe the properties of mud and sand. How is mud different from sand? Infer how much oxygen is in mud. Would it be easy or difficult to breathe in a mud filled world?

3. If possible, take the students to a mud flat and dig a hole a foot or two into the mud, or bring a bucket of mud to school. (Mud from the bottom of a pond would be an excellent substi-

tute.) Smell the mud. Observe the color. Why is the smell so strong? Why is the color of the mud black? Ask the students to infer why the mud smells like rotten eggs. Discuss bacterial decomposition with and without air. (Decomposition without air produces the smell.)

4. What would be the problems of living on a mud flat? What are the limiting factors? (Discuss the problems of moving, getting food, drying up, getting oxygen.)

5. Why are burrows comparatively safe places?

6. Consult local field guides to identify mud flat organisms. What kinds of organisms live in mud flats? Where in the mud flat do these animals live? The students should report their findings back to the class.

Brain-Buster Questions

1. Explain why a mud flat is considered a harsh environment. Or, in different words, why do so few plants and animals appear to live on a mud flat?

2. Describe how a stream or river affects a mud flat.

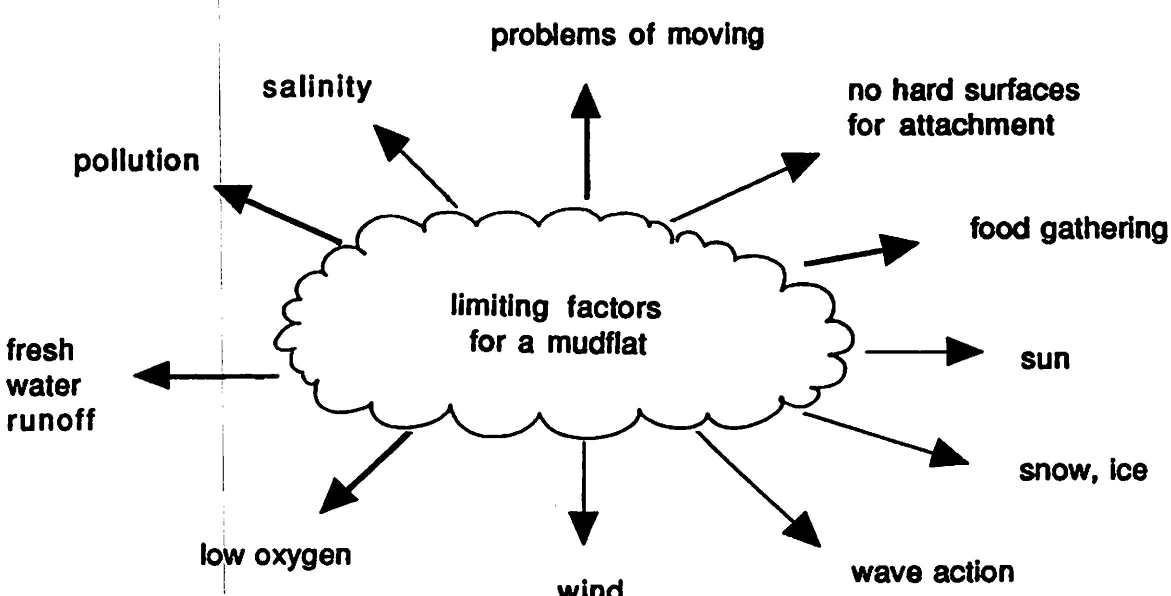
3. Why do mud flat animals live either on the surface or in shallow burrows beneath the surface?

4. What changes occur in a mud flat between high tide and low tide?

5. What changes occur seasonally?

6. Why do large numbers of shorebirds frequent mud flats?

7. Why are mud flats always located on a protected shoreline?



Adaptations of Mud Flat Animals

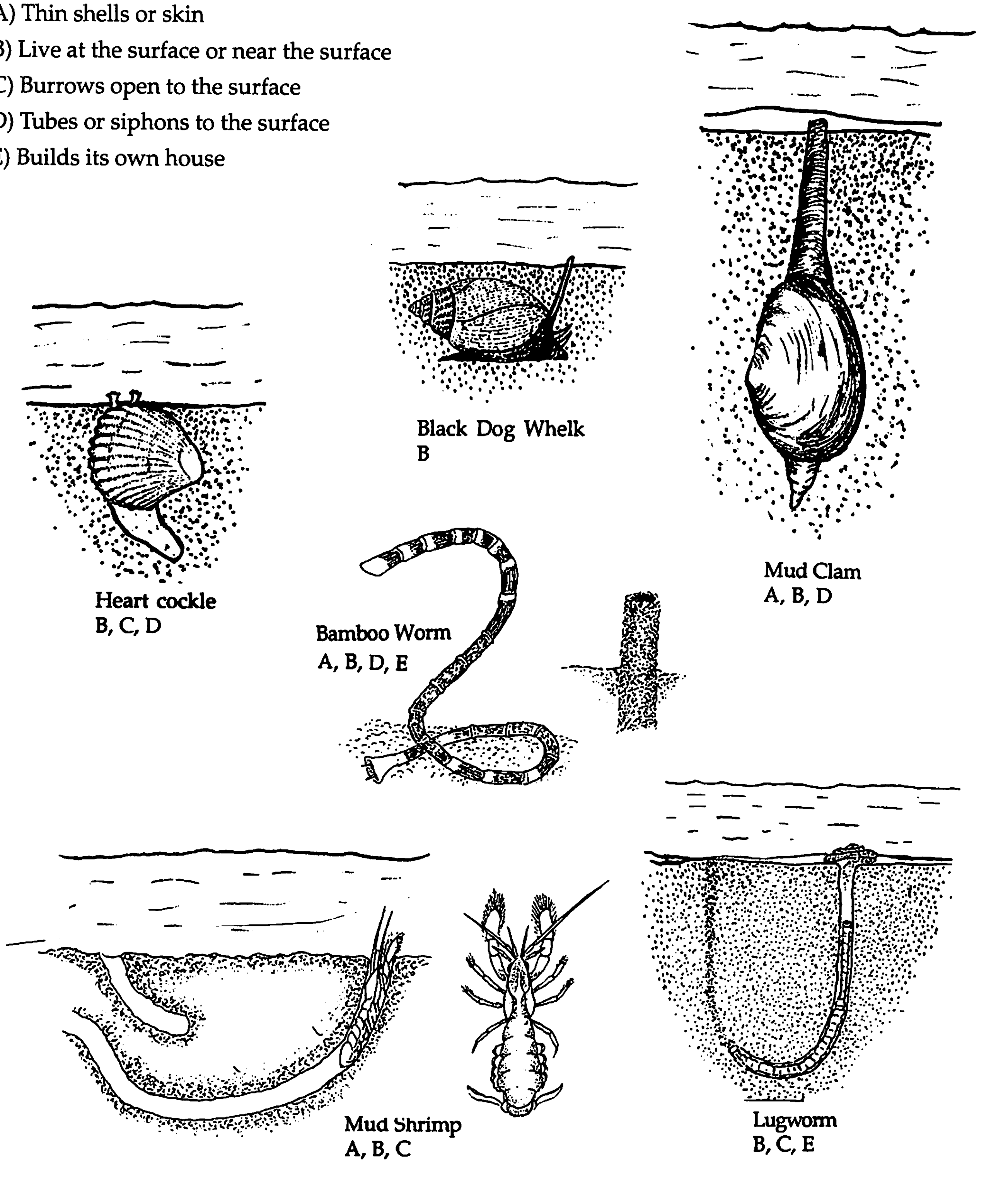
(A) Thin shells or skin

(B) Live at the surface or near the surface

(C) Burrows open to the surface

(D) Tubes or siphons to the surface

(E) Builds its own house



Imagine a Fish

Concepts

1. Marine fish are adapted to specific types of environments, e.g., kelp forest, eelgrass bed, sandy beach, rocky shore, deep sea.

2. Marine fish are the products of countless adaptations over long periods of time.

3. Adaptations are features that increase the animals' likelihood of surviving and reproducing in their environment.

Understandings

The students will be able to 1) describe the adaptations of fish to their habitat, 2) paint a mural of a specific marine habitat, and 3) invent a fish to survive in its habitat.

Materials

Butcher paper

Crayons

Pastels

Finger paint

Glue bottles

Scissors

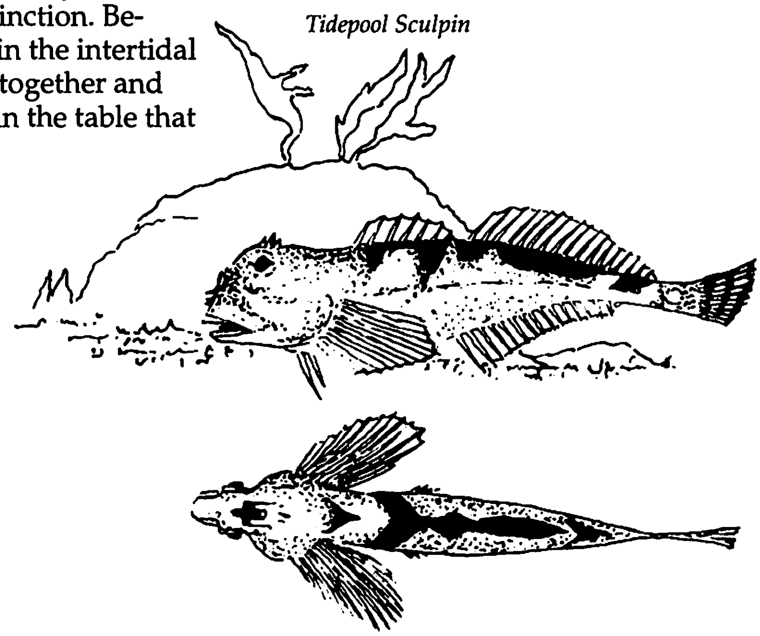
White paper

Teacher Information

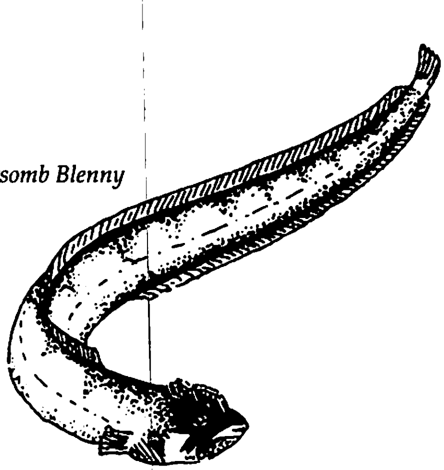
All plants and animals are the products of countless adaptations that have evolved over a long period of time. These adaptations are features that increase the organisms' chances for surviving and reproducing in their particular habitat.

When a habitat changes, plant and animal species with adaptations that allow them many options are the ones most likely to survive. Some species have adapted to such a narrow range of habitat conditions that they are extremely vulnerable to change. They are overspecialized and are usually more susceptible than other animals to death or extinction. Because of the variety of habitats that exist within the intertidal and in the ocean, many different fish can live together and flourish. Some adaptations of fish are shown in the table that follows.

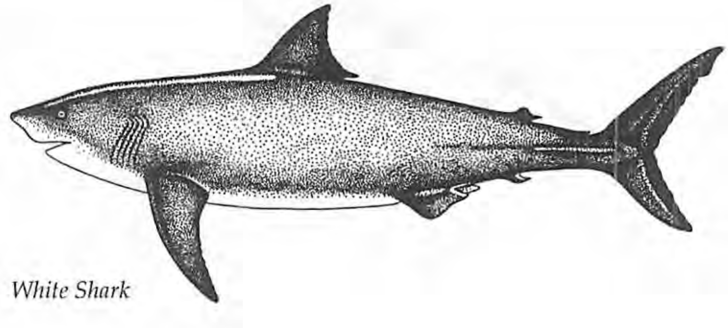
Tidepool Sculpin



High Cocksomb Blenny



Adaptation	Advantage	Examples
Coloration		
Dark upperside	Predators have difficulty seeing it from above	Flounder, sole, halibut herring, perch
Light-colored belly	Predators have difficulty seeing it from below	Perch, tuna, halibut
Mottled coloration	Can hide in rocks and on bottom	Sculpin, Rock Cod, Wolf Eel, High Cockscomb Blenny, Rock Bass, Greenling
Stripes, either vertical or horizontal	Can hide in vegetation	Yellow and White Bass, Striped Bass, Kelp Bass
Black, metallic, bioluminescent	Can hide in darkness, can attract predators, mates	Viper Fish, Hatchet Fish, Angler Fish
Body Shape		
Elongate	Slithers over and under rocks, into holes	High Cockscomb Blenny, Wolf Eel
Flat bellied	Bottom feeder	Tidepool Sculpin, Northern Cling Fish
Torpedo shape	Fast moving	Salmon, tuna, barracuda
Horizontal disk	Bottom dweller	Sole, flounder, halibut
Hump backed	Stable in fast moving water	Sockeye Salmon, Chinook
Vertical disk	Feeds above or below	Butterfly Fish, Sunfish
Mouth		
Elongate upper jaw	Feeds on prey it looks down on	White Shark
Elongate lower jaw	Feeds on prey it sees above	Barracuda
Extremely large jaws	Surrounds prey	Bass, grouper, sculpin
Extremely large jaws and extremely long teeth	Surrounds and swallows prey much larger than itself	Hatchet Fish, Angler Fish, Viper Fish, Lantern Fish
Doglike teeth	Crushes prey; urchins, crabs, and invertebrates	Sheephead, Wolf Eel, Moray Eel, Garibaldi

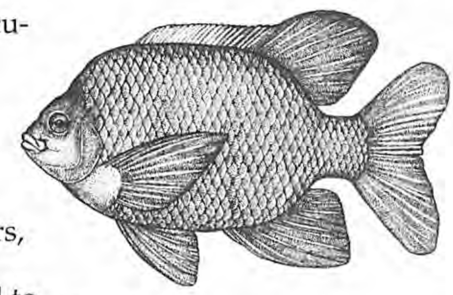


White Shark

Procedures

1. Ask the students to recall their favorite fish. Are all fish shaped the same? Colored the same? Why are there so many different shapes and colors of fishes? Conduct a discussion on the value of different kinds of adaptations to animals.

2. Tell the students that they're going to design a fish to live in a particular type of marine habitat. Write the following habitats on the blackboard:



Garibaldi fish

Eelgrass bed	Rocky shore	Kelp forest
Rockweed bed	Sandy shore	Deep sea

For each type of environment, ask the students to brainstorm the colors, shapes, shadows, etc. that would be typical of that environment. For example, rocky shores tend to be dark and mottled; eelgrass beds tend to be elongate and bright green; kelp is elongate and olive or light brown; sandy beaches tend to be light or dark brown with speckled sand grains and possibly circular pebbles; the deep sea is virtually black. Discuss how many eelgrass bed animals are well camouflaged to blend perfectly with their surroundings; for example, how the color and shape of many eelgrass animals match the color and width of eelgrass stems and fronds (pages 245-247).

3. Divide the class into five groups with five or six students in each group. Have each group choose one type of environment. If this isn't possible, put the names of the six habitats listed above in a hat. Allow one student from each group to choose a take a piece of paper. The students should research the types of adaptations typical of that environment.

4 Give each group of students a piece of construction paper approximately 1.5 meters long. They are to use pastels and crayons to draw a picture of their environment. Then each student in the group is to invent an imaginary fish that is adapted to live in the students' particular environment. They should brainstorm amongst themselves the physical characteristics of the environment and the special adaptations that will best enable their fish to survive. They should consider the color, shape, mouth parts, fins, etc. Then cut out and paste their fish onto the habitat mural.

5. An alternate method is to have students invent a fish and draw their own background, rather than create a group mural.

6 Ask each group to report to the rest of the class about the characteristics of the fish they have designed, including its name, identifying features, adaptations, predators and prey. How is their fish adapted for survival?

Enrichment Activities

1. Research various interesting fish.

2. Make a collection of actual fish pictures. Classify the set of pictures according to their own classification system.

3. Ask the students to categorize the class's imaginary fish according to their own classification system.

4. Look at examples of actual fish. Speculate on the fishes' actual environment by examining their color, shape, mouth parts, etc.

Invent a Lifelike Imaginary Animal

Tell the students that today they're going to invent a lifelike animal that is equipped to survive in one of the following places:

- A rocky shore
- A sandy beach
- A cobblestone beach
- An estuary
- A mud flat
- Eelgrass bed

Tell the students that all plants and animals are equipped to live in a special kind of surrounding. For instance, some animals must be able to survive varying differences in the amount of time that they're covered or uncovered with seawater. In addition, they must be able to live on a particular type of seashore.

To help students visualize the behavioral and structural adaptations of an animal, an imaginary activity can be used. For example, students can close their eyes and imagine they are an organism on a rocky shore. While their eyes are closed ask various questions that will enhance their imagery. How would you hold onto the rocks when the tide changes? How would you keep from drying out when the tide goes out? How would you protect yourself from predators at high tide? Would you sit and lie very still or get away quickly? Do you have camouflage? What do you eat? How would you capture and eat food? Depending on previous lessons, you might ask them to imagine themselves a predator, a grazer, a filter feeder, a scavenger, or a deposit feeder.

Once you have finished asking the above questions, have the students open their eyes and discuss what images, inferences, and observations they visualized for their organisms? Challenge the students to invent a lifelike imaginary animal. They should consider the following:

- What will it eat?
- Is the animal attached? If so, how?
- If the animal moves, how does it move: swim, fly, crawl, burrow?
- How will the animal capture its food? What special physical adaptations (equipment) will it have?
- How will the animal protect itself from predators?
- How will the animal keep from drying out at low tide?
- Will the animal be able to see, feel, and sense its surroundings? If so, how? What special adaptations will it have?

Each student should make a list of words that describe their animal's adaptations. They should write a paragraph describing the animal, its habitat, and how it is adapted to live in its habitat. Then, write a realistic story describing a day in the life of their imaginary animal.

Use a pencil to make several large sketches. Make one large sketch and use colored pencils to show its coloration. On one of the sketches you may want to label the parts.

Each student should make a presentation to the class. They should describe the animal's habitat and how it captures food and survives in its habitat.

The Study of Colonization

The study of succession is the study of how plants and animals establish themselves in new communities. Such a study is extremely valuable and very interesting, and although it requires patience, it is relatively simple and easy to carry out.

Succession on a Rock

Have the class select a large cobblestone or small boulder that is free of any marine plants and animals. The students should sketch the rock from various angles. Students with cameras should be encouraged to take photographs.

Have the students roll the rock into the middle tide or low tide zone. Sometimes it's a good idea to have the students draw a map of the beach that pinpoints the exact location of the rock. In this way other students can find the rock and contribute to the upkeep of a continuous record of growth. If possible, store this data on a computerized database system.

The students should keep a record of the order (colonization) in which all new plants and animals settle on the rock. They should record the date, time, temperature, and tide level when making observations. In addition, they should continue to sketch the rock and take photographs during the entire school year. The students should visit the rock whenever low tides occur. They should try to visit the rock at least once every two to three weeks.

Colonization of a Tire

An alternate method that works nicely is to attach a rope to a car tire. Secure the rope to a pier or wharf and lower the tire over the side into deep water. Keep a record of colonization over time.

1. What are the first plants and animals to settle on the rock or tire?

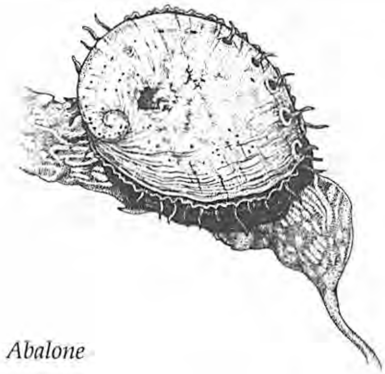
2. Why are barnacles one of the first animals to attach? During what months do they attach?

3. What are the last plants and animals to settle on the rock? Why were these organisms unable to colonize the rock earlier?

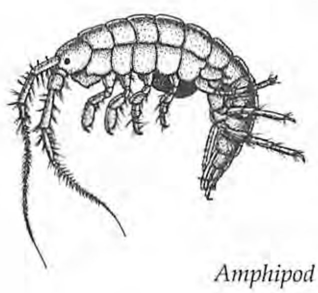
4. For each new plant or animal that colonizes the rock what are the environmental conditions necessary for the organism to survive there?

5. Why are the animals on the tire so different from the animals on the rock? Why would the animals living inside the tire be different from those living on the outside?

Seventh-grade students observing the diversity of organisms that attach to boat ramps and dock pilings, such as sea anemones, tube worms, sponges, nudibranchs, sea stars, and seaweeds.



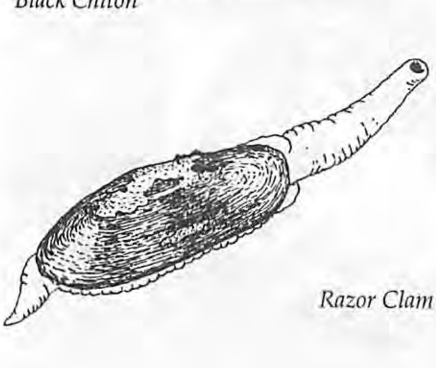
Abalone



Amphipod

Small Acorn Barnacle

Black Chiton



Razor Clam

Appendix

Illustrated Glossary

Abalone. A large snail valued both for food and for its single, flattened shell lined with mother-of-pearl.

Adaptation. The gradual changing of structure, form, or behavior of a plant or animal to increase its chances of survival and reproduction.

Amphipod. Tiny crustaceans, about 5 to 10 mm in length, with short antennae and flattened bodies, feeding on detritus, and themselves the food of countless marine animals.

Barnacle. Any of several species of small sea animals related to crabs with a cone-shaped shell. The larvae cement themselves permanently to rocks, wharves, and the bottom of ships to grow to adulthood.

Bacteria. (pl.) Any of numerous ,widely distributed, simple, one-celled microorganisms, important in the decomposition of plants and animals.

Bivalve. A group of soft-bodied organisms that live enclosed in two shells and have a muscular foot and siphons (e.g., mussels, clams, oysters, scallops).

Bladelet. The small, flat blades protruding just above the hold-fast of some seaweeds.

Burrow. A hole or tunnel under the sediments in mud, sand, or a combination in which some animals (most clams, sandworms, and mud shrimp) spend a portion of life.

Byssal threads. Strong threads produced by a gland attaching mussels and some clams and oysters to rocks and hard surfaces.

Camouflage. A color pattern enabling some animals to hide in, or blend in with, their surroundings.

Carapace. The hard outside covering of crab bodies.

Carnivore. An animal feeding on the flesh of other animals.

Chiton. Any of several species of primitive sea animals related to snails having a shield made up of eight separate plates; a girdle that may be scaly or bristly; and a large, flat, muscular foot that allows the animal to adhere tightly to rocks.

Clam. Any of a group of bivalves with siphons to draw in and out for eating, a large mantle cavity, a hatchet-shaped foot for digging, and living partly or wholly buried in sand, mud, or gravel.

Consumer. An animal that eats plants or another animal for food.

Community. A group of plants and animals living in the same area and depending on one another for survival.

Competition. When two or more organisms attempt to use the same limited resource, as when organisms compete for food and space.

Crab. A crustacean having a flattened body, four pairs of legs, plus a pair of grasping claws, and a reduced abdomen.

Crustacean. A group of animals characterized by a hard outside shell, antennae, mandibles, and compound eyes (e.g., lobsters, crabs, shrimps, amphipods, isopods, and barnacles).

Currents. Mighty rivers of moving ocean water that occur both at the surface and ocean bottom.

Desiccation. When a plant or animal is exposed to the sun or wind and it is unable to maintain needed moisture, and dries out.

Detritus. Small particles of dead plant and animal matter.

Decomposer. Those organisms such as bacteria that obtain energy by breaking down dead plants and animals.

Diatom. A one-celled microscopic plant living in water, some forming a major component of plankton and others creating the thin brown scum on the bottom.

Dinoflagellate. A type of plantlike organism found in the plankton, often having one or two whiplike tails used for locomotion.

Ecology. The study of how organisms interact with the physical (nonliving) and biological (living) parts of their environment.

Ecosystem. A unit consisting of a community interacting with its physical environment.

Endangered. Any indigenous plant or animal whose existence is threatened with extinction through all or a significant portion of its range, owing to the action of humans.

Environment. The combination of all factors that affect and influence the growth, development, and reproduction of organisms—water, air, vegetation, animals, human elements, climate, and location.

Estuary. The wide mouth of a river that flows into the sea and into which the tide flows.

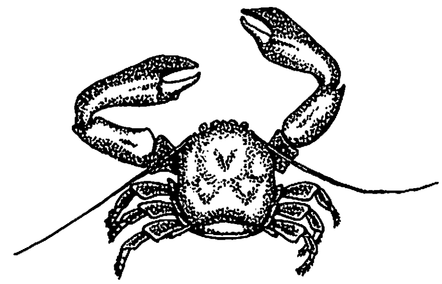
Exploiters. People who take from an environment for profit without putting anything back to conserve it, e.g., early fur traders, modern companies that overfish the seas, companies that dump pollutants in the ocean.

Extinction. The complete elimination of a species with no survivors.

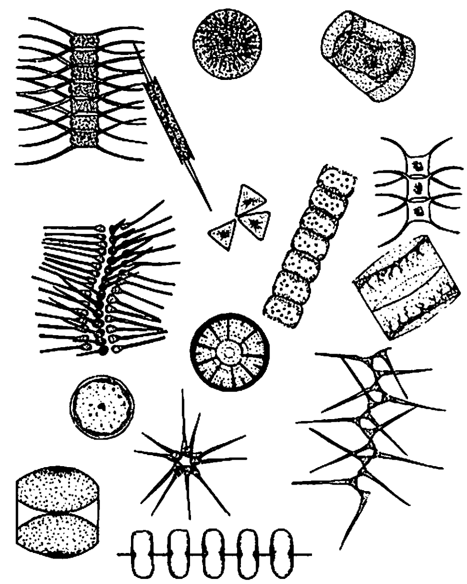
Exposed shore. A coastline that has no offshore islands to shelter it, or bays and inlets to provide shelter from the full force of waves.

Feces. Solid waste material passed out from the body through the anus.

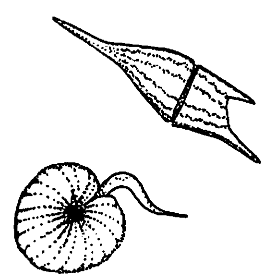
Filter feeder. An animal equipped with hairs, tentacles, sieves, or other devices for straining plankton and minute particles of detritus from the water (e.g., clams, oysters, mussels, tube worms, and barnacles).



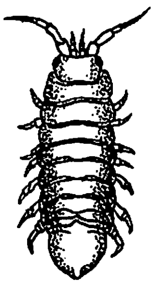
Porcelain Crab



Diatoms



Dinoflagellates



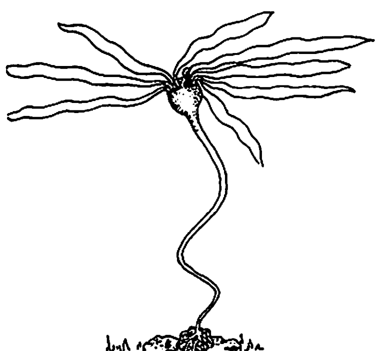
Rockweed Isopod

Food chain. The transfer of food energy from the source in plants through a series of animals, with repeated eating and being eaten (e.g., seaweed, seaweed-eating urchins, urchin-eating Sea Otters).

Food web. An interlocking pattern of food chains.

Frond. The blade-like or leaflike expansion of seaweeds in which the functions of stem and leaf are not distinguished.

Grazer. An animal that feeds on attached plants, seaweeds, and the film of diatoms and other tiny algae that carpet the rock surfaces.



Bull Kelp

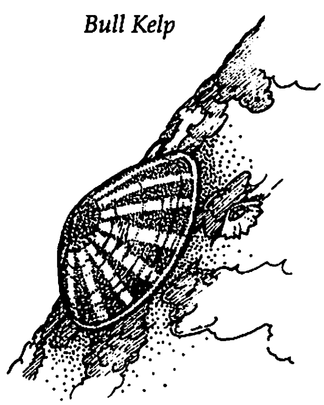
Habitat. The place in which a plant or an animal lives.

Herbivore. An animal feeding on plants (e.g., limpets, chitons, sea urchins, isopods, and many snails).

Holdfast. A structure anchoring seaweeds to rocks and other hard surfaces.

Intertidal. The area between the high tide mark and the low tide mark on a seashore.

Isopod. An animal with a long, flattened body, usually quite small, and having six pairs of short legs of about equal size, and one pair of modified legs.



Limpet

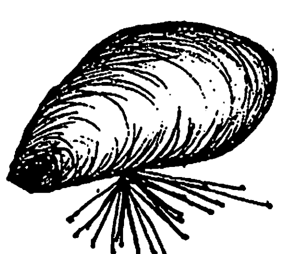
Kelp. Large, brown seaweeds with strong holdfasts.

Krill.

Larva. (larvae pl.) The free-swimming stage in the development of an animal. Often the larva appear different from the adult form.

Limpet. A slow-moving animal with a large, flat, muscular foot, and a hard shell into which the animal can withdraw.

Limiting Factors. Influences on an organism's ability to maintain its population (e.g., food, water, shelter, space, temperature, light, salinity, oxygen, type of bottom; as well as predators, competition, pollution, and overharvesting).



Mussel

Marine. Relating to the ocean.

Marine ecology. The study of the relationships among the organisms of the sea and relationships between these organisms and their environments.

Mud flat. A protected shoreline where a river or stream enters a bay or inland channel, where large quantities of mud accumulate, subject to the rise and fall of the tide.

Opalescent Nudibranch

Muscular foot. The wide, flat-ended or wedge-shaped muscle used for crawling or digging (found on snails, limpets, chitons, abalones, and clams).

Mussel. A bivalve clinging to rocks and pilings with byssal threads.

Niche. The role played by an organism in a community; its requirements for food and shelter, special behaviors, as well as its function (e.g., predator, decomposer, scavenger, and how it performs that function).

Nudibranch. A soft-bodied, slug-like, shell-less snail with exposed branched gills.

Ocean. A vast body of water occupying a major part of the earth's surface.

Operculum. A shell-like "trapdoor" used for closing the shell of a snail or the tube of a worm; a protective device for an animal that has withdrawn into its shell or tube.

Operculum on a Checkered Periwinkle

Organism. A single living plant or animal.

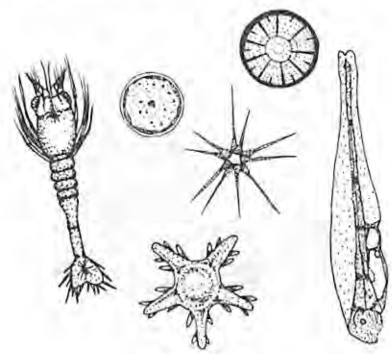
Oyster. A type of bivalve characterized by an irregular, double shell.

Japanese Oyster

Photosynthesis. The process in which the radiant energy of the sun is captured and used by plants to convert water and carbon dioxide into carbohydrates such as glucose, starch, and other food molecules.

Phytoplankton. The plant plankton, including diatoms and dinoflagellates.

Plankton. The often minute plants and animals drifting in the ocean currents; the food of filter-feeders.



Plankton

Population. A group of individuals of the same kind living and reproducing in an area. Population size is determined by the number of individuals in the group and not by the physical size of the individuals.

Predator. An animal that eats other animals; a carnivore.

Prey. An animal eaten by another animal.

Proboscis. Specialized mouth parts that can be extended for sucking.

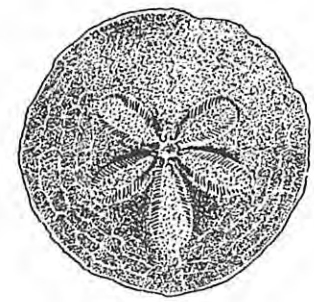
Producer. An organism that uses sunlight to convert carbon dioxide, water, and nutrients into food (e.g., plants).

Productivity. The amount of life (organic matter) produced in an area.

Protected shores. A coastline that has offshore islands to shelter it, or bays and inlets to provide shelter from the full force of waves.

Radula. A rasping, tonguelike structure used for scraping food from rocks and sometimes for boring through shells.

Range. The area in which members of the same species are distributed.



Sand Dollar

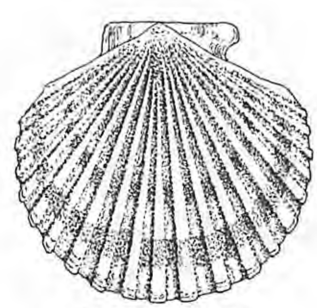
Regeneration. The ability to grow lost body parts, such as an arm or leg.

Reproduction. The process by which new members of a species are produced.

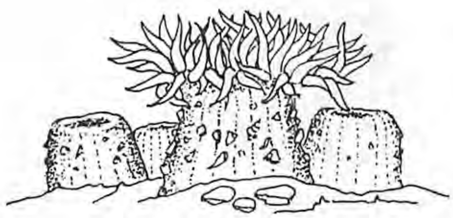
Salinity. The concentration of dissolved minerals, including salts, in water.

Sand Dollar. An animal with a very flattened, circular body (or test) covered with spines and showing the five-star pattern; related to sea stars, sea urchins, and sea cucumbers.

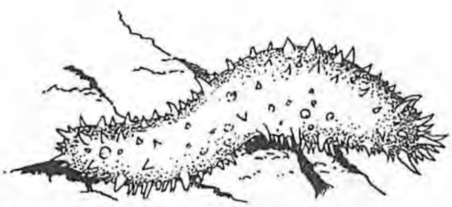
Scallop. A bivalve with a "scalloped" shell.



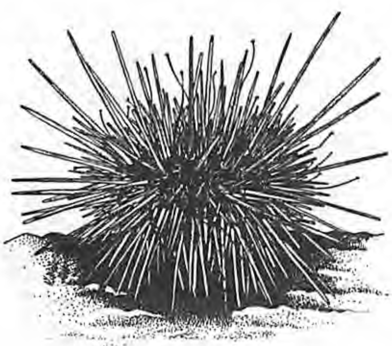
Pink Scallop shell



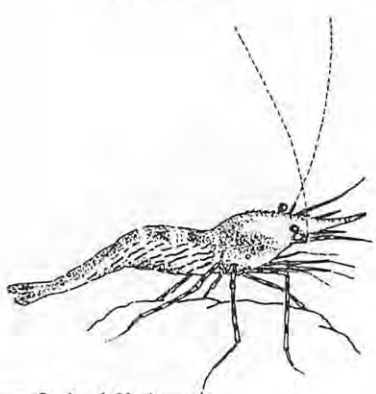
Giant Green Sea Anemone



Giant California Sea Cucumber



Red Sea Urchin



Coon-Striped Shrimp

Encrusting Sponge

Scavenger. An animal that eats the remains and wastes of other animals and plants.

Sea anemone. An attached marine animal with tentacles around the mouth opening, creating a flowerlike appearance. The tentacles have stinging cells which capture food.

Sea cucumber. An elongated animal with generally five rows of tube feet running the length of the body, and a ring of mop-like tentacles around the mouth. Related to sea stars and sea cucumbers.

Sea star. A star-shaped animal having a central area and five or more rays with tube feet which adhere firmly to rocks and aid in movement and food capture.

Sea urchin. Animals with long, bristling spines, tube feet, and five movable, toothlike parts in the mouth; related to sea stars, sea cucumbers, and Sand Dollars.

Seaweed. A marine plant, also called algae.

Shrimp. A long-tailed crustacean having a fused head and thorax, and powerful segmented abdomen.

Snail. A slow-moving animal with eyes sometimes on stalks, a muscular foot, and a hard coiled shell into which the snail can at least partially withdraw.

Species. (sp.) A particular kind of animal or plant able to breed with one another, but unable to breed with those of other species.

Stipe. The stem-like part of many seaweeds.

Sponge. A permanently attached animal having a soft, porous skeleton and being of various sizes, shapes, and colors.

Tentacle. A long, arm-like appendage, generally used for feeding.

Test. The external covering of the soft body of animals such as sea urchins and Sand Dollars.

Tides. The twice-each-day rise and fall of seawater.

Transitional shore. A coastline that can be calm, but suddenly become violent and change from "protected" into dangerously "exposed" shores.

Tube feet. Special attachment appendages for movement and for collecting food: as in sea stars, urchins, and cucumbers.

Wetlands. Any land area that tends to be regularly wet or flooded.

Zonation. An arrangement of plants and animals in horizontal levels on the shore.

Zooplankton. The animal plankton that includes permanent and temporary animals.

Plankton Sampling Equipment

Taking a sample of plankton can be quite easy and the equipment inexpensive. It's exciting to discover plankton in the classroom as the variety of organisms that can be collected is extensive.

Plankton nets are inexpensive and simple to make. Some students like to make their own nets and continue their studies at home. Here's how to make two different kinds of plankton nets.

Wire Hanger Plankton Net

Materials

A wire clothes hanger

25–50 meters of twine

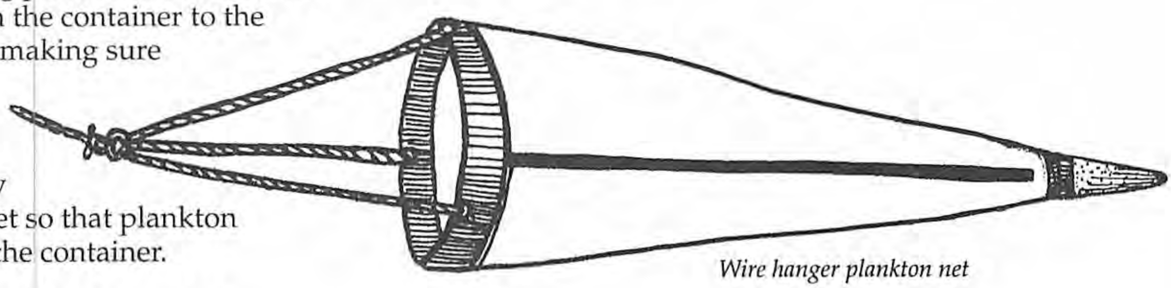
Cloth such as nylon or silk (parachute materials is best); nylon stockings work well for pond organisms, but "run" easily when used on barnacle-covered beaches

A long, narrow, tubelike container such as a plastic baby bottle, plastic test tube, pill bottle, plastic food container, etc. If a plastic food container is used, cut a hole in the lid and sew the lid to the material at the opposite end of the hoop. Choose a container the size of a cottage cheese container but with a tight-fitting lid.

A weight such as a fish weight, rock, water-filled container, etc.

Directions

Bend the clothes hanger into a hoop shape. Sew a cone-shaped, one-meter-long piece of the cloth to the hanger. Attach the container to the opposite end, making sure there is no leakage. Water should be able to flow through the net so that plankton can collect in the container.



Wire hanger plankton net

Hand-Held PVC Pipe Net

Equipment and Materials

Blister scope*

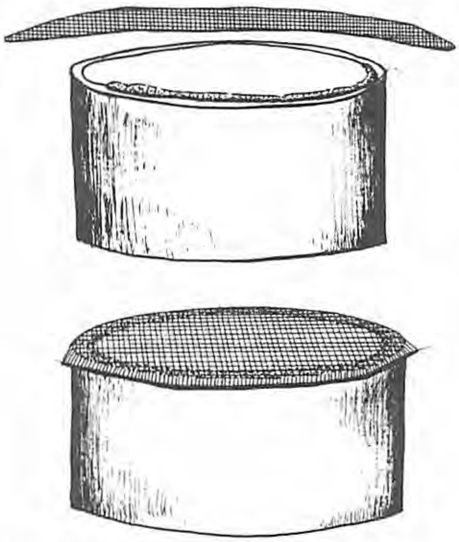
4-inch diameter PVC pipe cut into 3- to 5-inch lengths

Nytex*—plankton netting (80-micron mesh size will collect diatoms)

PVC pipe cement

Directions

Have the pipe cut into lengths so that the cut edge is relatively smooth. Apply the cement to the cut edge of the pipe and lay the plankton netting over the pipe. Smooth the netting over the cut edge so that it will attach smoothly to the cut edge. Let dry and trim the netting.



Hand-held plankton net

Collecting the sample

Take a bucket and pour several buckets of water through the hand-held net. The more water that is filtered, the better the sample. Rinse the filtered sample into a bottle and add several drops of water. Place a drop of the sample under a microscope and explore the fascinating world of plankton.

Blister scopes (or Discovery Scopes) provide high enough magnification to observe plankton. They are relatively inexpensive (about $50.00 each).

Supplies

*Nytex plankton netting may be ordered by the yard from:
Aquaculture Research Environmental Association
P.O. Box 1303
Homestead, Florida 33030
305-248-4205

*Blister scopes may be ordered from:
IMED
1520 Cotner Avenue
Los Angeles, California 90025
213-879-0377

Discovery Scopes may be ordered from:
Discovery Scope
15721 Bernardo Heights Parkway
Suite E, Box 401
San Diego, CA 92128-3159
1-800-398-5404
Web: www.discoveryscope.com

Field Guides

Class sets (10 or more copies) of *Exploring the Seashore in British Columbia, Washington and Oregon: A Guide to Shorebirds and Intertidal Plants and Animals*, by Gloria Snively, can be purchased at a 40% discount. Order from either of the following addresses:

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Metric and U.S. Measurement

Units of Measurement

Metric unit	Equivalent	U.S. unit	Equivalent
Length		**Length**	
1 centimeter (cm)	10 millimeters (mm)	1 foot (ft)	12 inches (in)
1 meter (m)	100 centimeters	1 yard (yd)	3 feet
1 kilometer (km)	1,000 meters	1 mile	1,760 yards
Area		**Area**	
1 square centimeter (cm^2)	100 square millimeters (mm^2)	1 square foot (ft^2)	144 square inches (in^2)
1 square meter (m^2)	10,000 square centimeters	1 square yard (yd^2)	9 square feet
1 hectare (ha)	1,000 square meters	1 acre	4,840 square yards
1 square kilometer (km^2)	1 million square meters	1 square mile	640 acres
Volume		**Volume**	
1 cubic centimeter (cc or cm^3)	1 milliliter (ml)	1 pint	34.68 cubic inches (in^3)
1 liner (l)	1,000 milliliters	1 quart	2 pints
1 cubic meter (m)	1,000 liters	1 gallon	4 quarts
Mass		**Mass**	
1 kilogram (kg)	1,000 grams (g)	1 pound (lb)	16 ounces (oz)
1 tonne (t)	1,000 kilograms	1 ton	2,240 pounds

Metric Units to U.S. Units (Approximate)

To convert	Into	Multiply by
Length		
centimeters	inches	0.39
meters	feet	3.28
kilometers	miles	0.62
Area		
square cm	square inches	0.16
square meters	square feet	10.76
hectares	acres	2.47
square km	square miles	0.39
Volume		
cubic cm	cubic inches	0.061
liters	pints	1.76
liters	gallons	0.22
Mass		
grams	ounces	0.04
kilograms	pounds	2.20
tonnes	tons	0.98

U.S. Units to Metric Units (Approximate)

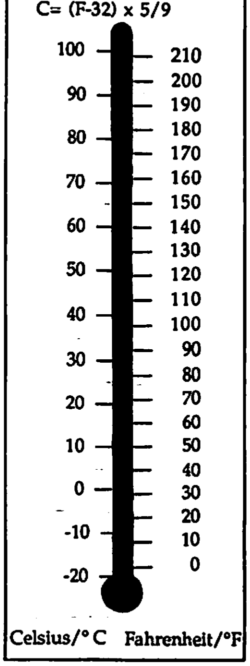
To convert	Into	Multiply by
Length		
inches	centimeters	2.54
feet	meters	0.30
miles	kilometers	1.61
Area		
square inches	square cm	6.45
square feet	square meters	0.09
acres	hectares	0.40
square miles	square km	2.59
Volume		
cubic inches	cubic cm	16.39
pints	liters	0.57
gallons	liters	4.55
Mass		
ounces	grams	28.35
pounds	kilograms	0.45
tons	tonnes	1.02

TEMPERATURE SCALES
Temperature is measured using a thermometer. This measures how hot or cold an object or person is. Some objects measure below zero degrees Celsius, the freezing point of water, below which the Celsius reading becomes a minus figure.

TEMPERATURE SCALES

To convert from Celsius to Fahrenheit:
$F = C \times 9/5 + 32$

To convert from Fahrenheit to Celsius:
$C = (F - 32) \times 5/9$



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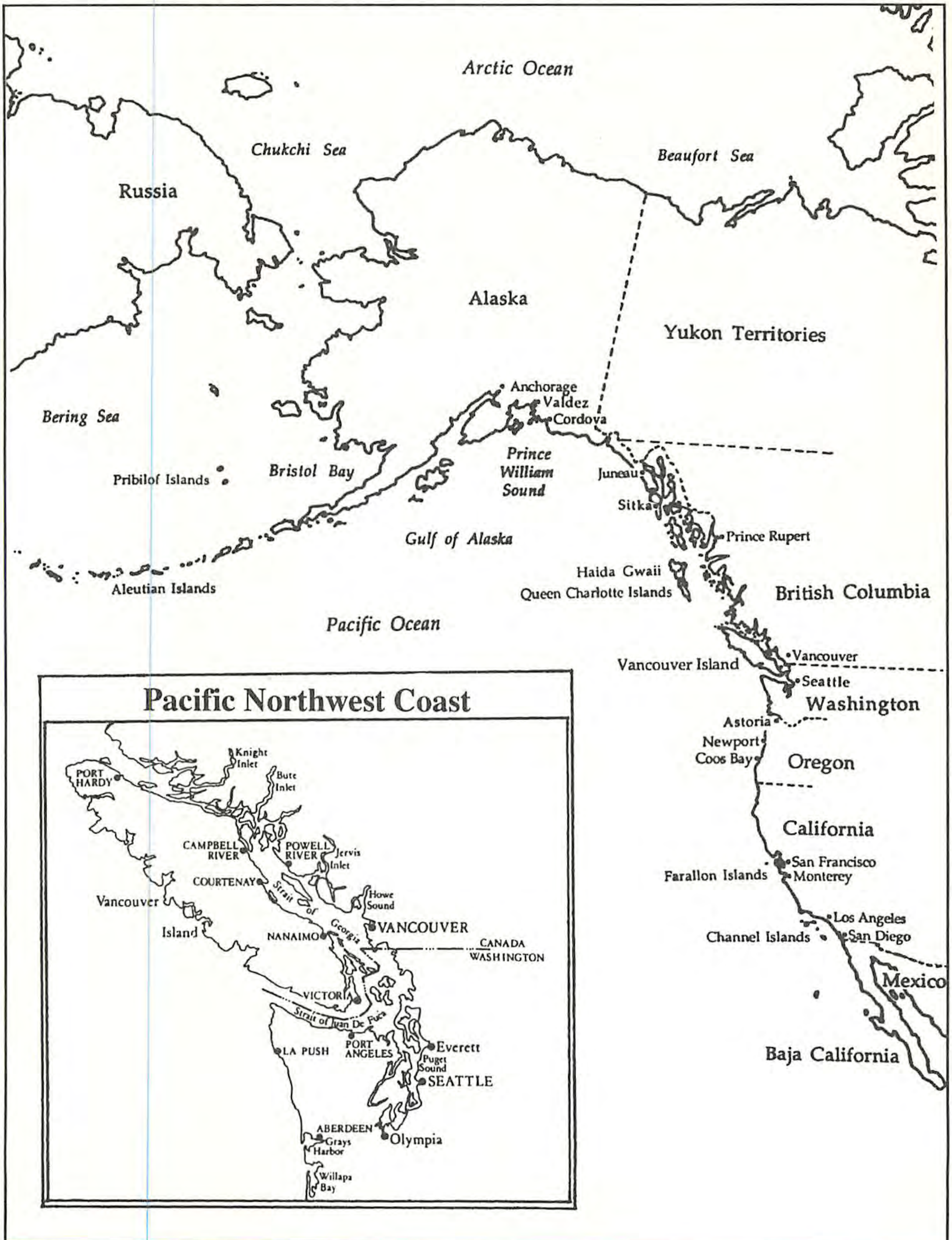
West Coast of North America



Easy to use and lavishly illustrated, this curriculum enables any teacher—beginner to expert—to help students understand basic seashore relationships.

What's that? Is it a plant or animal?

What kind of crab is this? On what kind of beach? In what tide zone? What does it eat? How does it reproduce its young?

Why do some creatures live on a rocky shore, while others live on a sandy beach?

How is a mud flat different from a salt marsh or an estuary?

This resource book is concerned with teaching students basic marine ecology concepts: habitat, tidal cycle, predator and prey, microscopic plankton, life cycles, food relationships, adaptation, and above all, conservation. Observation, inquiry, understanding, and appreciation lead to the preservation of beaches and marine organisms.

Besides a glossary of illustrated terms, this resource book contains 39 overhead transparencies and 15 student worksheets. A set of 86 beautifully illustrated Pacific Coast Information Cards can be ordered to use with the resource guide.

Sea Grant

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