DOCUMENT RESUME

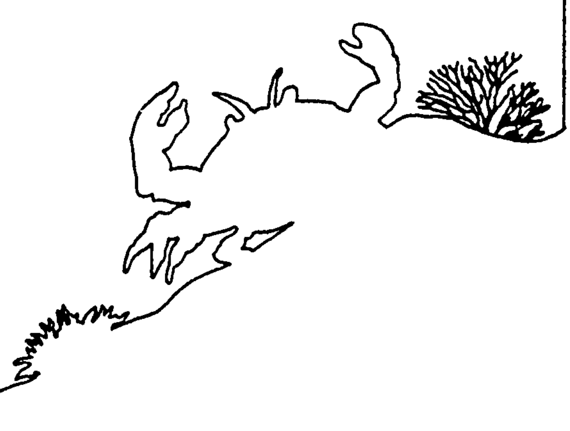
ED 289 680 SE 048 765

AUTHOR	Pauls, John
TITLE	Marine Biology Activities. Ocean Related Curriculum Activities.
INSTITUTION	Pacific Science Center, Seattle, Wash.; Washington Univ., Seattle. Washington Sea Grant Program.
SPONS AGENCY	National Oceanic and Atmospheric Administration (DOC), Rockville, Md. National Sea Grant Program.; Washington Office of the State Superintendent of Public Instruction, Olympia.
PUB DATE	80
NOTE	106p.; Drawings may not reproduce well.
AVAILABLE FROM	Pacific Science Center Giftshop, 200 2nd Ave. North, Seattle, WA 98109 ($6.00).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Environmental Education; Interdisciplinary Approach; *Marine Biology; Marine Education; *Oceanography; *Science Activities; Science and Society; Science Curriculum; Science Education; *Science Instruction; Secondary Education; *Secondary School Science; Water Resources
IDENTIFIERS	*Project ORCA; Washington

ABSTRACT

The ocean affects all of our lives. Therefore, awareness of and information about the interconnections between humans and oceans are prerequisites to making sound decisions for the future. Project ORCA (Ocean Related Curriculum Activities) has developed interdisciplinary curriculum materials designed to meet the needs of students and teachers living in Washington State. Each activity packet provides the teacher with a set of lessons dealing with a particular topic related to the oceans. Included are student worksheets, lesson plans, and a bibliography. This activity packet, designed for the junior high school through community college levels, introduces students to the major themes of marine biology. Through classroom, laboratory, and field trip activities, it is intended that students develop an understanding of structural adaptation, behavioral adaptation, zonation, and habitat. (TW)

MARINE BIOLOGY ACTIVITIES



ORCA

OCEAN RELATED CURRICULUM ACTIVITIES

PACIFIC SCIENCE CENTER / SEA GRANT
MARINE EDUCATION PROJECT

Andrea Marrett, Manager
John Pauls, Writer
Susan Lundstedt, Illustrator

ORCA PUBLICATIONS

ELEMENTARY

High Tide, Low Tide (4th Grade)
Life Cycle of the Salmon (3rd - 4th Grade)
Waterbirds (4th - 5th Grade)
Whales (4th - 6th Grade)

JUNIOR HIGH

Beaches
Beach Profiles and Transects
Early Fishing Peoples of Puget Sound
Energy from the Sea
Literature and the Sea
Tides
Tools of Oceanography

SENIOR HIGH

American Poetry and the Sea
Marine Biology Activities
Marine Biology Field Trip Sites
Marshes, Estuaries and Wetlands
Squalls on Nisqually: A Simulation Game

This activity packet was produced at the Pacific Science Center in cooperation with Washington Sea Grant and Office of the Superintendent of Public Instruction.

ACKNOWLEDGEMENTS

The senior high series of ORCA (Ocean Related Curriculum Activities) is the product of a cooperative effort between many people and organizations. The primary responsibility for the program belongs to the Pacific Science Center, where the materials were developed. Financial assistance and technical support were provided by the National Oceanic and Atmospheric Administration (N.O.A.A.) Sea Grant, held by the University of Washington.

TRIAL TEACHERS

Trial teachers help us by testing the materials with students in the classroom and by reading, evaluating and offering suggestions for more effective curriculum. The teachers who gave their time, effort and advice were:

Bill Bond
Bill Brockman
Dave Brubaker
Ceclia Moore
John Pauls
Shirley Pauls
Kathy Sider

CONSULTANTS

A variety of people were asked for information, advice and help during the development of the curriculum. Their support and interest were greatly appreciated.

The many people and organizations who provided technical assistance and expertise were:

King County Planning Commission
League of Women Voters
Seattle Aquarium
Weyerhauser Industries

Lexie Borrie-Bakewell, U.S. Geological Survey
Dick Butler, King County, Division of Resource Planning
Bill Eckel, King County, Divison of Resource Planning
Ellie Hencke, U.S. Fish and Wildlife Service, Nisqually Delta
Ron Hirschi, Washington State Department of Game
Ernie McDonald, U.S. Forest Service
Jed Marshall, Seattle Audubon Society
Sam Mitchell, Federal Way School District
Alvie Moritz, Edmonds School District
Liz Sears, Edmonds School District

The aid, advice and encouragement of the following educators was essential to the successful development of this project:

Lynda Blakely, Pacific Science Center
Ralph Carlson, Evaluator
Claire Dyckman, Environmental Education Program, Northwest Section, Washington State
Lolly Greathouse-Smith, Environmental Education Programs, Northwest Section, Washington State

PROJECT ORCA

The ocean? It's 2 miles away; it's 200 miles away; it's 2000 miles away. What does it matter to me? For those students who live close to the ocean, a lake or a stream, the effect of water might be more obvious. For the student who lives on a wheat farm in the arid inlands, the word ocean is remote. It may conjure up images of surf, sand and sea gulls, experiences far removed from their daily lives; or it may have no meaning at all. Yet for that same youngster, the reality of the price of oversea wheat shipments or fuel costs for machinery are very real. The understanding of weather and its effects on the success or failure of crops is a basic fact of everyday life. The need for students to associate these daily problems with the influence of the marine environment exists. It requires exposure to ideas, concepts, skills and problem solving methods on the part of the youngsters. It also requires materials and resources on the part of our educators.

The goals of ORCA (Ocean Related Curriculum Activities) are: 1) to develop a basic awareness of ways in which water influences and determines the lives and environments of all living things; and 2) to develop an appreciation of the relationship of water to the study of the natural sciences, social sciences, humanities and the quality of life.

ORCA attempts to reach these goals by: 1) developing interdisciplinary curriculum materials designed to meet the needs of students and teachers living in Washington State, 2) developing a marine resource center, and 3) providing advisory services for marine educators. In conjunction with these efforts, ORCA is coordinating communication among educators throughout the state and the rest of the nation.

The curriculum materials are developed to be used in many areas including the traditional science fields. They consist of activity packets which fit existing curricula and state educational goals and are designed for use as either a unit or as individual activities.

The ocean affects all our lives and we need to be aware and informed of the interconnections if we are to make sound decisions for the future of the earth, the ocean and our own well being. We hope that through Project ORCA, teachers will be encouraged to work together to help students understand and appreciate the ocean and the world of water as a part of our daily existence.

Melinda Mueller, Poet-Botanist, The Northwest School of the Arts, Humanities and Environment
Shirley Pauls, Edmonds School District.

A sincere thank you to two consultants who gave extensive time, support and special expertise:

Alyn Duxbury, Ph.D., Assistant Director of New Programs, Divison of Marine Resources, University of Washington
David Kennedy, Supervisor of Science, Environmental Education and Marine Education, Office of the Superintendent of Public Instruction

ADVISORY COMMITTEES

The Marine Education project was reviewed annually by the Sea Grant Site Evaluation Committee. We thank them for their advice and support.

Continuing guidance for the program direction was provided by the Pacific Science Center Education Committee, the members of which are:

Levon Balzer, Ph.D., Dean of Instruction, Seattle Pacific University
Helen Frizzell, Teacher, Northshore School District
Charles Hardy, Coordinator, Math and Science, Highline School District
David Kennedy, Supervisor of Science, Environmental and Marine Education, Office of the Superintendent of Public Instruction
Roger Olstad, Ph.D., Associate Dean of Graduate Studies, University of Washington, Committee Chairperson
Alice Romero, Teacher, West Seattle High School, Seattle School District
William Stevenson, Superintendent, Shoreline School District
Mark Terry, Associate Director, Environment, The Northwest School of the Arts, Humanities, and the Environment, Seattle

STAFF

Finally, the production of the senior high series could only occur with the immense help of staff members who were instrumental in creating, developing and supporting this project.

As one of the curriculum writers for the senior high series, I can truly appreciate the efforts of the other writers:

Cecelia Moore, John Pauls and Peggy Peterson

The efforts of all people responsible for graphics, design and paste-up are greatly appreciated:

Laurie Dumdie, paste-up
Susan Lundstedt, graphics
Valene Starrett, cover design

The necessary job of reviewing, editing and typing take time and patience. Those who handled that task were:

Lynda Blakely, editing
Maxine Fischer, typing
Peggy Peterson, editing

Most especially I want to thank the Director of Education and Project Investigator, Bonnie DeTurck; Laurie Dumdie, the Marine Education Assistant; John Kenning and Peggy Peterson for their continued support and efforts for the marine education project.

Andrea Marrett
Manager, Marine Education Project
Pacific Science Center
200 Second Avenue North
Seattle, WA 98109

MARINE BIOLOGY ACTIVITIES

ABSTRACT: Marine Biology Activities is an activity packet that introduces students to the major themes of marine biology. Through classroom, laboratory, and field trip activities, students develop an understanding of structural adaptation, behavioral adaptation, zonation, and habitat. This packet includes teacher background information, student handouts, and tests.

SUBJECTS: Biology, Life Science, and Environmental Education

GRADE LEVELS: Junior High School, High School, Community College

WRITTEN BY: John Pauls

ACTIVITY 1:

INTERTIDAL ZONATION

(4 DAYS)

TABLE OF CONTENTS AND OVERVIEW

MARINE BIOLOGY ACTIVITIES

OBJECTIVES

The student will demonstrate understanding of the concept of zonation by:

1. identifying intertidal zones.
2. describing the characteristics of each zone.
3. naming reasons why organisms are often confined to a certain zone.
4. explaining the causes of zonation.
5. matching marker organisms with the correct zone.
6. describing the concept of zonation.

The student will demonstrate understanding of the technique of making a transect by:

1. selecting the best site for a transect.
2. making a quadrat count.
3. graphing the data from the class count.
4. explaining the graphed results in terms of zonation.

The student will demonstrate understanding of the concept of structural adaptation for survival by:

1. explaining how nematocysts are used to capture food.
2. explaining how cirri are used to capture food.
3. explaining how tube feet prevent echinoderms from being washed away by wave action.
4. explaining how byssal threads prevent mussels from being washed away by wave action.
5. explaining how pedicellarias keep the aboral surfaces of sea stars and sea urchins clean.
6. relating the above structures to increased chance of survival of the organisms involved.

The student will demonstrate understanding of the concept of behavioral adaptation for survival by:

1. explaining the behavior of limpets in the presence a sea star predator.
2. describing the behavior of hermit crabs when food is made available.
3. describing the color changes of octopus when threatened.
4. describing evisceration.
5. relating the above behaviors to increased chances for survival of the organism involved.

The student will demonstrate understanding of the biology of a group of marine organisms by:

1. making an oral and/or written report on that group.
2. acting as a reference source to other students who have questions about that group while on the field trip.

The student will demonstrate understanding of the concept of habitat by:

1. explaining habitat.
2. naming 3 major intertidal habitats.
3. describing the physical factors that caused each habitat.
4. identifying key intertidal life of each habitat.
5. explaining how organisms have adapted to the physical characteristics of each habitat.

ACTIVITY 1:
INTERTIDAL ZONATION
(4 DAYS)

ACTIVITY 1: INTERTIDAL ZONATION (4 DAYS)

CONCEPTS:

1. Intertidal organisms are distributed across a beach in zones which correspond to tidal levels.

OBJECTIVES:

The student will demonstrate understanding of the concept of <u>zonation</u> by:

1. identifying intertidal zones.
2. describing the characteristics of each zone.
3. naming reasons why organisms are often confined to a certain zone.
4. explaining the causes of zonation.
5. describing the concept of zonation.

The student will demonstrate understanding of the technique of <u>making a transect</u> by:

1. selecting the best site for a transect.
2. making a quadrat count.
3. graphing the data from the class count.
4. explaining the graphed results in terms of zonation.

TEACHER PREPARATION:

1. Make arrangements for the field trip, (see ORCA activity packet, <u>Marine Biology Field Trip Sites.)</u>
2. Reproduce class sets of the student handouts:
   "Activity 1: A Beach Transect"
   "Worksheet: Intertidal Zonation"
   "Intertidal Zonation"
3. Read the suggested Teacher Background Information "Intertidal Zonation".
4. Make a 100 meter long transect line of heavy string. Use a tough tape (such as Mystik Tape or silver duct tape) to mark the line at one meter intervals. Label the tapes from 0 to 100. Fasten a wooden stake (approximately 35 cm long) to each end of the transect line.
5. Make two gradient sticks. Each is made of 1" x 2" or 1" x 1" wood, 1.5m long. Mark each in 0.1m intervals. Label the marks: 0, 0.1, 0.2, 0.3,.....1.4, 1.5
6. Buy, borrow, or make a spirit level. A suitable one is a 9" torpedo level. Your school shop may have one.
7. It is desirable that the teacher survey the field trip site just prior to the field trip to make certain that the organisms to be surveyed are to be found in that locality at that particular time of the year.
8. Cut one piece of string 120 cm long for each class member.

MATERIALS:

1. Class sets of student handouts:
   "Activity 1: A Beach Transect"
   "Worksheet: Intertidal Zonation"
   "Intertidal Zonation"
2. Class sets of student equipment:
   Quadrat strings, 120 cm long
   Clipboards (provided by students)

3. Transect line, 100 meters long, marked at 1 meter intervals.
4. 2 gradient sticks, 1" x 2" x 1.5m, marked into 0.1m intervals.
5. Spirit Level.
6. Marine organisms on the beach.

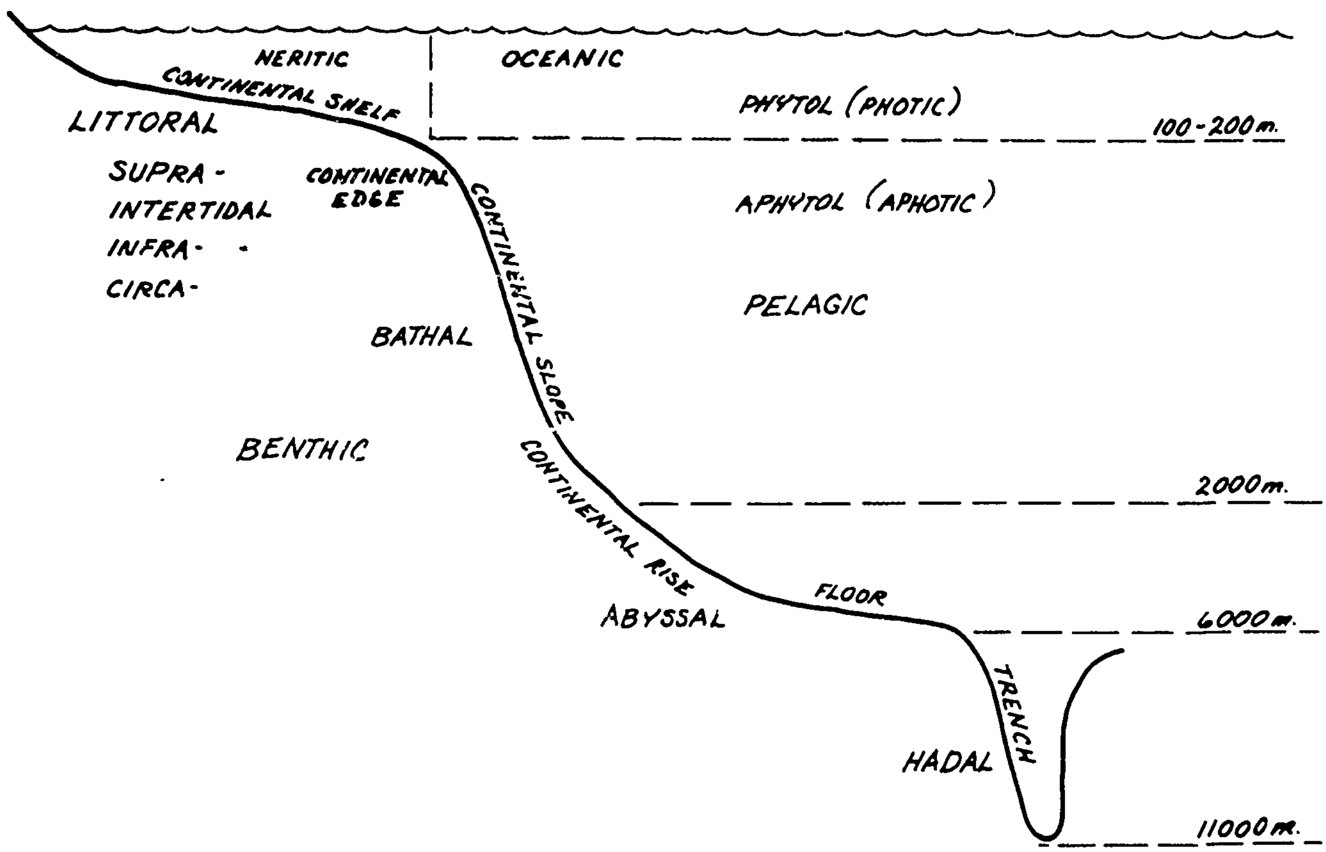
PROCEDURES:

1. Introduce the subject of zonation by eliciting students' observations of tidal effects. They might relate their experiences in digging clams, boarding the ferry, etc. This will establish a mental set.
2. Have the students read and study the student handout "Intertidal Zonation".
3. Have the students complete the worksheet 'Intertidal Zonation". Discuss it with the class.
4. Discuss the techniques involved in Activity 1. Emphasize the need to minimize the class's impact on the beach ecology. Students should restore the rocks, seaweed, and other organisms to their former positions. Students should not leave the string on the beach.
5. Have students do Activity 1 at the beach. It works well as the first activity upon arrival. Activities 2 and 3 may be done concurrently after students have finished Activity 1.
6. When back in the classroom, pool the class data. Each student should have a copy.
7. Have the students graph the data from the transect.
8. Analyze the data. See if the students can come to their own conclusions regarding zonation and its causes before you discuss it in detail.

Teacher Information Sh.et

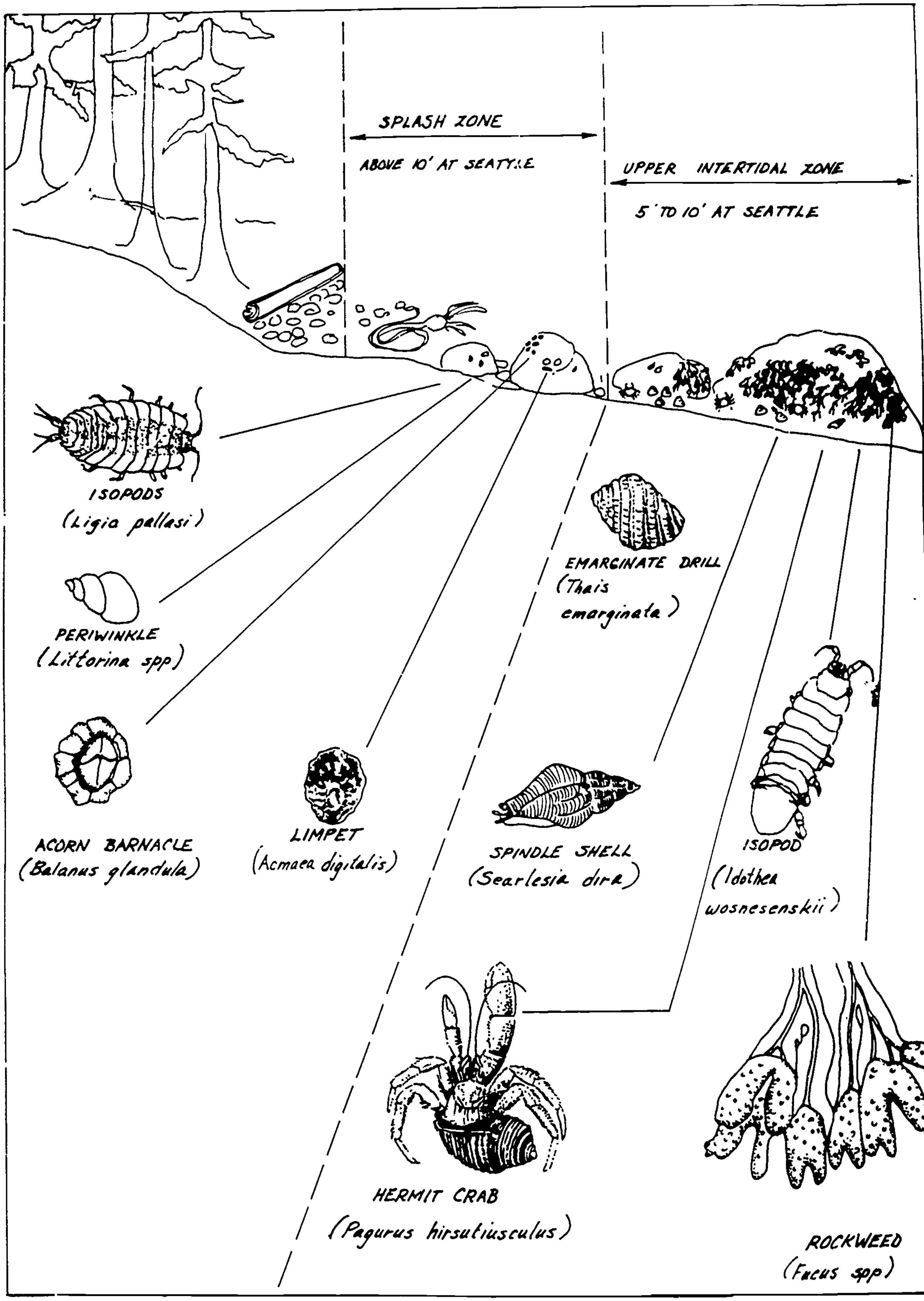
INTERTIDAL ZONATION

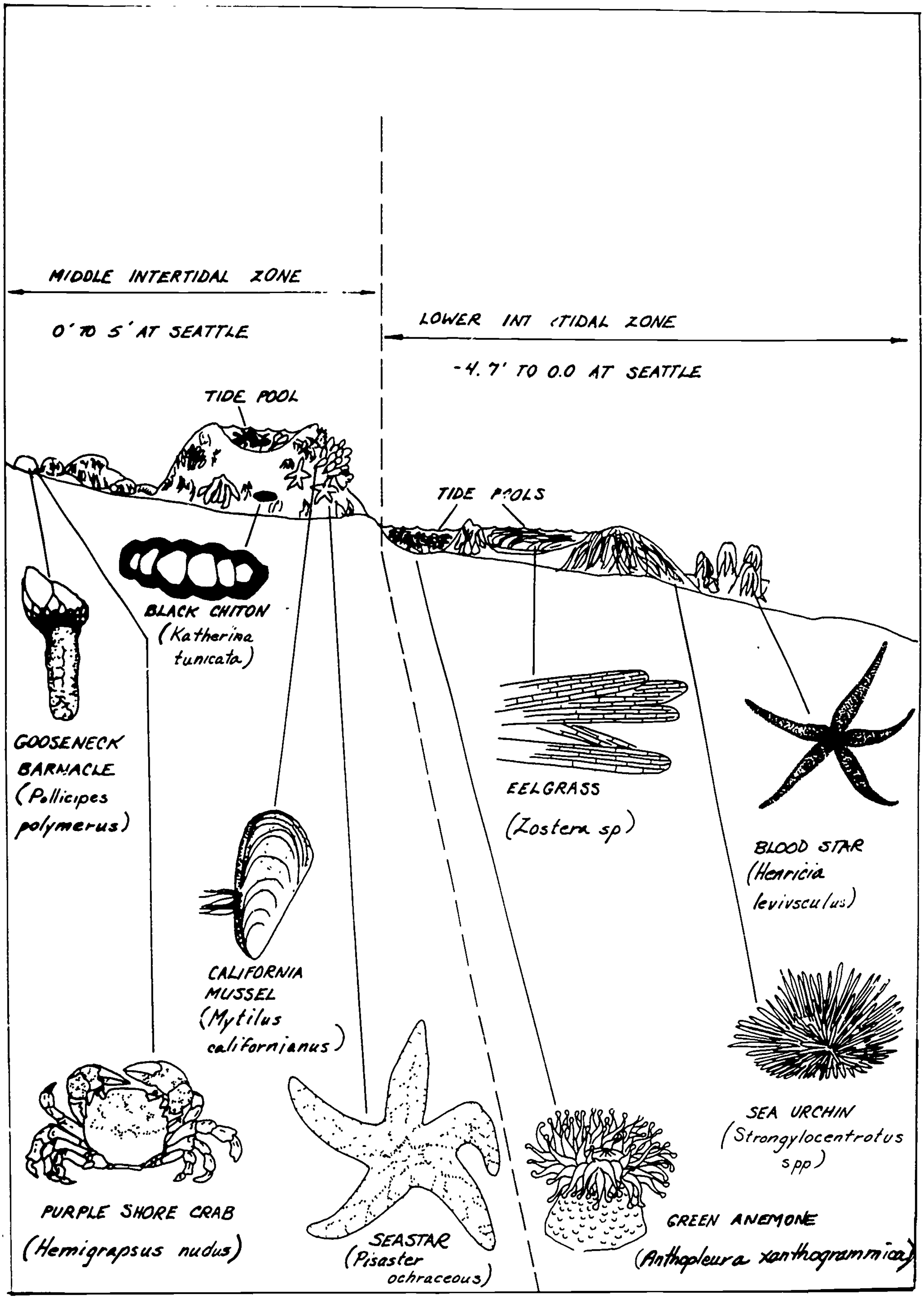
The waters of the world may be divided into zones based on relative depth. The diagram below shows this classification.



This activity concerns itself only with the littoral zone, that is, the sea-land interface.

Littoral organisms seek a suitable habitat such as a sandy beach, muddy beach, rocky beach, or piling. Superimposed upon this habitat selection is a zonation which corresponds to the tidal levels. Certain organisms prefer the Splash Zone, the Upper Intertidal Zone, the Middle Intertidal Zone, the Lower Intertidal Zone, or the Open Sea. (See the following diagram.) A brief description of these zones follows.


SPLASH ZONE
ABOVE 10' AT SEATTLE
UPPER INTERTIDAL ZONE
5' TO 10' AT SEATTLE
ISOPODS
(Ligia pallasi)
PERIWINKLE
(Littorina spp)
ACORN BARNACLE
(Balanus glandula)
LIMPET
(Acmaea digitalis)
EMARGINATE DRILL
(Thais emarginata)
SPINDLE SHELL
(Searlesia dira)
ISOPOD
(Idothea wosnesenskii)
HERMIT CRAB
(Pagurus hirsutiusculus)
ROCKWEED
(Fucus spp)


MIDDLE INTERTIDAL ZONE
0' TO 5' AT SEATTLE
LOWER INT TIDAL ZONE
-4.7' TO 0.0 AT SEATTLE
TIDE POOL
TIDE POOLS
BLACK CHITON
(Katherina tunicata)
GOOSENECK BARNACLE
(Pollicipes polymerus)
EELGRASS
(Zostera sp)
BLOOD STAR
(Henricia levivsculus)
CALIFORNIA MUSSEL
(Mytilus californianus)
SEA URCHIN
(Strongylocentrotus spp)
PURPLE SHORE CRAB
(Hemigrapsus nudus)
SEASTAR
(Pisaster ochraceous)
GREEN ANEMONE
(Anthopleura xanthogrammica)

Teacher Information Sheet

The Splash Zone (above the 10 foot mark at Seattle)* is a region which is only occasionally wetted by spray from surf when the tide is high. The sparse population of marine organisms must be able to endure very long periods of exposure to air (80% of the time or more), must face include large temperature fluctuations and solar radiation. Organisms characteristic of the Splash Zone are:

Isopods (Ligia pallasii)
Periwinkles (Littorina spp)
Limpets (Acmaea digitalis)
Acorn barnacles (Balanus glandula)
(also found in the zone below)

The Upper Intertidal Zone (5 to 10 foot tide level at Seattle) is the upper tide pool region. Organisms here must be adapted to frequent, prolonged exposure to air (35 to 80% of the time). Organisms characteristic of the High Beach zone are:

Emarginate Drill (Thais emarginata)
Rockweed (Fucus distichus)
Spindle snail (Searlesia dira)
Hermit crab (Pagurus hirsutiusculus)
Isopods (Idothea wosnesenskii)

The Middle Intertidal Zone (0 to 5 foot mark at Seattle) contains organisms that must be adapted to daily exposure to air (10 to 35% of the time) alternating with submersion in sea water. They include:

Gooseneck barnacle (Pollicipes polymerus)
California mussel (Mytilus californianus)
Black chiton (Katherina tunicata)
Purple shore crab (Hemigrapsus nudus)
Edible mussel (Mytilus edulis)
Purple sea star (Pisaster ochraceous)

The Lower Intertidal Zone (-4.7 to 0 foot mark at Seattle) is exposed to air only a few hours per month (not at all during some months). These organisms are exposed to the air only 10% of the time, or less. A large variety of organisms live here, including:

Eelgrass (Zostera sp)
Green Sea anemone (Anthopleura xanthogrammica)
Laminarians (Laminaria spp)
Blood star (Henricia leviuscula)
Sea urchins (Strongylocentrotus spp)

*Heights of tides are relative to the zero tide mark, which is the level of the water at mean lower low water. A tide of -1.1 is 1.1 feet below mean lower low water.

Teacher Information Sheet

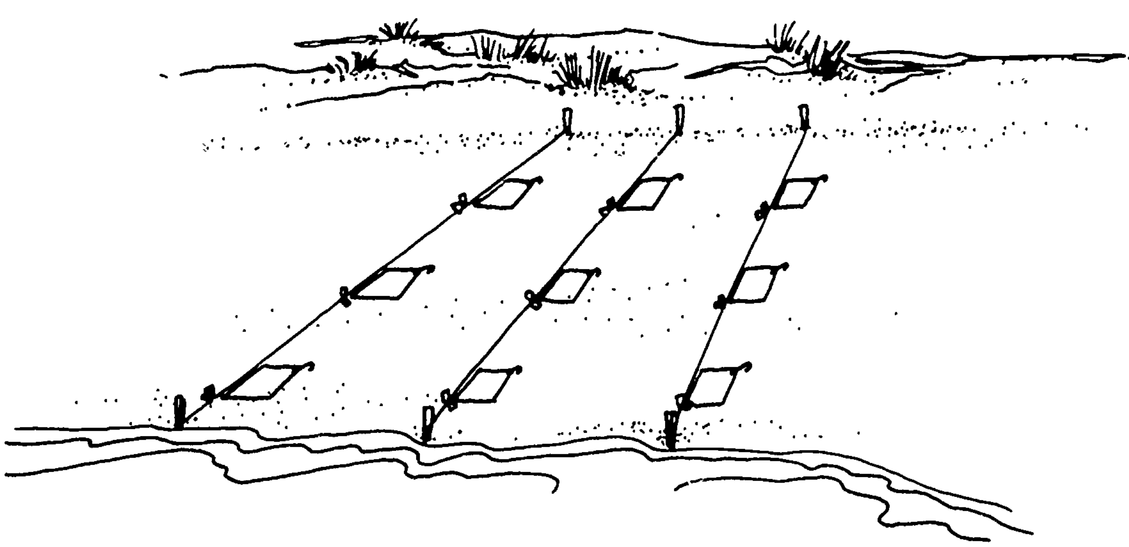
Causes of Zonation

Although it might seem at first that zonation is caused by the tides, it is actually more complex than that. Animals and plants are probably responding to the changes that result from the periodic covering and uncovering by sea water. The upper limits of zonation are set by tolerance to physical factors such as drying, large temperature changes, solar radiation, and changes in salt content due to rain. The lower limits of zonation are set by biological factors such as competition for space and predation. It must be noted that the conditions for survival must not only be right for an adult specimen of sea cucumber, crab, or barnacle, but also for their larvae, which are often much more fragile.

Making A Transect

Zonation may be made apparent by making a transect study. It will be seen that organisms are not scattered randomly about the beach, but occur in very definite zones. The zones may be broad or narrow, they may have fuzzy edges, and the actual height may be influenced by local factors, but zonation is very real.

To make the transect, stretch a 100 meter string, marked in one meter intervals, from the water's edge to the highest extent of marine life. The transect line is perpendicular to the water's edge. Distribute the students equidistant along the line. For example, if the line is 90 meters from water to highest level, and if you have 30 students in the class, assign a student to each third meter. Each student forms a 120 cm long string into a square and counts all of the individuals of certain species contained in the square. One side of the square should be parallel to the transect line and touching it. Students must be certain to turn over rocks and probe just under the surface (to a depth of 5 cm). It is important to select a transect line that runs across only one habitat. Probably the easiest habitat to study would be that of a rocky beach. A small group of students can measure the gradient (steepness) of the beach.



Teacher Information Sheet

Measuring The Gradient

To measure the gradient of the beach, a team of three students takes elevations from the 0 mark on the transect line to its upper end. The point of this lesson is intertidal zonation, not surveying gradients. If the principles of taking gradients are important enough to emphasize, refer to Beach Profiles and Transects, a Pacific Science Center/Sea Grant Activity Packet.

Graphing The Data

Graphing the data may require little help from the teacher if the students are well experienced in graphing skills. Other students, however, may require step-by-step instructions. Step-by-step directions follow:

Step 1: Select the proper graph paper. If the transect line was quite long (100 m), then it may be necessary to use graph paper with 8 or 10 squares to the inch.

Step 2: Placing the paper horizontally, rule in a horizontal axis two or three centimeters from the bottom. Rule in a vertical axis two or three centimeters from the left edge.

Step 3: Label the vertical axis, "Elevation (m)" and choose a suitable scale. Label the horizontal axis, "Distance from water (m)" and choose a suitable scale. Number the spaces, not the lines, on the horizontal axis.

Step 4: Enter the data for the beach gradient as small dots. Draw in a line which represents the beach. (See the sample graph.)

Step 5: Enter the data from the Transect Data Sheet. Do one organism at a time. Place one small x in a square for each organism counted at a particular distance. If ten organisms were counted, place ten x's above the appropriate distance. Always place the first x on the profile of the beach, not on the original horizontal axis.

Step 6: Draw in a smooth curve that approximates the data. (See the second sample graph.)

Step 7: Use different symbols or different colors for other organisms. If a great deal of overlap is seen, it may be best to use different sheets of graph paper. (See the third sample graph.)

Teacher Information Sheet

When it is time to graph the results of the transect, it is necessary to provide the students with the class data. It may be accomplished in one of three ways: on the chalkboard, on a ditto, or on an overhead projector. Data may take the form of the sample shown below.

The following three pages are sample of graphs of these data.

TRANSECT STUDY SUMMARY SHEET
May 24, 1978 Edmonds Beach
-2.9 Tide

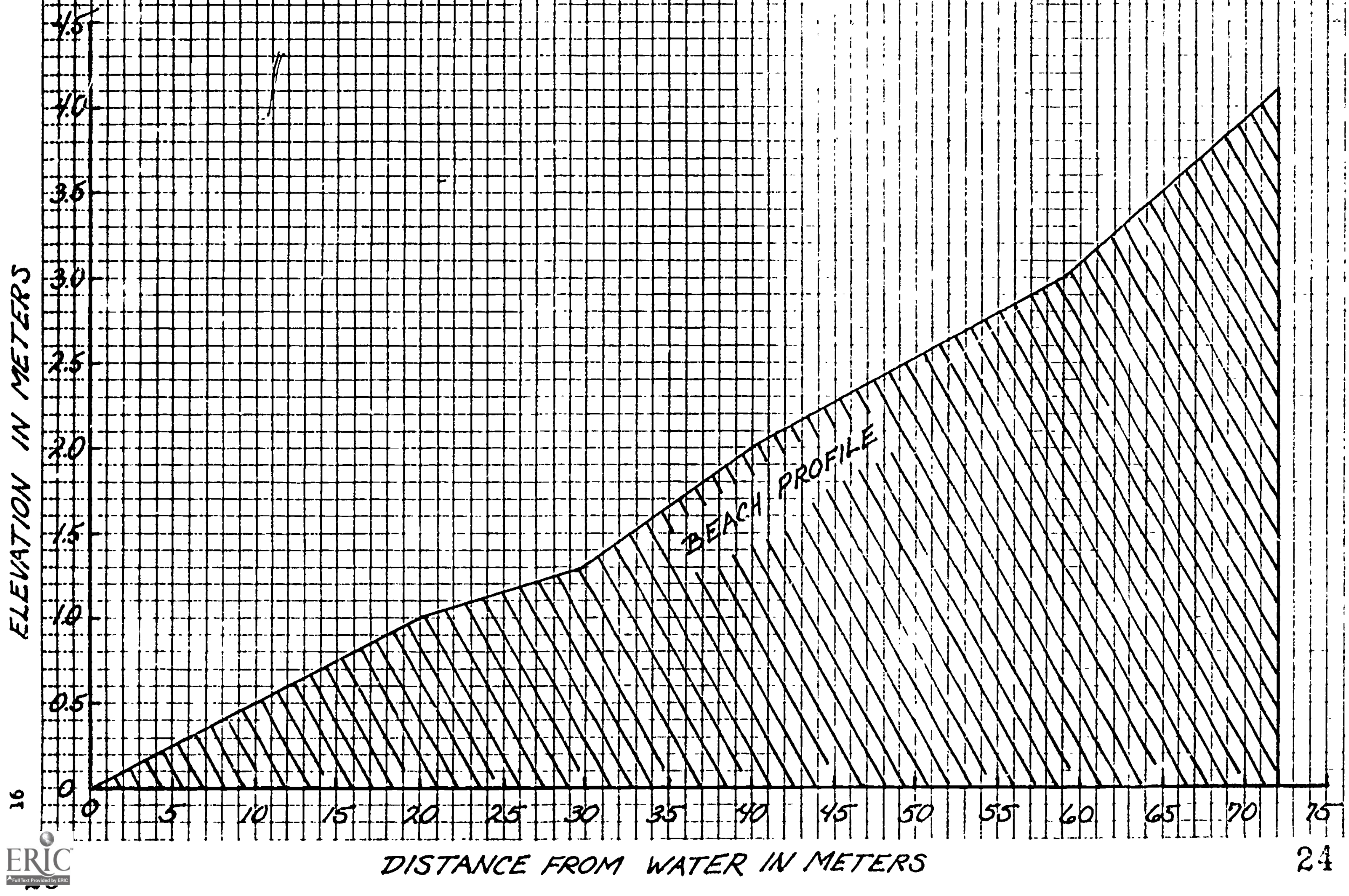
Distance From water (Meters)	Brown Seaweed (Cystoseira sp)	Crabs (Hemigrapsus sp)	Limpets
45	0	0	40
10	2	0	0
3	7	1	0
33	4	0	0
24	15	1	1
0	4	1	1
27	5	2	0
12	5	0	0
60	0	10	34
63	0	10	4
39	0	0	8
42	0	2	0
36	0	0	1
2	2	0	0
57	0	4	21
9	1	0	0
69	0	20	0
48	3	1	0
49	0	0	2
21	2	1	2
54	0	5	23
30	3	0	3
51	0	8	7

GRADIENT DATA SHEET
(From Survey Team)

Distance from water's edge (m)	0	10	20	30	40	50	60	70
Elevation (m)	0	0.5	1.0	1.3	2.0	2.5	3.0	4.0

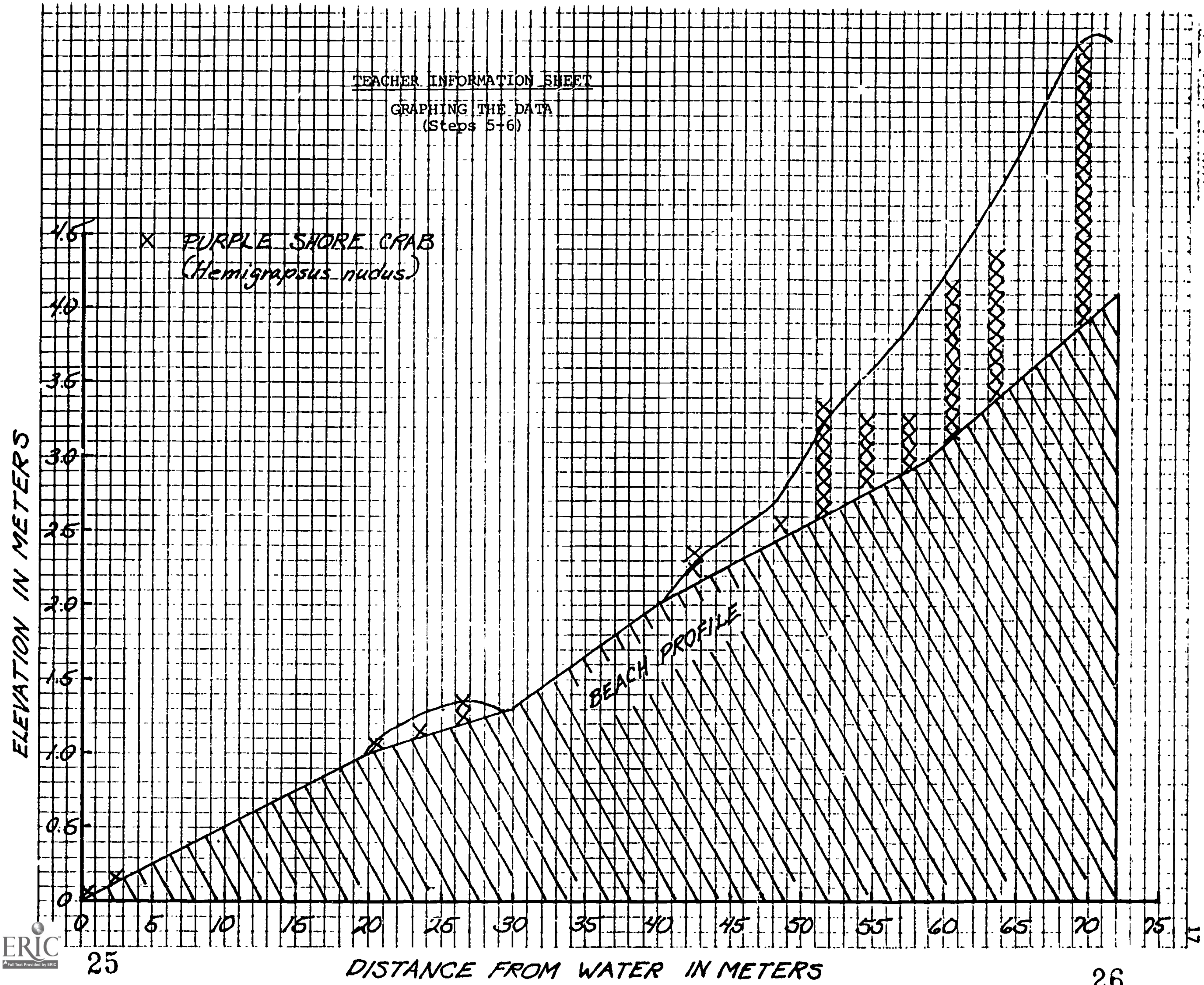
TEACHER INFORMATION SHEET

GRAPHING THE TRANSECT DATA
(Steps 1-4)



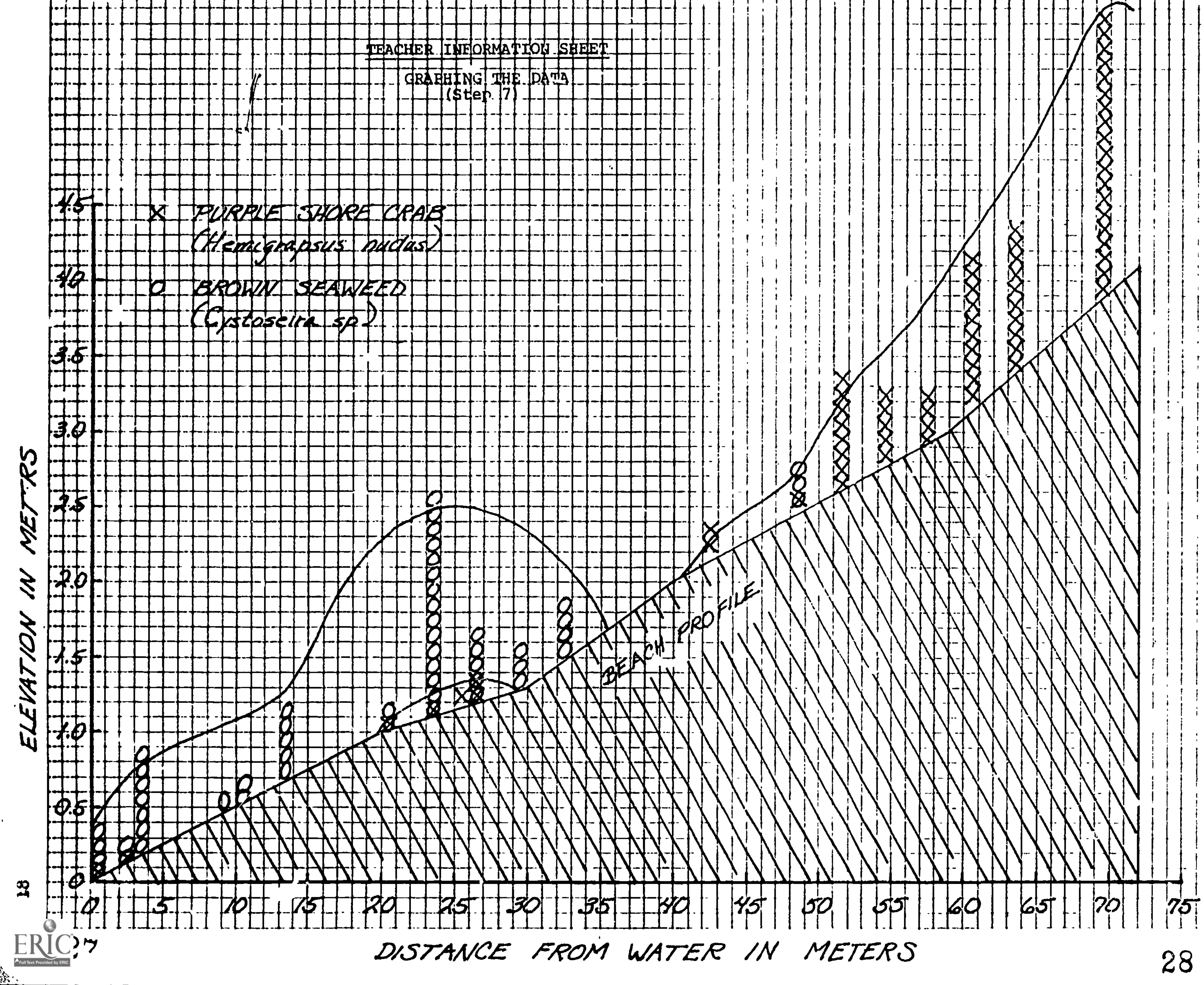
TEACHER INFORMATION SHEET

GRAPHING THE DATA
(Steps 5-6)



TEACHER INFORMATION SHEET

GRAPHING THE DATA
(Step 7)



Teacher Information Sheet

Analysis Of The Data

It is very important to relate the results of the transect and graphing to the major point being made by Activity 1--intertidal zonation. Do this by a discussion of the results.

Here are some suggested points to consider during the discussion.

1. Where was the greatest proportion of Purple Shore Crabs (or other organisms) found?
2. What intertidal zone do you suppose this is?
3. What are some factors which might keep these crabs from moving higher on the beach?
4. What are some factors which might keep these organisms from moving into a lower zone?
5. Were there any strays (a few crabs in other zones)?
6. What factors might allow these strays to survive in zones below their primary one? above their primary one?
7. In which zones would humans exert the greatest pressure?
8. Are there any organisms on the graphs which might directly affect each other?

NAME________________

INTERTIDAL ZONATION

The rise and fall of the tides have a very important effect on the plants and animals that live along the shores of Puget Sound. Each kind of organism seems to prefer certain parts of the beach which we call intertidal zones. These zones depend upon how much of the time they are covered by water and how much of the time they are exposed to air. In this unit you will learn about intertidal zonations -- the way beach plants and animals are arranged in zones according to tidal levels.

Objectives:

In this activity you will learn:

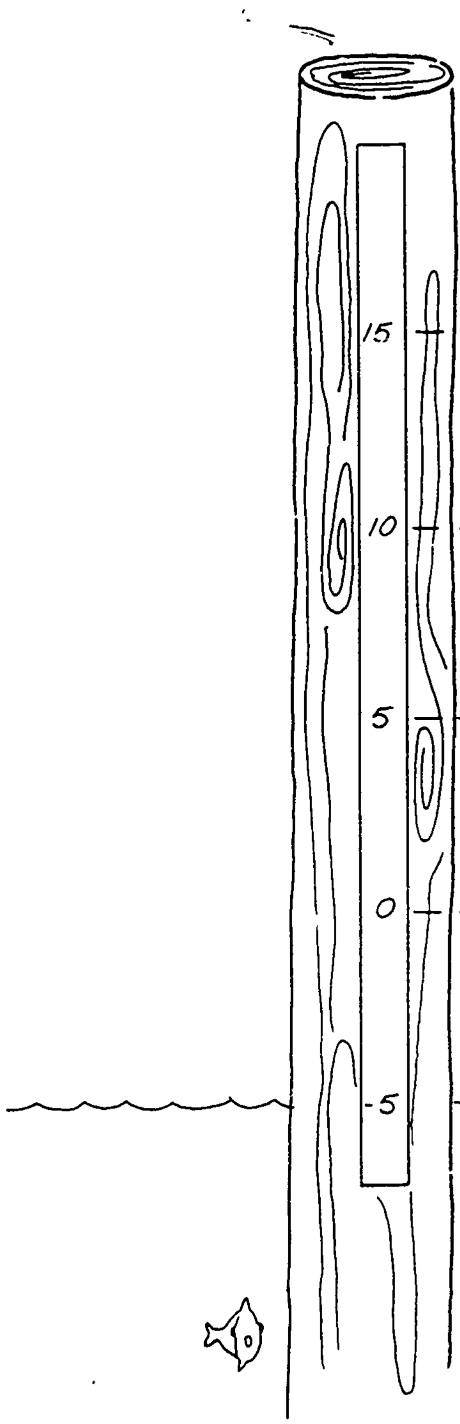
1. the names of the four intertidal zones.
2. descriptions of each zone in terms of relative exposure to air and water.
3. four marker organisms for each zone.
4. the causes of intertidal zonation.
5. how to make a transect of a beach.
6. how to graph the results of a transect.

What Are The Intertidal Zones?

There are four. They are the Splash Zone, the Upper Intertidal Zone, the Middle Intertidal Zone, and the Lower Intertidal Zone. Each one has certain characteristics. It may be easier to see these zones if we imagine we are looking at a wooden piling at the end of a pier. The zones are marked below. Read and learn the descriptions of each. (The numbers on the piling are tide heights at Seattle.)

NAME____________________

ZONATION ON A VERTICAL PILING



This part of the piling is never covered by water. It is not intertidal.

SPLASH ZONE: This part of the piling is almost always exposed to air. It is seldom covered by seawater, but it is often wet by splash from waves.

UPPER INTERTIDAL ZONE: This part of the piling is exposed to air much more than it is covered by water.

MIDDLE INTERTIDAL ZONE: This part of the piling is covered and uncovered by water every few hours.

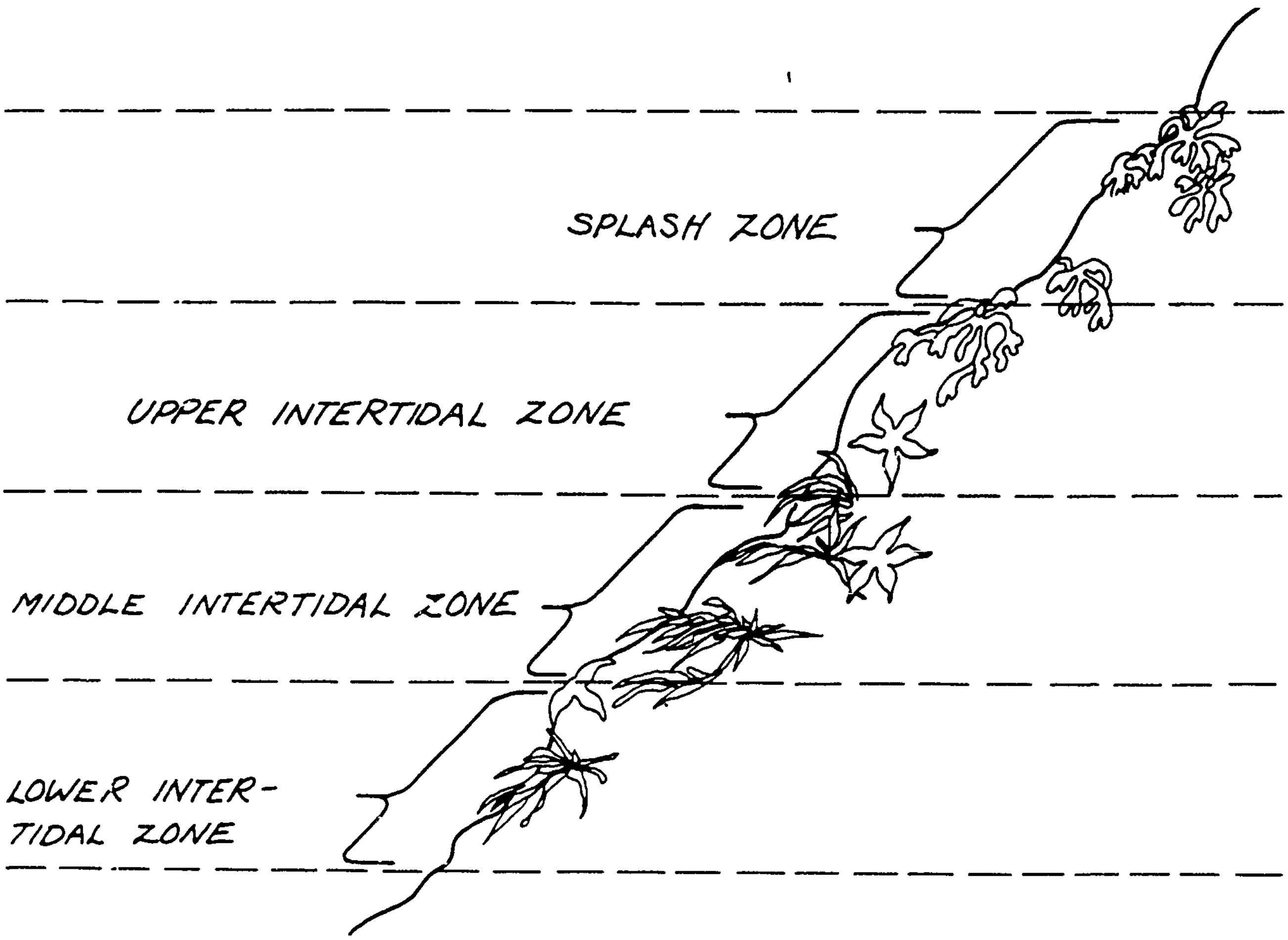
LOWER INTERTIDAL ZONE: This part of the piling is not exposed to air very often--only during the very lowest tides.

This part of the piling is never exposed to air. It is intertidal. It is in the "open water".

NAME ______________________

If we were to look at the same zones on a steep beach, instead of on a piling, we would see that they would have the same vertical arrangement, but would be broader horizontally. The drawing below shows how the zones might appear on a steep beach.

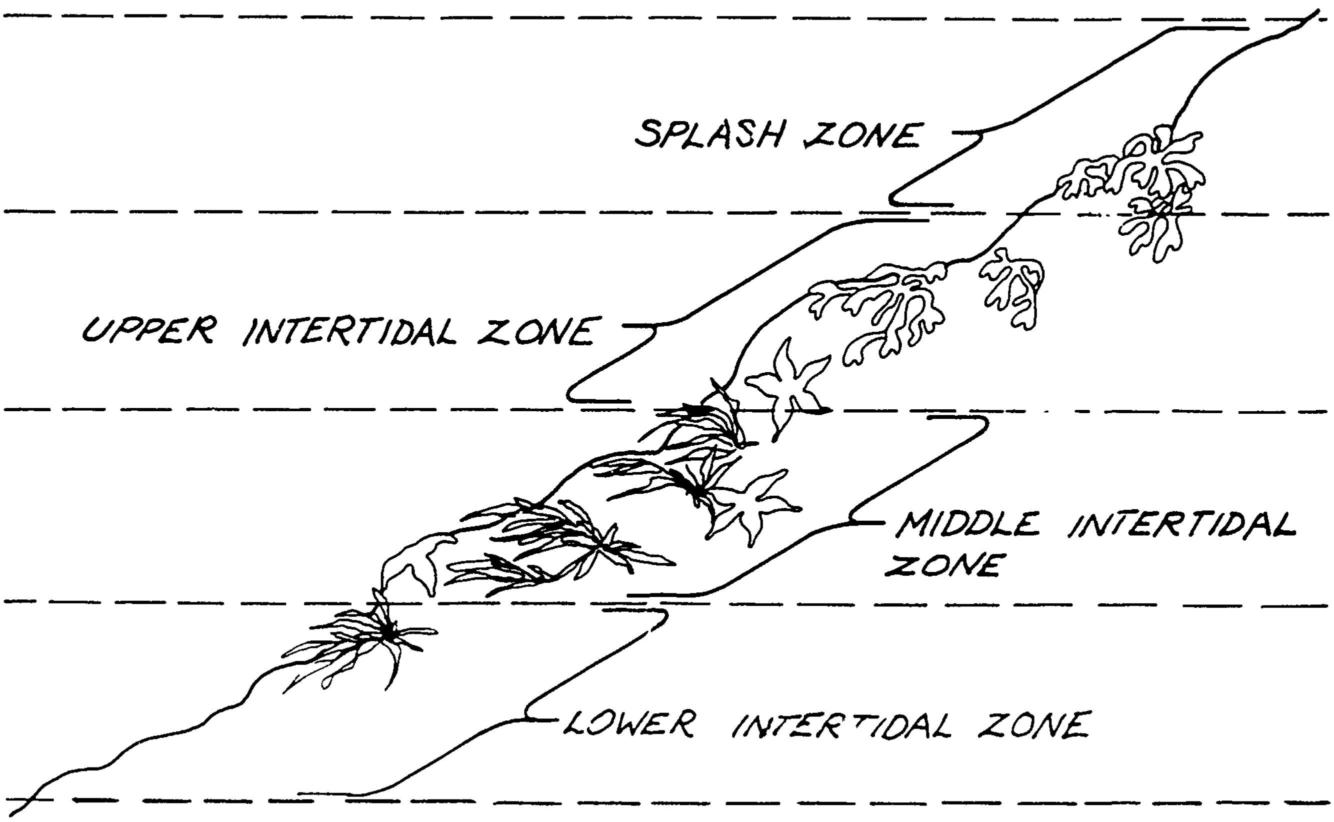
Zonation On A Steep Beach



NAME________________

A gently sloping beach would show the same zones, but they would be stretched over an even wider area. A gently sloping beach is shown below.

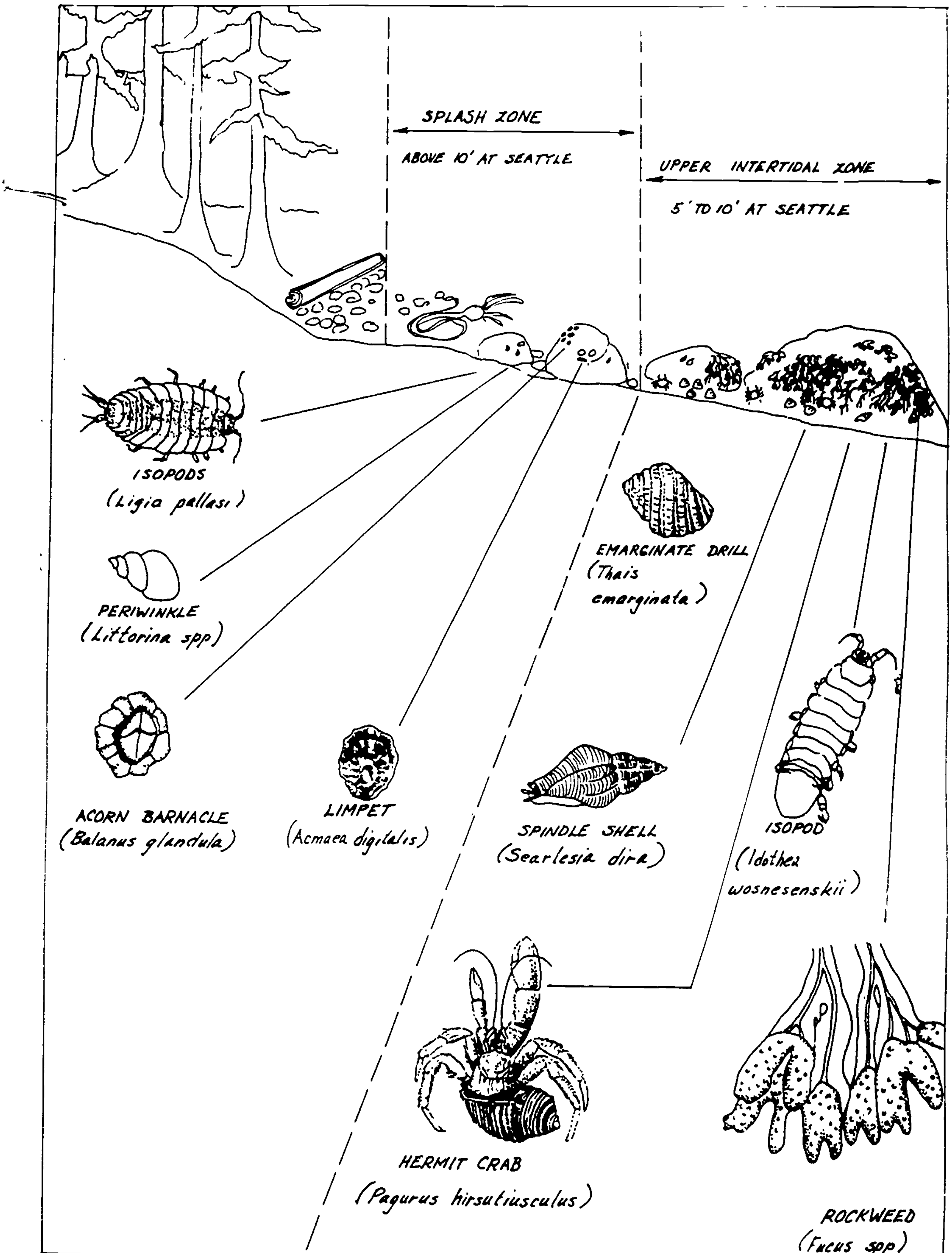
Zonation On A Gently Sloping Beach

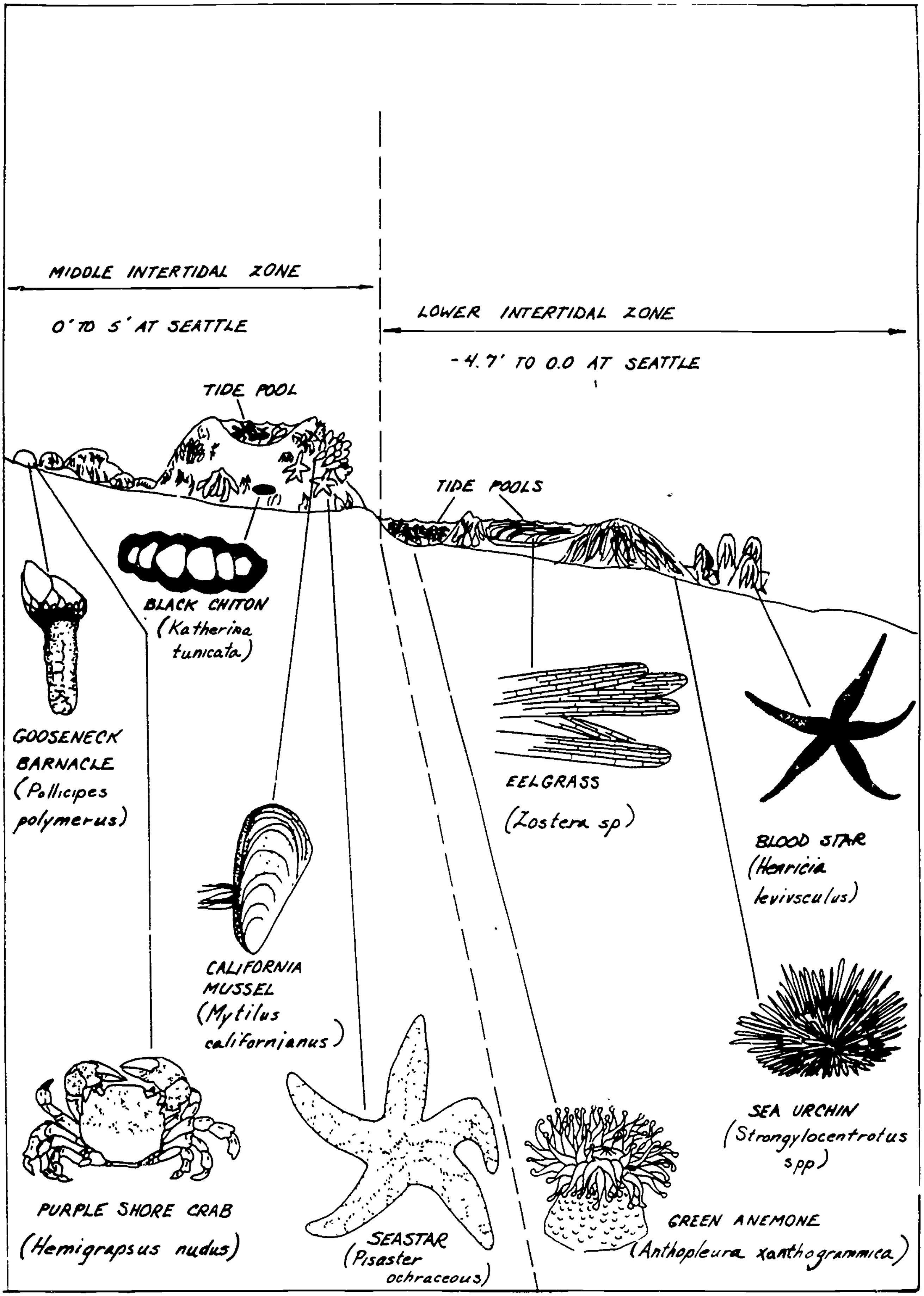


The vertical height of the zones depends upon the rise and fall of the tides. The width of the zones on the beach depends on the slope of the beach.

What Plants And Animals Live In These Zones?

Certain plants and animals are markers, and you can identify the zones if you know which organisms live in which zones. Study the following diagram.


SPLASH ZONE
ABOVE 10' AT SEATTLE
UPPER INTERTIDAL ZONE
5' TO 10' AT SEATTLE
ISOPODS
(Ligia pallasi)
PERIWINKLE
(Littorina spp)
ACORN BARNACLE
(Balanus glandula)
LIMPET
(Acmaea digitalis)
EMARGINATE DRILL
(Thais emarginata)
SPINDLE SHELL
(Searlesia dira)
ISOPOD
(Idothea wosnesenskii)
HERMIT CRAB
(Pagurus hirsutiusculus)
ROCKWEED
(Fucus spp)


MIDDLE INTERTIDAL ZONE
0' TO 5' AT SEATTLE
LOWER INTERTIDAL ZONE
-4.7' TO 0.0 AT SEATTLE
TIDE POOL
TIDE POOLS
BLACK CHITON
(Katherina tunicata)
GOOSENECK BARNACLE
(Pollicipes polymerus)
EELGRASS
(Zostera sp)
BLOOD STAR
(Henricia levivsculus)
CALIFORNIA MUSSEL
(Mytilus californianus)
SEA URCHIN
(Strongylocentrotus spp)
PURPLE SHORE CRAB
(Hemigrapsus nudus)
SEASTAR
(Pisaster ochraceous)
GREEN ANEMONE
(Anthopleura xanthogrammica)

NAME ______________________________

What Causes Intertidal Zonation?

Zonation is not just simply due to tides. Organisms are probably responding to changes that result from periodic covering and uncovering by sea water. Here are some of the factors.

1. Drying. Some organisms are more resistant to drying out than others. For example, acorn barnacles can live in the Splash Zone because they are able to close up their "shells". This traps a small amount of sea water next to their bodies. On the other hand, the green sea anemone must be covered by water most of the time, or it would dry out and die.

2. Temperature Change. When an animal, such as a fish, lives in the open water of Puget Sound, it is surrounded by water at a very constant temperature. Purple shore crabs, periwinkles, and mussels, however, must adapt to larger temperature changes. At high tide, the water covering these organisms might be at 11° C, but at low tide the temperature might soar to 25° C. This temperature change might kill some organisms, but intertidal organisms have adapted to it.

3. Solar Radiation. Ultraviolet (UV) radiation from the sun can be harmful. Many intertidal organisms, such as anemones, have no skin or shell to protect them from the harmful UV rays and must live in lower zones where sea water acts as a filter. The higher the zone, the less protection there is to UV light. Organisms that live in the upper zones must have adaptations such as shells or they must seek refuge under rocks, sand, or seaweed during low tide.

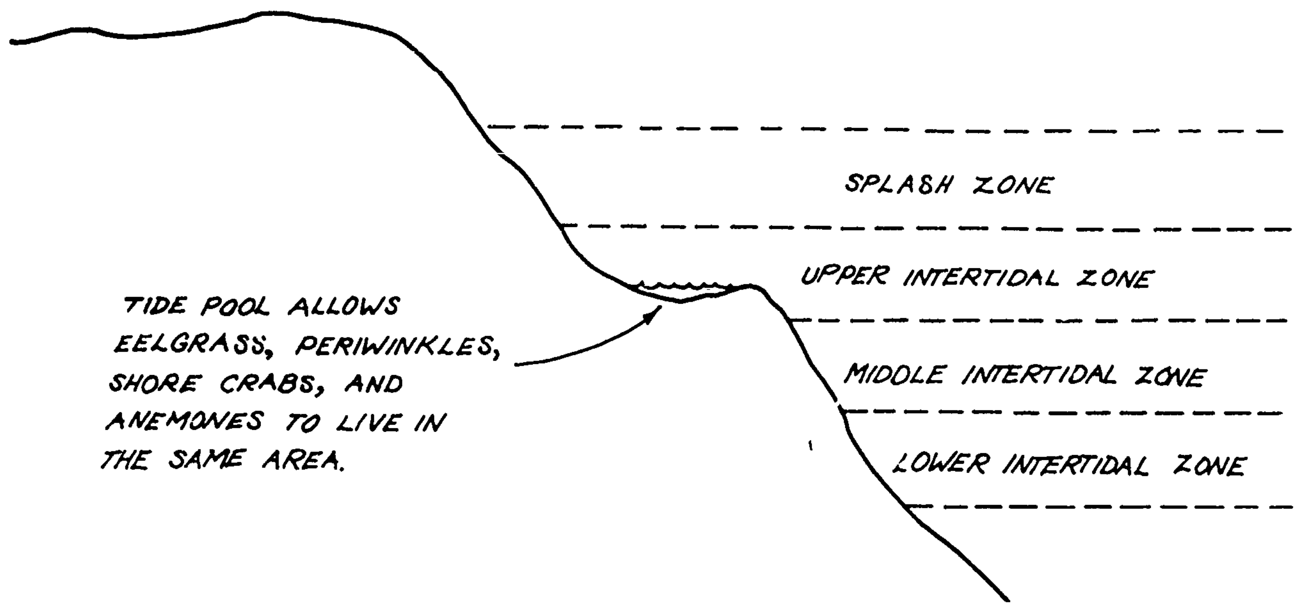
4. Competition for Space. There is only so much space on a rock or on a patch of sand. Some species can overgrow or force out other species.

5. Predation. The black turban snail is common in the Upper Intertidal Zone. If it moves down into the Middle Intertidal Zone, it stands a good chance of being eaten by the purple sea star which lives there.

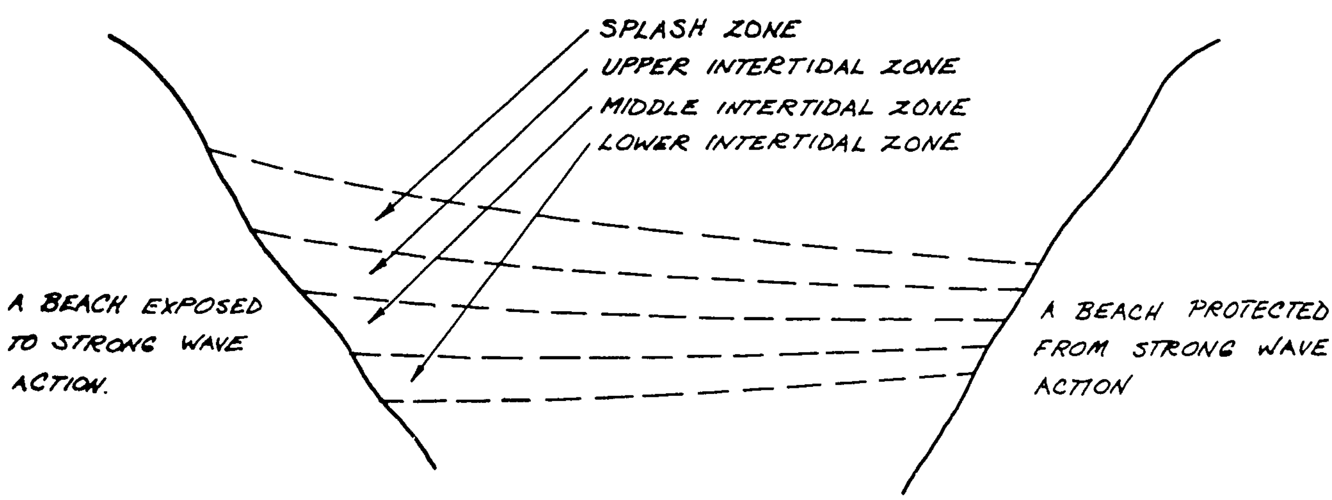
Why Are The Zones Sometimes Difficult To Identify?

One reason is that tide pools catch enough water to allow some organisms to live higher on the beach than they might otherwise be able to. For example, a depression in a rocky ledge might allow purple shore crabs, anemones, and eelgrass to live as high as the Splash Zone.

NAME ______________________



Another reason that zones are sometimes indistinct is that each zone is displaced upward by increased wave action. That is, the zones are all higher in an area which is exposed to the spray of breaking waves. The diagram below shows two areas, one protected and one exposed to waves, and the relative heights of the intertidal zones.



Since temperature extremes, solar radiation, and wave action change with the seasons, the zones change somewhat with the seasons, too.

Teacher Information Sheet
Key

WORKSHEET: Intertidal Zonation

1. Name the four intertidal zones. Tell how often each is covered by water.

The splash zone - often wetted only by spray from waves.
The upper intertidal zone - seldom covered by water.
The middle intertidal zone - covered by water, about as often as it is exposed to air.
The lower intertidal zone - usually covered by water. Exposed only at the lowest tides.

2. Give four reasons why an animal or plant might live in one zone and not in another.

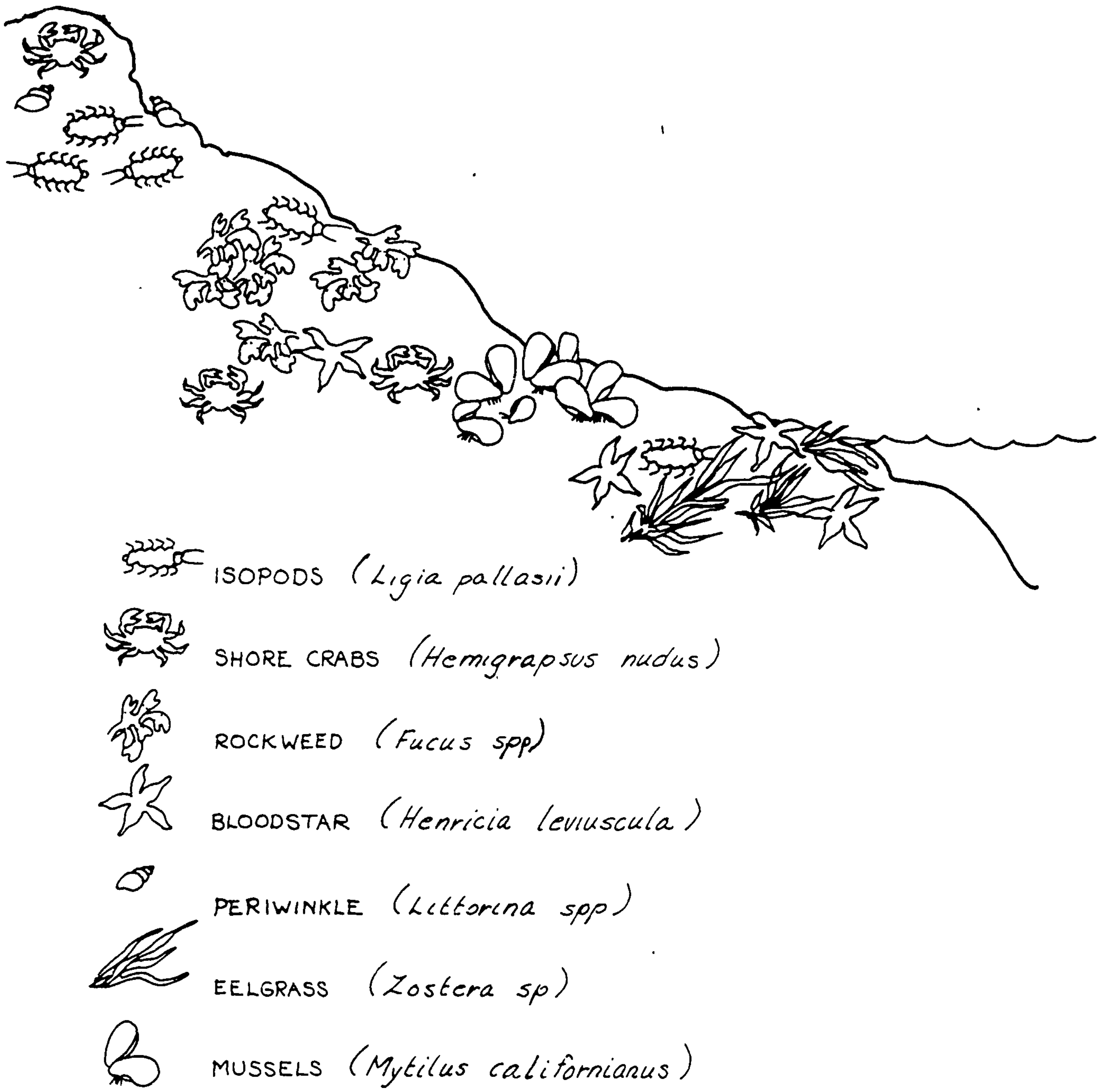
Organisms seek specific zones because of the following factors:
1. *predation.*
2. *solar radiation.*
3. *competition for space.*
4. *variations in temperature.*
5. *drying.*

3. What are some factors, not mentioned in the student reading on intertidal zonation, which might cause a plant or animal to live in one zone and not in another?

Answers will vary. They might include:
1. *oxygen-getting (some animals will need air to breathe, while others need to extract oxygen from water).*
2. *salt content of tide pools (tide pools will get saltier as they dry out).*
3. *availability of food.*
4. *resistance to the impact of waves.*
5. *pollution.*
6. *human usage.*
7. *the requirements of reproduction.*
8. *weather and seasonal changes.*

Teacher Information Sheet
Key

4. A profile (side view) of a beach is shown below. Using your knowledge of marker organisms, draw in lines to separate the zones. Label the zones. Watch out for strays!



NAME____________________________

WORKSHEET: Intertidal Zonation

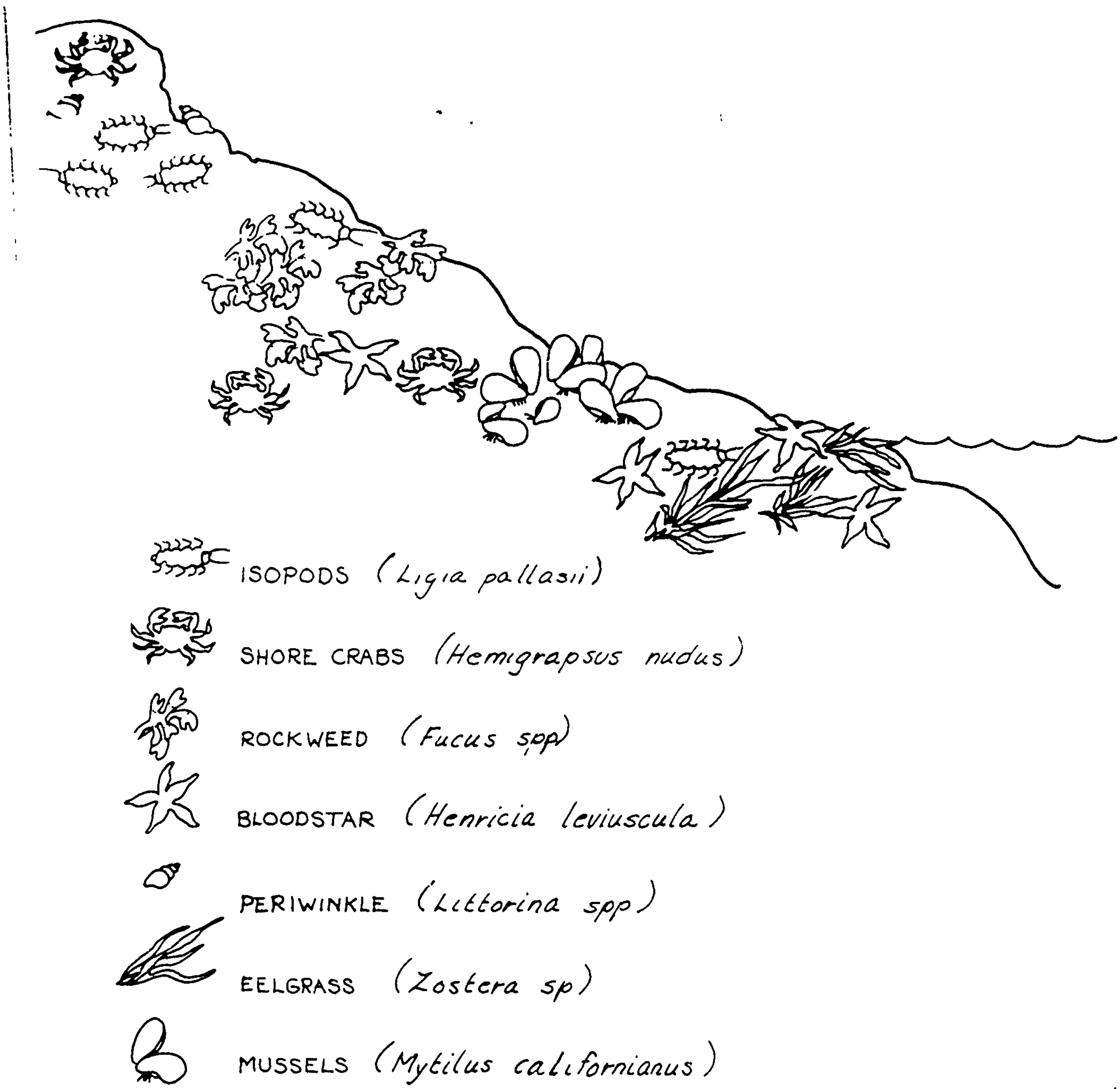
1. Name the four intertidal zones. Tell how often each is covered by water.

2. Give four reasons why an animal or plant might live in one zone but not in another.

3. What are some factors, not mentioned in the student reading on intertidal zonation, which might cause a plant or animal to live in one zone and not in another?

NAME____________________________

4. A profile (side view) of a beach is shown below. Using your knowledge of marker organisms, draw in lines to separate the zones. Label the zones. Watch out for strays!



NAME ____________________________

ACTIVITY 1: A BEACH TRANSECT

CONCEPT: A beach transect can be used to show how a beach is divided into intertidal zones.

MATERIALS:

1. Student handout, "Activity 1: A Beach Transect"
2. 2 ballpoint pens; one is a spare. Felt pens smear when wet, so they are not acceptable.
3. 1 clipboard
4. Marine organisms on the beach
5. A transect line (one for the entire class)
6. One 120 cm long string

PROCEDURES:

1. The transect line will be stretched from the water's edge to the highest level of marine life. It is marked off in one meter intervals. The teacher will assign you a place along the line. The transect line should cross only one kind of habitat (rocky shore, sandy beach, or mud flat).
2. Fill in the data at the top of the "Transect Data Sheet".
3. Upon arrival at your assigned mark, form the 120 cm string into a square. Count all organisms listed on the "Transect Data Sheet". When counting, take all possible measures to avoid injuring the marine life. When finished, restore the area to the condition in which you found it. Take the string with you.
4. One group will be assigned the job of finding the gradient of the beach. Directions are separate.
5. Go on to the other assigned activities.
6. (To be done in the classroom when the class returns.) Graph the results of the transect.

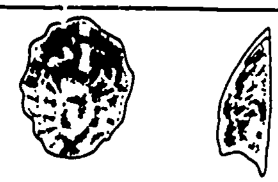
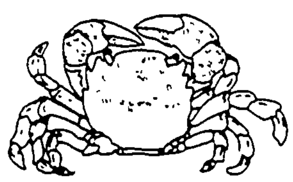
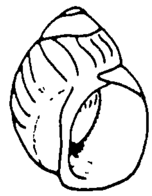
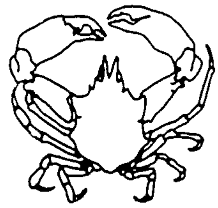
NAME________________________

TRANSECT DATA SHEET

Time______________________________ Tide____________________________

Location__________________________ Area of Square__________________

Assigned distance from the water's edge_____________________________ meters

Name of Organism	Illustration	Count
Limpet Acmaea digitalis		
Sargassum Cystoseira sp		
Purple Shore Crab Hemigrapsus nudus		
Periwinkles Littorina sp		
Kelp Crab Pugettia sp		

NAME ____________________

Finding the Beach Gradient

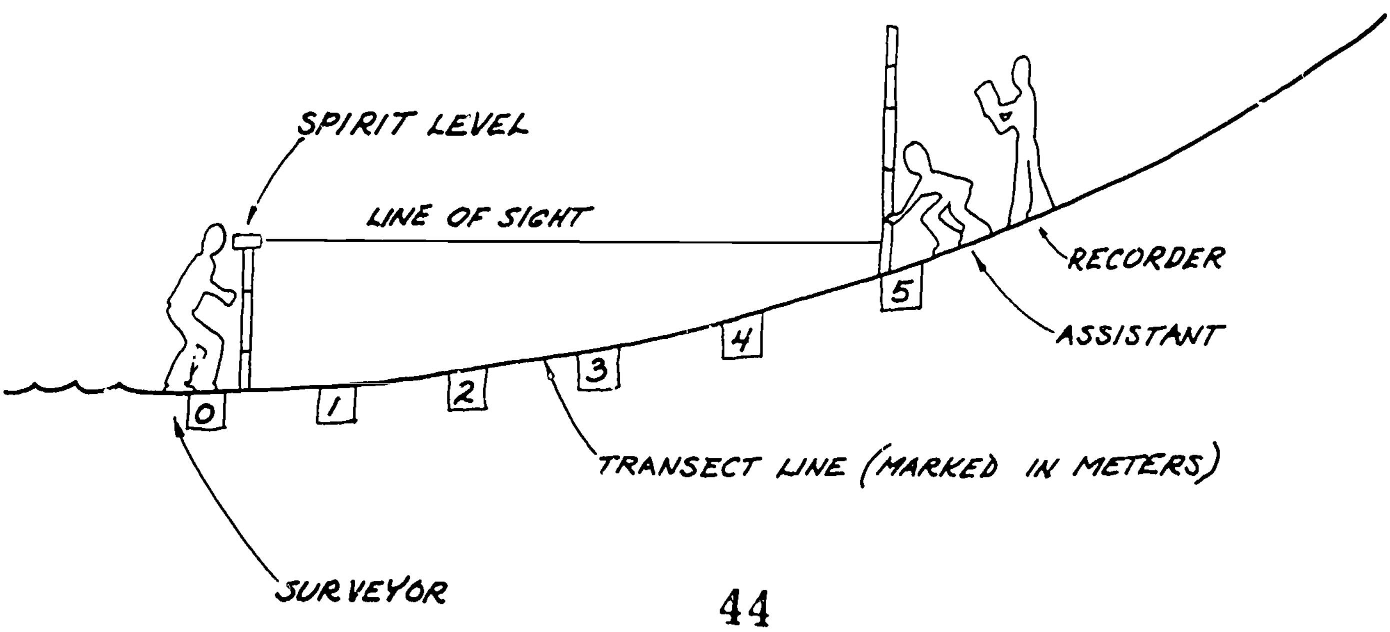
This part of the exercise is to be done by a specially assigned team of three. It will measure the steepness of the beach. This information will be used by all students during the graphing of the data from the beach transect.

MATERIALS:

1 spirit level
2 1x2 inch sticks, 1.5 meters long, divided into tenths of a meter
1 clipboard
2 ball point pens (One is a spare. Felt pens smear when wet.)
1 "Gradient Data Sheet"

PROCEDURES:

1. Assign each member of the team one of the following jobs.
   a. Recorder. This person takes down the data on the "Gradient Data Sheet".
   b. Surveyor. This person holds the stick with the spirit level.
   c. Assistant. The assistant holds the stick without the spirit level.
2. Place the surveyor's stick at zero (0) on the transect line. This is the end next to the water's edge. The elevation at Distance 0 is 0 Note that this is already marked on your "Gradient Data Sheet."
3. With the surveyor's stick at 0 m, move the assistant's stick to 5 m on the transect line. The surveyor places the spirit level on top of the stick. The surveyor sights along the spirit level (be certain 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.



NAME______________________

Finding the Beach Gradient

PROCEDURES.
(continued)

4. 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 distance 5 m.

5. Now the team moves 5 meters up the transect line. The surveyor should now be at 5 meters, and the recorder and assistant should be at 10 meters. Take another elevation at this point (10 m.)

6. Continue taking elevations until the team reaches the higher end of the transect line.

7. When the Gradient Data Sheet is filled in, give it to the teacher so copies can be made for all students. Return the sticks and spirit level to the proper storage place.

NAME________________________

Gradient Data Sheet

Team members: Recorder________________________

Surveyor________________________

Assistant________________________

Date________________________ Location________________________

Time________________________ Tide________________________

DISTANCE FROM WATER'S EDGE (METERS)	ELEVATION (METERS)

ACTIVITY 2:

OBSERVING STRUCTURAL ADAPTATIONS (1 DAY)

ACTIVITY 2: OBSERVING STRUCTURAL ADAPTATIONS (1 DAY)

CONCEPTS:

1. Organisms have specialized structures that are adaptations for survival

OBJECTIVES:

The student will demonstrate understanding of the concept of structural adaptation by:

1. explaining how neamatocysts are used to capture food.
2. explaining how cirri are used to capture food.
3. explaining how tube feet prevent echinoderms from being washed away by wave action.
4. explaining how byssal threads prevent mussels from being washed away by wave action.
5. explaining how pedicellarias are used to clean the aboral surfaces of sea stars and sea urchins.
6. relating the above structures to increased chances for survival of the organisms involved.

TEACHER PREPARATION:

1. Make arrangements for the field trip, (see ORCA activity packet, Marine Biology Field Trip Sites).
2. Duplicate a class set of the student handout "Activity 2: Observing Structural Adaptations".
3. Prior to class time, read "Teacher Information Sheet".

MATERIALS:

1. Class sets:
   "Activity 2: Observing Structural Adaptations"
   Clipboards (provided by students)

PROCEDURES:

1. Discuss the student handout "Activity 2: Observing Structural Adaptations" with the class prior to the field trip. Emphasize the need to minimize the class's impact on the beach ecology. Students should restore organisms, rocks, etc. to the condition in which they were found.
2. Have the students do Activity 2 at a beach. Have extra student handouts at the field trip site to replace lost or damaged copies. Activity 2 may be run concurrently with "Activity 3: Observing Behavioral Adaptations".
3. When back in the classroom, discuss observations made by the students. Elicity responses from several students for each question.

EXTENDED ACTIVITIES:

1. Observe the oxygen-getting structures of various marine organisms such as clams (siphons and gills), sea cucumbers (branchae), and sea stars (dermal gills).

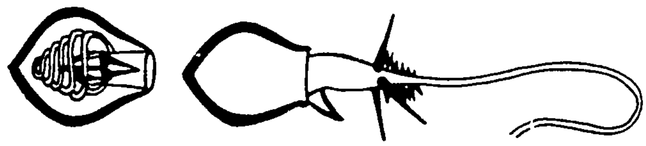
2. Observe the means by which marine organisms avoid drying (dessication). Specimens might include limpets (shell fastened tightly to rock), snails (operculum), nudibranches (hiding under seaweed), and sea stars (retaining water in the water vascular system).

3. Measure the effect of temperature or salinity changes on the rate of feeding of barnacles.
4. Refer to the Pacific Science Center/Sea Grant publication Beaches for further activities.

TEACHER INFORMATION SHEET

Organisms use a variety of structural modifications as adaptations to their environment. Littoral organisms are particularly well suited to study of these adaptations, since their environment changes drastically during the course of a day. With the change of the tides there are enormous changes in temperature, salinity, food availability, and oxygen availability. To survive these changes, littoral organisms have developed structural adaptations for feeding, attachment, oxygen-getting, protection against predators, and protection from dessication.

Feeding. Two methods of feeding are studied in this exercise. Nematocysts are specialized stinging cells located on the tentacles of sea anemones and jellyfish. These cells are everted (turned inside-out) when stimulated by a combination of touch and chemical presence. The mechanism of firing is not definitely known. Discharge is caused either by pressure caused by rapid intake of water or contractile fibers surrounding the capsule. Nematocysts are used only once.



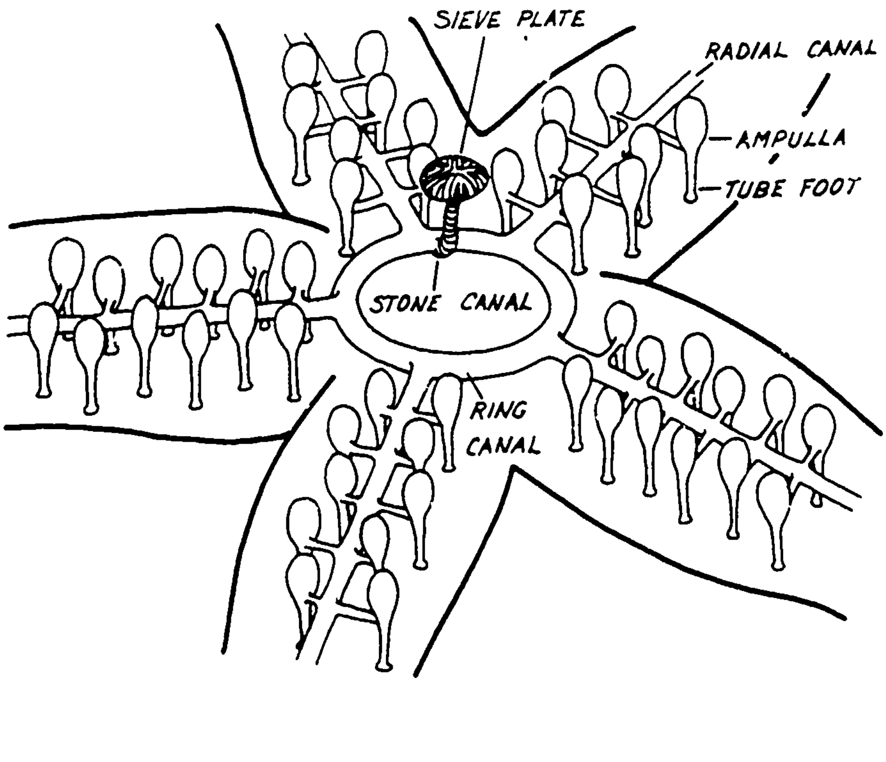
The barbed stinging capsule of the nematocyst injects a toxin into the victim. This is of no consequence to humans, since they are protected by a thick skin, but a small invertebrate which is covered only by a single-cell layer of epidermis can be killed or paralyzed. Larger invertebrates can be discouraged from attacking as hundreds of nematocysts discharge. The nematocyst is barbed and may be torn away from the tentacle as a larger organism tries to escape.

Nematocysts may be no match for the thick skin of a human, but a sensitive tongue will receive a sharp sensation. This is not recommended, however. It is possible to feel the resistance of clinging nematocysts by touching the hairs on the back of a hand to the tentacles of a sea anemone. (This provides the basis for one of the activities of this section.) Once the nematocysts have immobilized the prey, the tentacles are drawn toward the mouth by sets of longitudinal muscles in the anemone's stalk. The food is digested in the gastrovascular cavity, and waste material is ejected back through the mouth. Without one of the two required stimuli (mechanical and chemical) the sea anemone will not exhibit the feeding response, therefore a shell or small stone will not cause the tentacles to close. Nematocysts function not only in feeding; they are also defensive structural adaptations. Only one organism, the nudibranch Aeolidia papillosa, is known to feed on anemones. In fact, not only is the nudibranch able to ingest the nematocysts without firing them, it is also able to pass them through its tissues to the finger-like cerata on its back. These may be caused to explode if the cerata is torn off, but there is no evidence that the nudibranch actually uses this as a defense mechanism.

The second feeding adaptation that students will observe is that of the barnacle. The barnacle is an anthropod, related to the lobster and the crab. It is in the unique position of sitting on its head, waving its feet above it. The barnacle larva comes to rest on an appropriate substratum and cements to it with one of its antennae. The mantle secretes a calcareous shell, and six pair of feathery appendages (corresponding to the legs of a crab) develop. These appendages are called cirri. The cirri sweep through the seawater as if they were nets being cast. They filter plankton and detritus from the water, and mouth parts move the food to the mouth. If a prevailing current is present, the barnacle larva orients itself so the adult's cirri oppose the current. In this way it maximizes its ability to filter food. If the current fluctuates, most barnacles have the ability to rotate 180°. The sweep rate is rather constant, although it increases with increasing temperature and decreasing salinity. The sweeping action can occur only when the barnacles are submerged in water, so specimens which live in the higher tide zones must feed only during the few hours of the month when they are submerged by the highest high tide.

Attachment. Most littoral organisms must avoid being dislodged in order to escape being battered by the surf and to remain in a suitable habitat. The three main methods of accomplishing this are by attachment to rocks, by self-burial in sand or mud, and by hiding under rocks or seaweed. Obviously, an attempt to attach to surface sand would fail, so organisms have developed structural adaptations specific to habitats. Two means of attachment are studied by the students in Activity 1--the tube feet of the sea star and the byssal threads of the mussel.

Sea stars attach themselves firmly to rocks by means of hundreds of tube feet which are operated by a water vascular system.

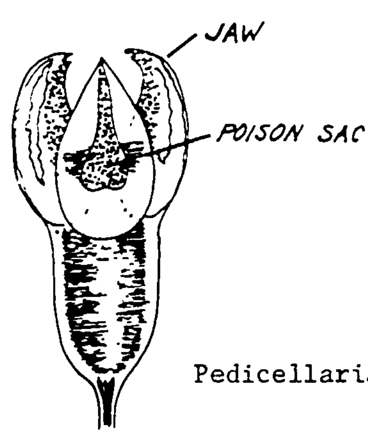


Water enters the system of canals through the sieve plate (madreporite). Muscular contractions shorten the tube foot to attach to the substrate. The foot can be released by contraction of the ampulla, which forces water into the foot, breaking the suction. The tube feet also function in locomotion and food acquisition. Some sea stars, such as the common Pisaster ochraceous, attach their tube feet to the shells of their prey (such as a clam) and exert steady outward pressure. When the clam's adductor muscles tire, the sea star everts it stomach and digests its meals "on the half shell."

The mussel attaches itself to rocks by strong, elastic byssal threads. The threads are formed by the hardening of a fluid secreted by the byssal glands upon contact with sea water. The mussel, which appears so immobile, can actually move to a new location by breaking old byssal threads and forming new ones. Mussels are further protected from wave action by their habit of forming densely populated mussel beds. The beds provide an interlocking network of threads and shells which , incidentally, form a habitat for worms, crabs, algae, and shrimp.

Other structural adaptations for attachment include the muscular foot of the limpet or snail, the suckers of the octopus, and the legs of crabs or isopods. These could provide a topic for further study by students.

Defense. A slow moving sea star is in danger of being grown over by algae, sponges, and barnacles. This would smother the dermal gills through which the sea star extracts oxygen from sea water. The structural adaptations by which sea stars accomplish this are the pediceliarias on its aboral surface. These small pincher-like structures clamp onto any organism which attempts to grow



Pedicellaria (enlarged)

or crawl across the sea star or sea urchin. A toxin, which is irritating to small organisms, further discourages intrusion.

Other structural adaptations for defense would include the parrot-like beak of the octopus, the powerful pinchers of the crab, and the hard shell of the clam, mussel, or limpet.

NAME______________________

ACTIVITY 2: OBSERVING STRUCTURAL ADAPTATIONS

CONCEPT: Marine organisms have specialized structures that are adaptations to the marine environment.

MATERIALS:

1. Student Handout, Activity 2, "Observing Structural Adaptations".
2. Two ballpoint pens. One is a spare. Felt pens will smear when wet, and are not acceptable.
3. One clipboard.
4. Marine organisms on the beach.

PROCEDURES:

1. Feeding by sea anemones. Locate a sea anemone which has its tentacles out. Drop one small bit of rock or shell on the tentacles. Describe what happens in the space below.

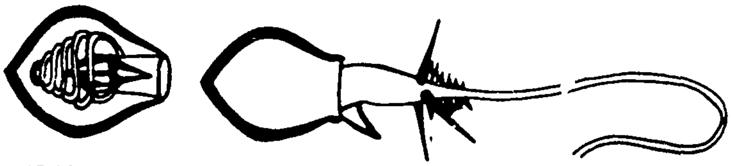
Now place a small bit of meat scooped from a limpet on the tentacle. Describe what happens.

Place your fingertip on the tentacles of another anemone. Describe what you feel.

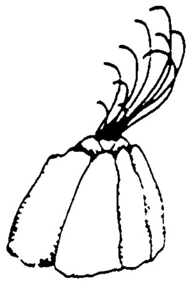
The anemone senses touch and the presence of certain biological chemicals. When both touch and the chemicals are present, the anemone reacts by shooting tiny stinging capsules called nematocysts into its victim. The tentacles then draw the paralyzed victim toward the mouth. You can just barely feel the nematocysts because of your thick skin.

NAME______________________

Look at the following drawing of a nematocyst (greatly enlarged), then write a description of what caused the sensation on your fingertip.



2. Feeding by barnacles. Locate a small tidepool in which barnacles are feeding. Lie on your stomach and quietly watch the barnacles for several minutes. Write a description of the barnacle's feeding movements.



NAME ______________________

What do you think the barnacle is eating?

How many times per minute does the barnacle move its feathery cirri (legs modified for feeding)?

What happens when you touch the cirri with your fingers?

3. Attachment by sea stars. Locate a mottled sea star (Evasterias troschelii) or a purple sea star (Pisaster ochraceous). Tug carefully on one of its rays. Careful inspection of its underside will show many tube feet. Sketch several tube feet near the tip of a ray as they appear before they are torn loose from the rock.

List three functions of the tube feet.

1.

2.

3.

How does the sea star hold onto the rock so tightly even though a tube foot is so tiny and weak?

Place the sea star on its back. Describe how it turns over. Tell how long it takes.

4. Attachment by mussels. Locate a mussel bed. Probe carefully among the mussels. They are held in place by string ce byssal threads. Sketch a single mussel and its thre to show the pattern of attachment.

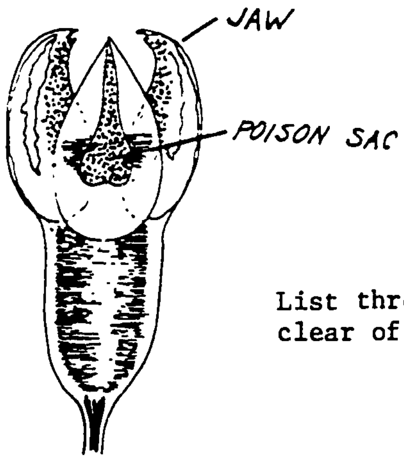
NAME ______________________________

Are the threads elastic or brittle?

Remove a small mussel from the bed and place it in a small quiet tidepool. If you are patient, you will see new byssal threads being formed. Describe how the threads are formed.

5. Defense by the sea star. Locate a mottled sea star (Evasterias troschelli) or a purple sea star (Pisaster ochraceous). Carefully remove one and place its top surface against your bare arm. Hold it in place for a minute. Describe what you feel.

The sea star attacks anything that falls on its back by tiny pinchers called pedicellarias. One is shown in the illustration below. You may use a hand lens to try to find some on the hairs of your arm. Between pinching the intruder and irritating it with a toxin, the sea star is able to keep its upper surface clean.



List three reasons why the sea star wants to keep its back clear of algae or small animals.

If you have something fuzzy, such as a mitten or sweater, it may be possible to demonstrate that the sea star can support its entire weight by the hundreds of pedicellariae on its back, all of which are grasping the fibers of the mitten. Try it. Tell how successful you were.

ACTIVITY 3:
OBSERVING BEHAVIORAL ADAPTATIONS (1 DAY)

ACTIVITY 3: OBSERVING BEHAVIORAL ADAPTATIONS (1 DAY)

CONCEPTS:

1. Organisms have specialized behavior patterns that are adaptations for survival.

OBJECTIVES:

The student will demonstrate understanding of the concept of behavioral adaptation for survival by:

1. explaining the behavior of limpets in the presence of a sea star predator.
2. describing the behavior of hermit crabs when food is made available.
3. describing the color changes of octopuses when threatened.
4. describing evisceration.
5. relating the above behaviors to increased chances of survival for the organism.

TEACHER PREPARATION:

1. Make arrangements for the field trip, (see ORCA activity packet, Beach Field Trip Sites).
2. Reproduce a class set of the student handout "Activity 3: Observing Behavioral Adaptations".
3. Prior to class time, read "Teacher Information Sheet".

MATERIALS:

1. Class set of "Activity 3: Observing Behavioral Adaptations".

PROCEDURES:

1. Discuss the student handout "Activity 3: Observing Behavioral Adaptations" with the class prior to the field trip. Emphasize the need to minimize the class's impact on the beach ecology. Students should restore organisms and rocks to the condition in which they were found.
2. Have the students do Activity 3 at the beach. Have extra student handouts available to replace lost or damaged copies. Activity 3 may be run concurrently with "Activity 2: Observing Structural Adaptations".
3. When back in the classroom, discuss observations made by the students. For each question, elicit responses from several students.

EXTENDED ACTIVITIES:

1. Study other forms of taxis. Phototaxis can be studied in the classroom using brine shrimp purchased from a pet store. A marine aquarium in the classroom will allow study of phototaxis of a variety of organisms, such as the sea star.
2. Study the response of the snail, Littorina sp., to the availability of water. See Pacific Science Center/Sea Grant publication "Beaches".
3. Place the polychaete worm, Nereis sp., in the center of a pan and surround it with choices of food (clam, fish, beef, liver, hamburger, cheese, etc. at distances of 25 cm. What is the food preference of Nereis?
4. Find out if purple shore crabs, Hemigrapsus nudus, will return to the same rock. Number each rock in a cluster of several rocks. Number individual crabs. Release the crabs in the center of the cluster of rocks to see if they return to their original hiding place.

5. See if the sea star, Pisaster ochraceous, will always use a preferred arm to right itself when turned over. The rays can be distinguished from one another by observing their positions relative to the madreporite, which is off-center.
6. Bring a rock or small log with attached barnacles to the classroom marine aquarium. For several days compare the feeding times with tide charts. It probably will be observed that the barnacles continue to feed during the times of high tide, even though there are ~~no~~ tides in the aquarium.

BEHAVIORAL ADAPTATIONS

Marine organisms exhibit certain behaviors that can be explained in terms of adaptations to their ecological niches. In Activity 3, students examine some of these behaviors.

It sometimes appears that organisms move randomly about the beach. In actuality, most organisms are responding to some factor in their environment. Organisms may move toward a stimulus, away from a stimulus, or they may remain stationary. Movement in response to a stimulus is called taxis. Movement toward a stimulus is positive taxis; movement away from a stimulus is negative taxis. The students will observe positive taxis in the hermit crab as it moves toward the food source and negative taxis as the limpet moves away from a predator. Other forms of taxis can be more easily studied in the classroom marine aquarium. Phototaxis is movement in response to light intensity. Geotaxis is movement in response to the force of gravity. And, in addition, it is possible to demonstrate that many organisms will seek a wet or dry part of an aquarium (see the Pacific Science Center/Sea Grant publication, "Beaches").

The movement of the limpet in response to the sea star, and the hermit crab in response to food, are indications of their abilities to detect chemical substances in sea water. In short, they have a keen sense of smell.

The color changes of the octopus are the result of the spreading of pigment spots called chromatophores. While it is tempting to relate the color changes to human emotions, it is probably unrelated. Gentle prodding of the octopus will bring on a series of color changes that vary from white to splotchy red to vivid red. The octopus will try to return to the shadows where it will darken and turn black. This is effective camouflage.

The sea cucumber will sometimes discharge its internal organs through its anus, mouth or its body wall when it is picked up, handled or threatened. This habit, which appears strange to humans, may effectively distract a potential predator. The sea cucumber is able to regenerate new internal organs over a period of several weeks. Other stimuli which cause evisceration are electrical shocks, fouling of the water, crowding, or a rise in temperature.

NAME ____________________

ACTIVITY 3: OBSERVING BEHAVIORAL ADAPTATIONS

CONCEPT: Marine organisms show certain behaviors that enable them to survive.

MATERIALS:

1. Student handout, Activity 3.
2. Two ballpoint pens. One is a spare. Felt pens will smear when wet and are not acceptable.
3. One clipboard.
4. Marine organisms on the beach.

PROCEDURES:

1. Locate a purple sea star (Pisaster ochraceous) or a mottled sea star (Evasterias trochelli), and place it near several limpets in a tide pool. Record what happens.

   What do you think is the ecological relationship between the sea star and the limpet?

2. Locate a quiet tidepool. Lie on your stomach so you can observe the activities in the pool. Identify the hermit crabs in their borrowed snail shells. Place a bit of meat scooped from a limpet in one part of the tidepool and remain motionless for a few minutes. Record what happens.

   What sense probably allowed the hermit crab to detect the limpet meat?

NAME ______________________

3. Locate an octopus if time allows. They are often found in the lower tidal zones in rocky crevices. While they are common on Puget Sound, they are shy and avoid people. They are capable of biting hard, so keep your hands and fingers away from the mouth which is located between its eight arms. Be careful not to tear the flesh of the octopus during this observation. Try to pull an arm off of the rock. Record the color changes that appear as a result of prodding. What color changes occur when the octopus is free to return to the shadows?

4. Locate a white sea cucumber, Eupentacta quinquesemita. Pick it up to determine which end is the mouth end and which is the anus. You may witness an alarming behavioral adaptation to threat - evisceration. Evisceration is the giving off of the sea cucumber's internal organs. Why would this be of use to the sea cucumber if it were attacked?

If you are fortunate enough to see evisceration, describe the way in which internal organs are shed.

ACTIVITY 4:

BE AN EXPERT . . .

(5-25 DAYS)

ACTIVITY 4: BE AN EXPERT... (5-25 DAYS)

CONCEPTS:

1. Each group of marine organisms has a characteristic anatomy, habitat, reproductive habit, life cycle, feeding mechanism, defense mechanisms, etc. which can be discovered through library and field research.

OBJECTIVES:

The student will demonstrate understanding of the biology of a group of marine organisms by:

1. making an oral and/or written report on that group.
2. acting as a reference source to other students who have questions about tnat group while on the field trip.

TEACHER PREPARATION:

1. The time required for Activity 4 may take up to three weeks prior to the field trip; one hour at the field trip site; and up to two weeks after the field trip. Consider what will be appropriate for your class.
2. Gather all the resource materials (books, films, and periodicals) available.
3. Reproduce a class set of the student handout"Activity 4: Be An Expert...".
4. Reproduce a class set of "Common Marine Genera".

MATERIALS:

1. Books, films, filmstrips, periodicals and any other references relating to marine biology.
2. Class sets of:
   "Activity 4: Be An Expert..."
   "Common Marine Genera"

PROCEDURES:

1. Gather all reference materials available on marine biology. Have them on a cart in the classroom. Develop some kind of check-out procedure.
2. Fill in the blank area on the student handout "Activity 4: Be An Expert..." with the names of one of the groups of marine organisms.
3. Distribute the student handouts. This may be random, student's choice, or teacher's choice.
4. Allow class time for students to research their assigned groups. This activity might begin up to three weeks prior to the field trip.
5. Allow time on the beach for students to research their assigned group.
6. After the field trip, allow time (up to two weeks) for the students to write their reports. Some may wish to give oral reports.

Teacher Information Sheet

Students like the idea of becoming an expert on something. The purpose of this activity is to give them that opportunity and to develop within them the concept of the interrelationships among an organism's anatomy, reproductive habits, habitat, life cycle, food, economic importance, etc.

Use the bibliography at the end of this activity packet to develop a library of reference materials.

You will find, on the following pages, these lists:

1. Suggested Marine-Group Assignments
2. Common Marine Genera
3. Alphabetical List of Common Genera

You may wish to duplicate the list(s) for student use.

Teacher Information Sheet

Suggested Marine-Group Assignments

Assign each of the following to one or two students. These groupings have been selected because specimens are (generally) readily found on field trips. Each group contains a reasonable number of species. Exotic animal groups, or groups with only one species, have been omitted.

GROUP	STUDENT	STUDENT
Sponges*		
Jellyfish		
Sea Anemones		
Polychaete worms		
Barnacles		
Isopods		
Amphipods		
Crabs		
Chitons**		
Limpets**		
Snails		
Nudibranchs		
Bivalves		
Sea Stars**		
Sea Urchins**		
Sea Cucumbers		
Tunicates*		
Vertebrates		
Green Algae		
Red Algae		
Brown Algae		

* Rather difficult group. Assign highly motivated students.

** Rather easy group. You may choose to save these groups for certain students.

NAME________________

COMMON MARINE GENERA

K - PROTISTA

P - CHLOROPHYTA

1. Enteromorpha
2. Ulva
3. Spongomorpha
4. Urospora
5. Codium

P - PHAEOPHYTA

6. Ralfsia
7. Leathesia
8. Heterochordaria
9. Desmarestia
10. Scytosiphon
11. Soranthera
12. Agarum
13. Costaria
14. Cymthere
15. Hedophyllum
16. Laminaria
17. Pleurophycus
18. Lessoniopsis
19. Macrocystis
20. Nereocystis
21. Alaria
22. Egregia
3. Pterygophora
24. Fucus
25. Cystoseria

P - RHODOPHYTA

26. Smithora
27. Porphyra
28. Constantinea
29. Farlowia
30. Bossiella
31. Calliarthron
32. Corallina
33. Lithothamnion
34. Polyporolithon
35. Endocladia
36. Gloiopeltis
37. Prionitis
38. Callophyllis
39. Agardhiella
40. Opuntiella
41. Sarcodiotheca
42. Plocamium

K - PROTISTA

P - RHODOPHYTA

43. Ahnfeltia
44. Gigartina
45. Iridaea
46. Halosaccion
47. Rhodymenia
48. Antithamnion
49. Callithamnion
50. Ceramium
51. Microcladia
52. Platythamnion
53. Ptilota
54. Rhodoptilum
55. Cryptopleura
56. Delesseria
57. Gonimophyllum
58. Polyneura
59. Laurencia
60. Odonthalia
61. Polysiphonia
62. Pterosiphonia
63. Rhodomela

K - METAPHYTA

P - ANTHOPHYTA

64. Phyllospadix
65. Zostera

K - METAZOA

P - PORIFERA

66. Myxilla
67. Plocamia
68. Halichondria
69. Haliclona
70. Cliona
71. Terpios

P - CNIDARIA

C - HYDROZOA

72. Tubularia
73. Obelia
74. Aglaophenia
75. Aequorea

NAME ____________

K - METAZOA

P - CNIDARIA

C - HYDROZOA

76. Phialidium
77. Stylantheca
78. Velella

C - SCHYPHOZOA

79. Aurellia

C - ANTHOZOA

80. Anthopleura
81. Epiactis
82. Metridium
83. Tealia
84. Balanophyllia

P - CTENOPHORA

85. Pleurobranchia

P - PLATYHELMINTHA

86. Notoplana

P - RHYNCHOCOELA

87. Emplectonema
88. Paranemertes

P - PHORONIDEA

89. Phoronis

P - ECTOPROCTA

90. Bugula
91. Membranipora

P - BRACHIOPODA

92. Terebratalia

P - SIPUNCULA

93. Phascolosoma

K - METAZOA

P - ANNELIDA

C - POLYCHAETA

94. Glycera
95. Nereis
96. Arctonoe
97. Halosydna
98. Abarenicola
99. Mesochaetopterus
100. Lumbrineris
101. Eudistylia
102. Schizobranchia
103. Serpula
104. Spirorbis
105. Neoamphitrite

Sub C - CIRRIPEDIA

106. Lepas
107. Pollicipes
108. Balanus
109. Chthamalus

Sub C - MALACOSTRACA

O - ISOPODA

110. Limnoria
111. Idothea
112. Ligia

O - AMPHIPODA

113. Orhcestoidea
114. Caprella

O - DECAPODA

T - CARIDEA

115. Crago
116. Spirontocaris

T - MACRURA

117. Callianassa
118. Upogebia

T - ANOMURA

119. Pachycheles
120. Petrolisthes
121. Pagurus

NAME ____________ ____________

T - BRACHYURA

122. Cancer
123. Hemigrapsus
124. Pinnixa
125. Lophopanopeus
126. Pugettia

K - METAZOA

P - MOLLUSCA

C - AMPHINEURA

127. Amicula
128. Ischnochiton
129. Tonicella
130. Katharina
131. Mopalia

C - GASTROPODA

Sub C - PROSOBRANCHIATA

132. Acmaea
133. Liodora
134. Calliostoma
134a. Collisella
135. Tegula
136. Littorina
137. Crepidula
138. Crepipatella
139. Polinices
140. Ceratostoma
141. Nucella (Thais)
142. Searlesia
143. Nassarius
144. Olivella

Sub C - OPISTHOBRANCHIATA

145. Phyllaplysia
146. Archidoris
147. Cadlina
148. Diaulula

150. Rostanga
151. Dirona
152. Chioraera
153. Aeolidia
154. Hermissenda
155. Onchidella

K - METAZOA

P - MOLLUSCA

C - PELECYPODA

O - FILIBRANCHIA

156. Mytilus
157. Modiolus
158. Hinnites
159. Pecten
160. Pododesmus

O - EULAMELLIABRANCHIA

161. Crassostrea
162. Ostrea
163. Clinocardium
164. Saxidomus
165. Protothaca
166. Tresus
167. Macoma
168. Siliqua
169. Mya
170. Panope
171. Penitella
172. Bankia

P - ECHINODERMATA

C - ASTEROIDEA

173. Dermasterias
174. Henricia
175. Solaster
176. Evasterias
177. Leptasterias
178. Pisaster
179. Pycnopodia

C - ECHINOIDEA

180. Strongylocentrotus
181. Dendraster

C - HOLOTHUROIDEA

182. Cucumaria
183 Eupentacta
184. Parastichopus

NAME______________________________

K - METAZOA

P - CHORDATA

Sub P - UROCHORDATA

186. Amaroucium
187. Chelyosoma
188. Corella
189. Boltenia
190. Pyura
191. Styela

Sub P - VERTEBRATA

192. Syngnathus
193. Anoplarchus
194. Oligocottus
195. Gobiesox

NAME__________ ______________

ALPHABETICAL LIST OF COMMON GENERA

98. Abarenicola
132. Acmaea
153. Aeolidia
75. Aequorea
39. Agardhiella
12. Agarum
74. Aglaophenia
43. Ahnfeltia
21. Alaria
77. Allopora
186. Amaroucium
127. Amicula
80. Anthopleura
48. Antithamnion
193. Anoplarchus
146. Archidoris
96. Arctonoe
79. Aurellia
84. Balanophyllia
108. Balanus
172. Bankia
189. Boltenia
30. Bossiella
55. Botryoglossum
90. Bugula
147. Cadlina
117. Callianassa
31. Calliarthron
134. Calliostoma
49. Callithamnion
38. Callophyllis
122. Cancer
114. Caprella
50. Ceramium
140. Ceratostoma
187. Chelyosoma
152. Chioraera
109. Chthamalus
163. Clinocardium
70. Cliona
5. Codium
134a. Collisella
28. Constantinea
32. Corallina
188. Corella
13. Costaria
115. Crago
161. Crassostrea
137. Crepidula
138. Crepipatella
182. Cucumaria
14. Cymthere
25. Cystoseria
[illegible]. Delesseria
181. Dendraster
173. Dermasterias
9. Desmarestia
148. Diaulula
133. Diodora
151. Dirona
22. Egregia
87. Emplectonema
35. Endocladia
1. Enteromorpha
81. Epiactis
101. Eudistylia
183. Eupentacta
176. Evasterias
29. Farlowia
24. Fucus
44. Gigartina
36. Gloiopeltis
94. Glycera
195. Gobiesox
57. Gonimophyllum
46. Halosaccion
68. Halichondria
69. Haliclona
97. Halosydna
15. Hedophyllum
123. Hemigrapsus
174. Henricia
154. Hermissenda
8. Heterochordaria
158. Hinnites
111. Idothea
4[illegible]. Iridaea
128. Ischnochiton
130. Katharina
16. Laminaria
59. Laurencia
7. Leathesia
106. Lepas
177. Leptasterias
18. Lessoniopsis
112. Ligia
110. Limnoria
33. Lithothamnion
136. Littorina
125. Lophopanopeus

NAME ____________________

100. Lumbrineris
19. Macrocystis
167. Macoma
91. Membranipora
99. Mesochaetopterus
82. Metridium
51. Microcladia
157. Modiolus
131. Mopalia
169. Mya
156. Mytilus
66. Myxilla
143. Massarius
95. Nereis
20. Nereocystis
105. Neoamphitrite
86. Notoplana
141. Nucella (Thais)
73. Obelia
60. Odonthalia
194. Oligocottus
144. Olivella
15[illegible]. Onchidella
40. Opuntiella
113. Orchestoidea
162. Ostrea
119. Pachycheles
121. Pagurus
170. Panope
88. Paranemertes
184. Parastichopus
159. Pecten
171. Penitella
120. Petrolisthes
93. Phascolosoma
76. Phialidium
89. Phoronis
145. Phyllaplysia
64. Phyllospadix
124. Pinnixa
178. Pisaster
52. Platythamnion
85. Pleurobranchia
17. Pleurophycus
67. Plocamia
42. Plocamium
160. Pododesmus
139. Polinices
107. Pollicipes
58. Polyneura
34. Polyporolithon
61. Polysiphonia
27. Porphyra
37. Prionitis
165. Protothaca
62. Pterosiphonia
23. Pterygophora
53. Ptilota
126. Pugettia
179. Pycnopodia
190. Pyura
6. Ra[illegible]sia
63. Rhodomela
54. Rhodoptilum
47. Rhodymenia
150. Rostanga
85. Sagitta
41. Sarcodiotheca
164. Saxidomus
102. Schizobranchia
10. Scytosiphon
142. Searlesia
103. Serpula
168. Siliqua
26. Smithora
175. Solaster
11. Soranthera
116. Spirontocaris
104. Spriorbis
3. Spongomorpha
180. Stronglyocentrotus
191. Styela
192. Synganathus
83. Tealia
135. Tegula
92. Terebratalia
71. Terpios
141. Nucella (Thais)
129. Tonicella
166. T[illegible]esus
72. Tubularia
2. Ulva
118. Upogebia
4. Urospora
78. Velella
65. Zostera

NAME ____________________

ACTIVITY 4: BE AN EXPERT . . .

We have studied marine biology only in very general terms. Now you will have the opportunity to specialize. You are assigned to learn everything you can about the following group.

You should research your group carefully before the field trip. During the field trip, questions about your assigned group of animals and plants will be referred to you.

Learn all you can about your group's:

Anatomy (internal and external)

Species to be found at the field trip site

Field identification of species

Life cycle(s)

Scientific names

Common names

Food; feeding mechanisms

Habitat(s)

Predators

Protection against predators

Oxygen-getting

Tidal zones

Protection against dessication (drying)

Economic importance (if any)

Edibility. Recipes?

Reproductive structures

Etc.

ACTIVITY 5: INTERTIDAL HABITATS (2 DAYS)

ACTIVITY 5: INTERTIDAL HABITATS (2 DAYS)

CONCEPTS:

1. Intertidal organisms live in three major habitats - mud flats, sandy beaches, and rocky shores.

OBJECTIVES: The student will demonstrate understanding of the concept of habitat by:

1. explaining habitat.
2. naming three major habitats.
3. describing key intertidal life of each habitat.
4. identifying key intertidal life of each habitat.
5. explaining how organisms have adapted to the physical characteristics of each.

TEACHER PREPARATION:

1. Read "Teacher Information Sheet".
2. Make class set of "Activity 5: Intertidal Habitats".
3. Make class set of "Quiz: Intertidal Habitats".

MATERIALS:

1. Class sets of:
   "Activity 5: Intertidal Habitats"
   "Quiz: Intertidal Habitats"

PROCEDURES:

1. Introduce the activity by having students describe some beaches to which they have been. Lead them toward a description of the 3 habitats.
2. Have students do the activity.
3. Discuss the results. Correct errors or misconceptions. You may wish to distribute the activity with answers (the Teacher Information Sheet).
4. Give the quiz.

EXTENDED ACTIVITIES:

1. Use tall-form bottles filled with a mud, sand, gravel mixture to demonstrate the relationship between particle size and settling rate, (see ORCA activity packet, Beaches).
2. Have students research and report on 'minor' habitats such as cobblestone, eelgrass, and salt marshes.
3. Before students disperse on a beach field trip, have them identify habitats that are present. Relate the scene before them to classroom activities on habitat formation and species adaptation.

Teacher Information Sheet

HABITATS

Habitats are the places where organisms live. A rapidly flowing stream will have a characteristic assemblage of plants and animals, as will a stretch of high desert. Marine organisms live in habitats of a wide variety. These include the open sea, pilings, salt marshes, and tide pools. This activity will deal with the three major intertidal habitats - the mud flat, the sandy beach, and the rocky shore.

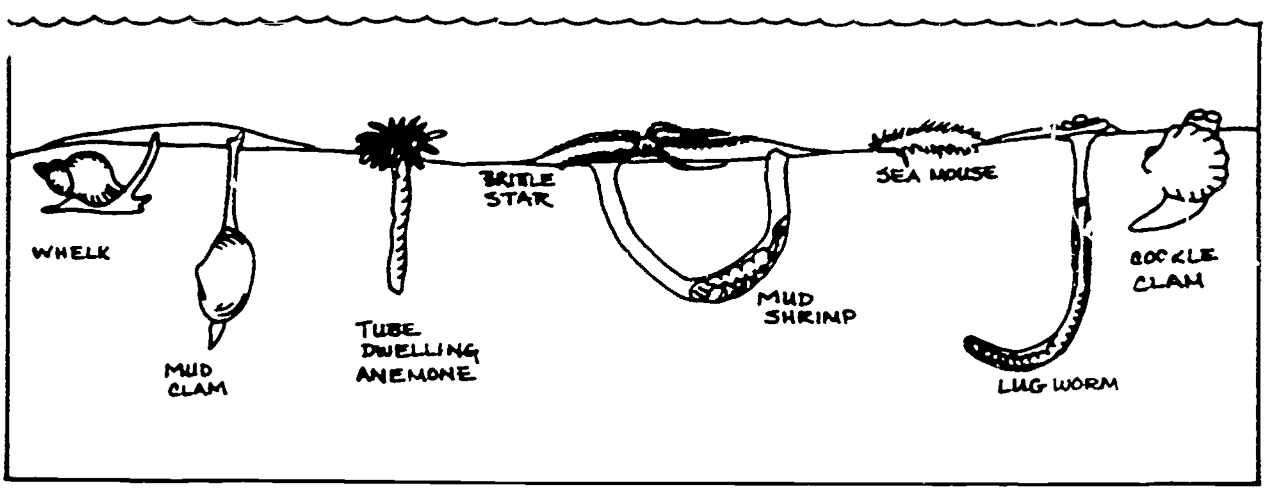
The Mud Flat

Mud flats are familiar to those who live or vacation near the southern tip of Puget Sound or in protected backwaters like Willapa Harbor. The name is descriptive of the habitat - flat and muddy. The area is submerged by incoming tides and then exposed to the air at low tide, often releasing a foul odor. Mud is composed of very small particles - those less than 1/16 mm in diameter. These very fine particles are deposited only in very calm waters. This accounts for the locations of mud flats at the furthermost reaches of sounds or bays. There is not sufficient wave action or current to keep the particles suspended, thus they settle out.

Mud flats may be found at Olympia, Bremerton, Everett, Squamish Harbor, Bellingham, Dungeness Spit, and Freshwater Bay.

Animals (other that fish or birds), that live on a mud flat must be able to burrow beneath the surface for protection. Since the fine particle size prevents oxygen from diffusing downward, the organism must either live within the top few millimeters of the surface or extend some portion of their bodies into the overlying water. Organisms avoid being swept away by moving water by burying themselves in mud. There are few, if any surfaces to anchor to, so very few organisms live on the surface. These constraints make for a dull habitat at first glance, but an exciting one for those who wish to dig beneath the surface.

The kinds of organisms that inhabit the mud are illustrated in the following diagram.



The Sandy Beach

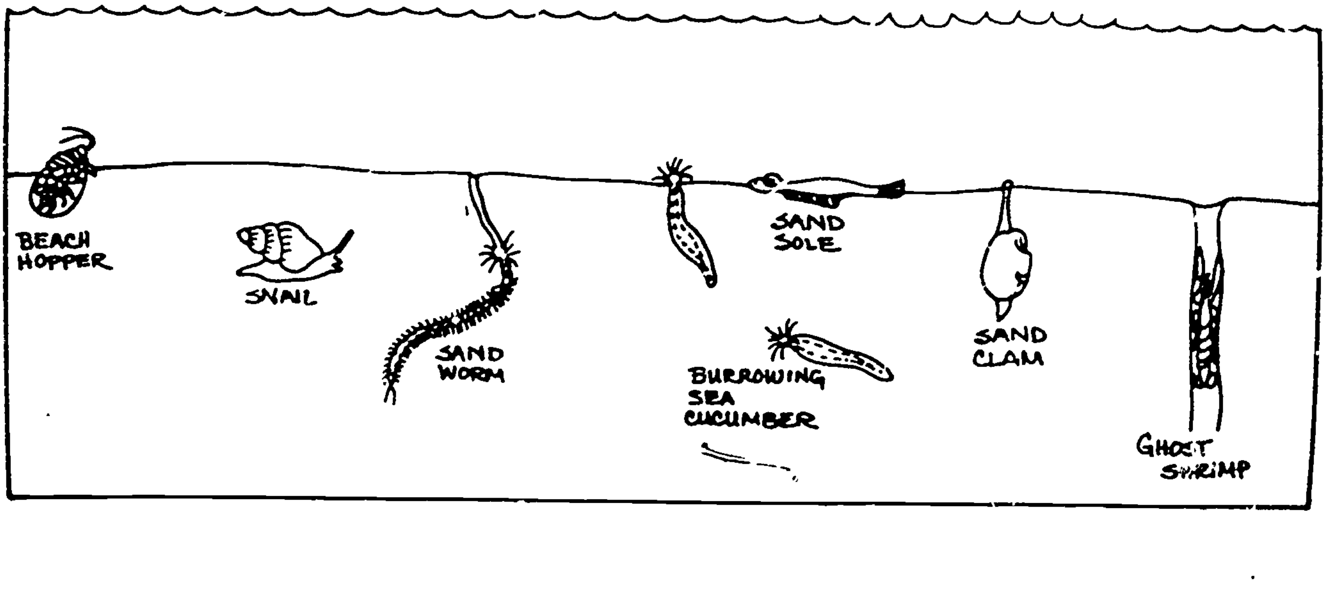
Sandy beaches are formed where more vigorous wave action or currents are able to winnow away the finest particles, leaving coarser, sand-sized particles. These particles range in size from 1/16 mm to 2 mm. Due to increased interstitial spaces, (perhaps 40% in medium grained sand), water drains away more readily than in mud, leaving a firm packed surface for walking. Air penetrates deeper into the substratum, so that organisms may live more deeply buried. The aeration of the sand prevents the growth of anaerobic bacteria which produce the hydrogen sulfide smell of some mudflats.

Sandy beaches may be found at Titlow Beach, Saltwater State Park, Richmond Beach, Edmonds, Everett, Port Townsend, and Crescent Bay.

With no places to anchor, there is the danger of being swept away by tides and currents. Organisms which can survive this problem either bury themselves beneath the surface (clams and worms) or move rapidly (birds and fish). Any organism which buries itself must contend with the danger of ever-shifting sands. Moving sand can clog breathing or feeding apparatus (such as clam siphons), therefore it is necessary that even the subsurface organisms be somewhat mobile. They must be able to move vertically according to the movement of sand in a current.

Feeding for those organisms which bury themselves is accomplished either by siphoning the water (as in clams) or by digesting nutrients from sand which is ingested (the worms). Crabs which are often partially buried, emerge to feed on detritus.

Characteristic species include clams, shrimp, worms, birds, fish, sand dollars, isopods, amphipods, and crabs.



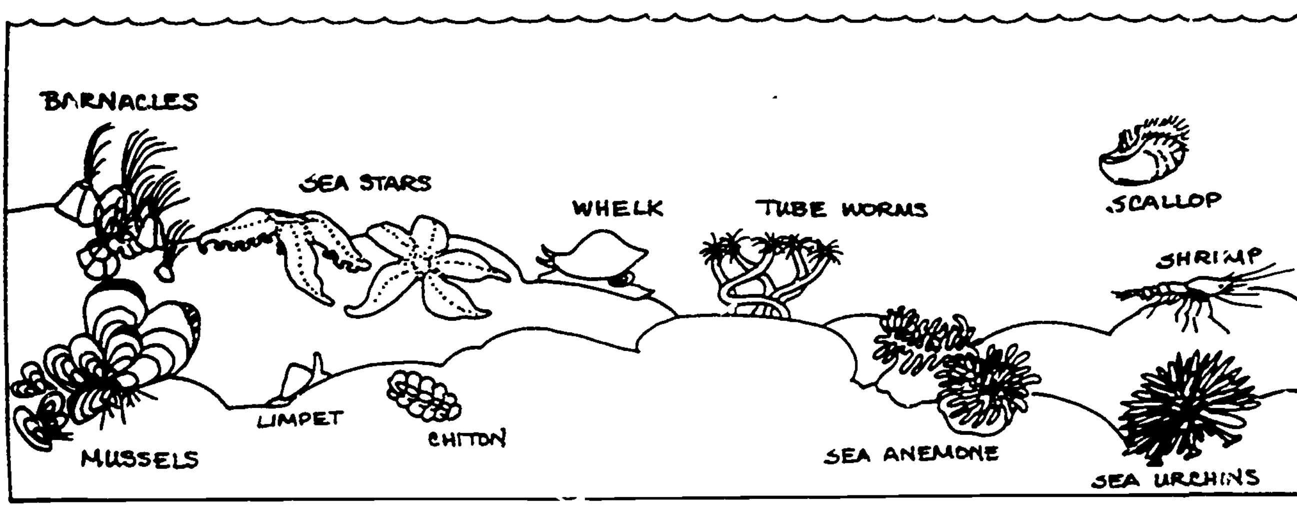
Rocky Shore

Rocky habitats are observable where vigorous wave action or currents have carried away all sand and finer material. These locations include Tongue Point, Edmonds, Port Townsend, Everett, Seattle, and Hood Canal.

The major distinction between the rocky shore and the sandy beach or mud flat is stability. The problem of living on a shifting medium is avoided. Animals avoid being swept away by attaching to the solid rock, or by slipping into crevices. Since the rock is often very hard, it usually is not possible to burrow beneath the surface. (The exceptions include boring clams and to some extent, sea urchins.) The variety of methods organisms use to hide from their enemies is what makes the rocky shore one of the most exciting to visit.

Organisms seek refuge under boulders or overhangs (sea anemones, sponges, tunicates, and sea stars), under mats of vegetation or animal life, like mussels (sea slugs, flat worms), or they protect themselves with strong shells (barnacles, and mussels). Those organisms which live their lives exposed to wave action must secure themselves to the rock with strong threads (mussels), cement, (barnacles), a muscular foot (chitons, snails, limpets), or tube feet (sea stars, sea urchins).

Characteristic organisms are shown in the following diagram.



Teacher Information Sheet
Key

ACTIVITY 5: Intertidal Habitats

The places where plants and animals live are called habitats. Three major beach habitats are the rocky shore, the sandy beach, and the mud flat. Each habitat has certain characteristics and certain kinds of plants and animals that live there. In this activity, you will discover:

1. the conditions that caused the habitat to form.
2. the important animals that live in each habitat.
3. the kinds of adaptations that organisms have made in order to survive in each habitat.

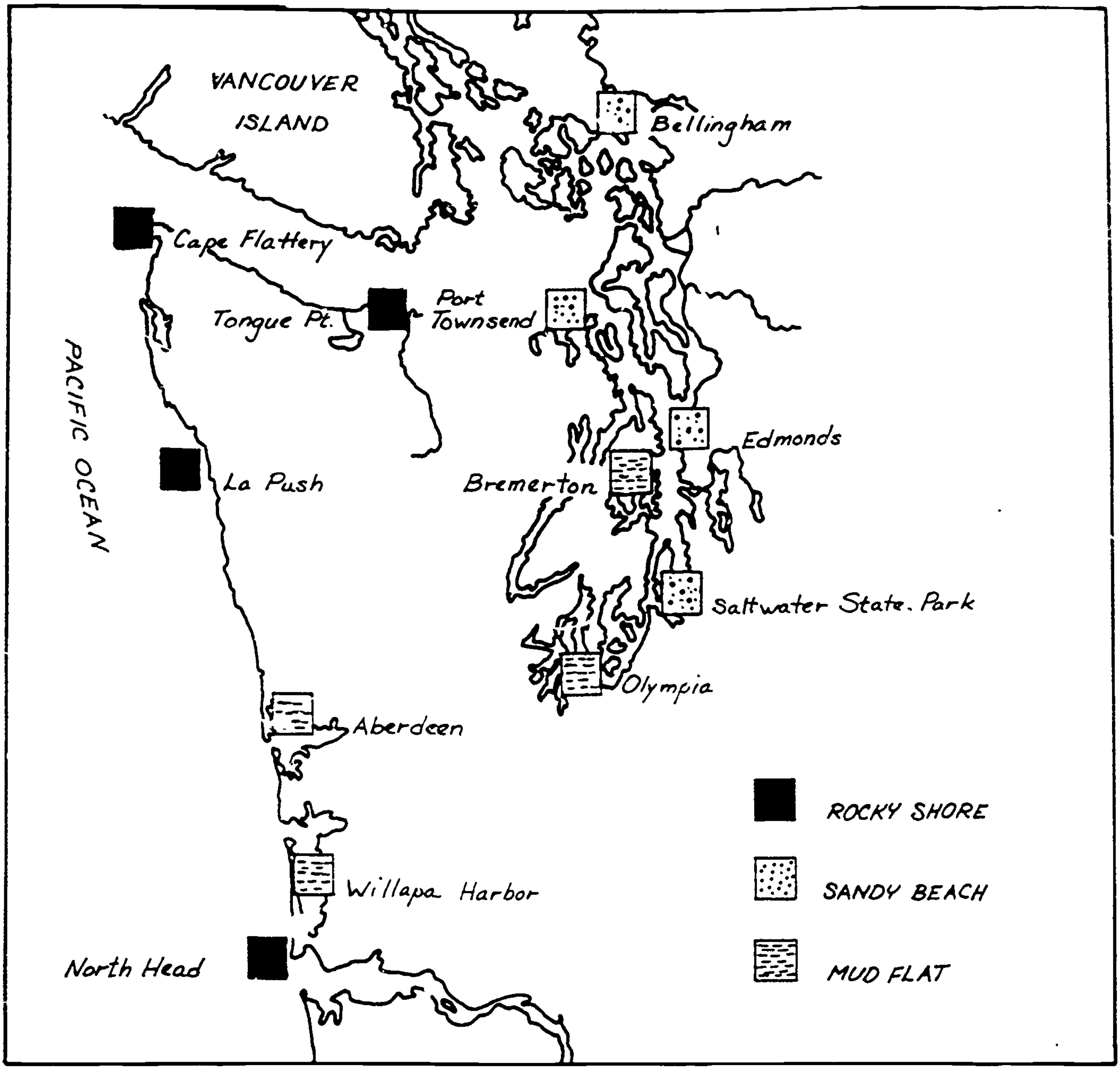
Part A: The Conditions That Form Each Habitat

This activity will show you how each habitat was formed.
Directions: Note that there are small boxes at various locations on this map. Use the lists of habitats at the bottom of the page to decide which symbol to use in each box. Use the following symbols:

- ■ Rocky Shore
- ⁙ Sandy Beach
- ☰ Mud Flat

Rocky Shores	Sand Beaches	Mud Flats
Tongue Point	Saltwater State Park	Olympia
Cape Flattery	Edmonds	Bremerton
North Head	Port Townsend	Willapa Harbor
La Push	Bellingham	Aberdeen

Teacher Information Sheet
Key



Teacher Information Sheet

Work in groups of three to answer the following. The map you just studied contains the information you need to answer these questions.

1. What kinds of places have mud flats?

   Places that are protected - like bays, estuaries, and the southern end of Puget Sound.

2. What kinds of places seem to have rocky shores?

   Places near the open sea.

3. What do you notice about the kinds of places that have sandy beaches?

   They are places between the open sea (rocky shores) and the protected bays (mud flats).

4. Use your answers to the above questions to help answer the following. What seems to be the relationship between the movement of water (waves and currents) and the formation of rocky, sandy, or muddy beaches? (Hint: Mud is composed of very small particles that are easily removed by flowing water. Sand is composed of larger particles that are moved around by water, but not quite as easily.)

   Where waves and currents are strongest, the beaches are rocky. Where waves and currents are weakest, mud flats form. Sand beaches form in areas where waves and currents are moderate.

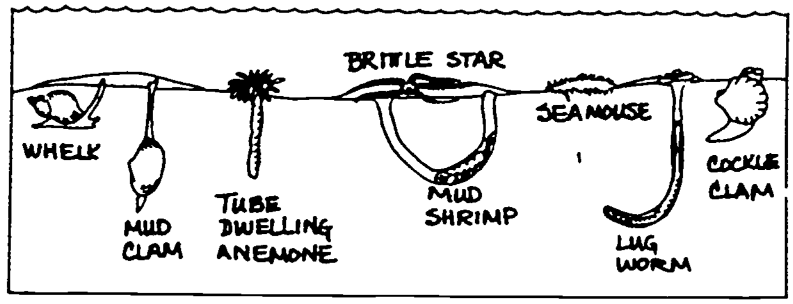
   The weaker the water movement, the finer the particles on the beach.

Teacher Information Sheet

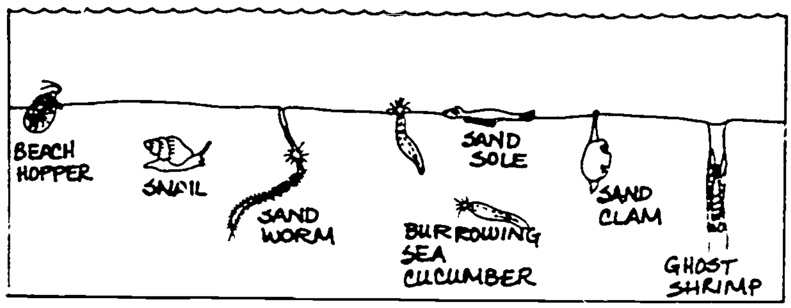
Part B: The Animal Life Of Each Habitat

This activity will show you what kinds of animals live in each habitat and what kinds of adaptations allow them to survive there.

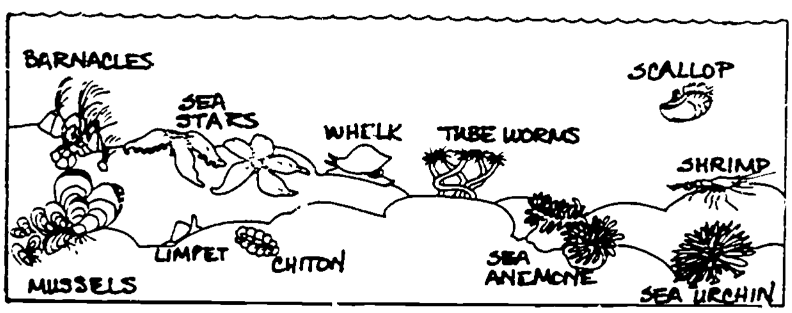
Directions: Study the following diagrams. These diagrams give you the information necessary to answer the questions. Work in groups of three.



MUD BEACH



SAND BEACH



ROCKY BEACH

Teacher Information Sheet
Key

1. What is the major difference between animals that live on a rocky shore and the animals that live in sand or mud?

   Animals live on rock but under sand or mud.

2. Compare the ways that animals in the three habitats avoid being washed away by strong waves or currents.

   Animals on rocks hold tight with cement (barnacles), tough threads (mussels), or a muscular foot (snails, chitons), and also tube feet (sea stars). Animals bury themselves in sand or mud.

3. Waves and currents move sand and mud from place to place. Sand and mud can be piled up or washed away. What special problems might an animal face if it lives under sand or mud? What might it do to solve the problem?

   An animal might get buried or uncovered by shifting sand or mud. They must be able to dig upward or downward or extend a 'neck' (siphon) to reach the surface, yet stay buried.

4. What special problems might an animal face if it lives on exposed rocks where powerful waves crash over it? What are some ways it might solve the problem?

   The animal could be crushed, or swept away. It needs to have strong shells, or live under mats of seaweed or mussels, or live under overhanging rocks.

5. Most intertidal animals get oxygen directly from sea water.
   A. Why might this be difficult in a mud flat?

      The fine particles fit closely together so that sea-water in the mud can't become aerated.

   B. What can an animal do to solve the problem?

      It can live very near the surface or it could take in seawater with its siphon (long neck).

NAME ______________________

ACTIVITY 5: Intertidal Habitats

The places where plants and animals live are called habitats. Three major beach habitats are the rocky shore, the sandy beach, and the mud flat. Each habitat has certain chracteristics and certain kinds of plants and animals that live there. In this activity, you will discover

1. the conditions that caused the habitat to form.
2. the important animals that live in each habitat.
3. the kinds of adaptations that organisms have made in order to survive in each habitat.

Part A: The Conditions That Form Each Habitat

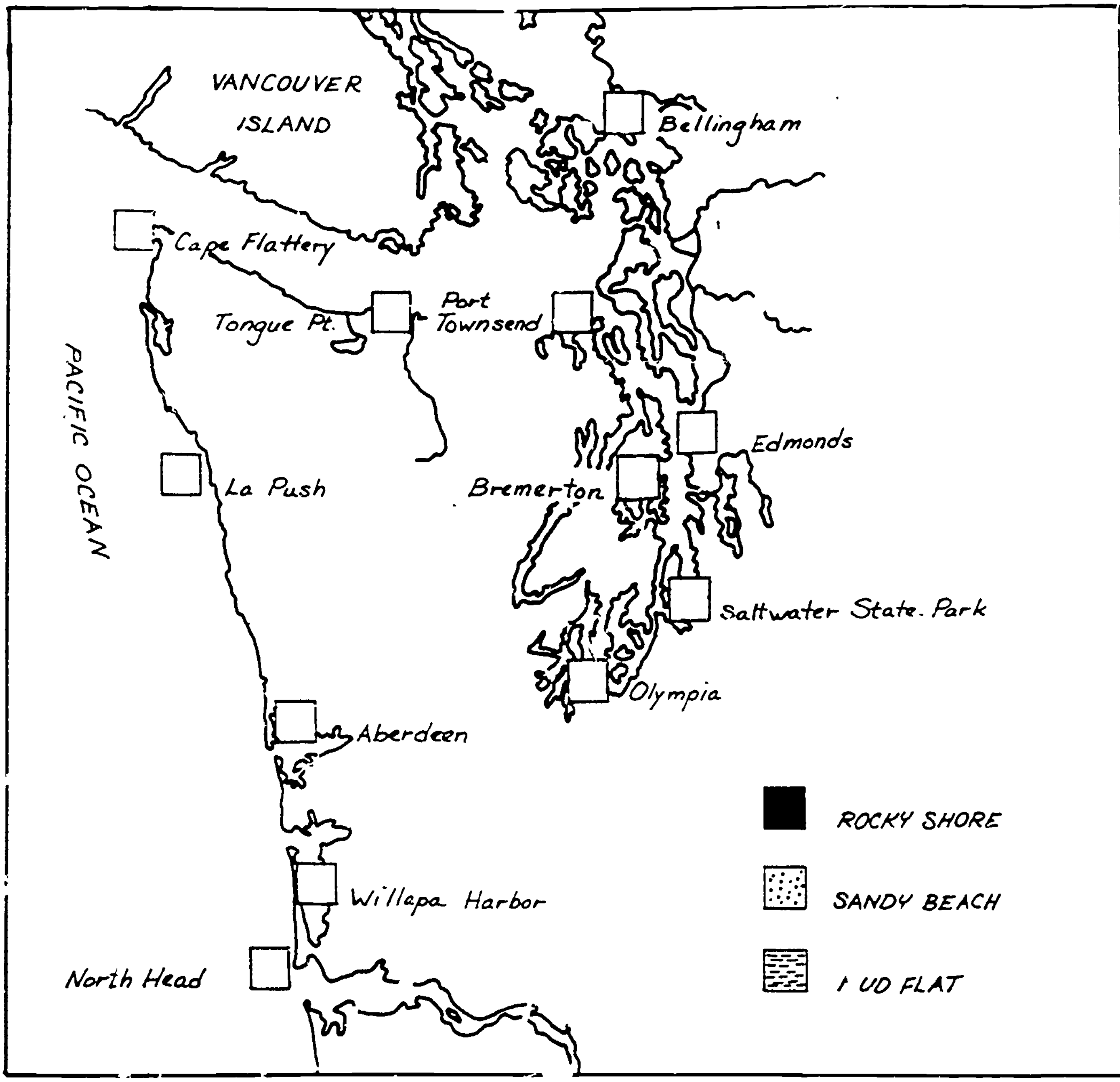
This activity will show you how each habitat was formed.

Directions: Note that there are small boxes at various locations on this map. Use the lists of habitats at the bottom of the page to decide which symbol to use in each box. Use the following symbols:

- Rocky Shore
- Sandy Beach
- Mud Flat

Rocky Shores	Sandy Beaches	Mud Flats
Tongue Point	Saltwater State Park	Olympia
Cape Flattery	Edmonds	Bremerton
North Head	Port Townsend	Willapa Harbor
La Push	Bellingham	Aberdeen

NAME _______________


VANCOUVER
ISLAND
Bellingham
Cape Flattery
Tongue Pt.
Port
Townsend
PACIFIC OCEAN
La Push
Bremerton
Edmonds
Saltwater State Park
Olympia
Aberdeen
Willapa Harbor
North Head
ROCKY SHORE
SANDY BEACH
MUD FLAT

NAME________________

Work in groups of three to answer the following. The map you just studied contains the information you need to answer these questions.

1. What kinds of places have mud flats?

2. What kinds of places seem to have rocky shores?

3. What do you notice about the kinds of places that have sandy beaches?

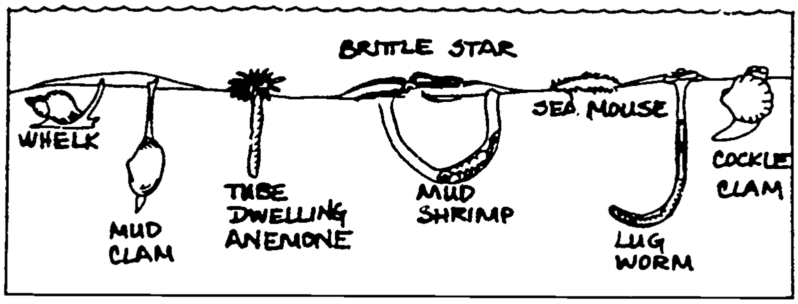
4. Use your answers to the above questions to help answer the following. What seems to be the relationship between the movement of water (waves and currents) and the formation of rocky, sandy, or muddy beaches? (Hint: Mud is composed of very small particles that are easily removed by flowing water. Sand is composed of larger particles that are moved around by water, but not quite as easily.)

NAME ______________________________

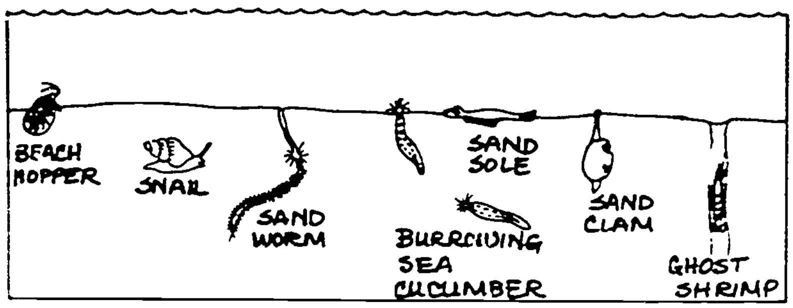
Part B: The Animal Life Of Each Habitat

This activity will show you what kinds of animals live in each habitat and what kinds of adaptations allow them to survive there.

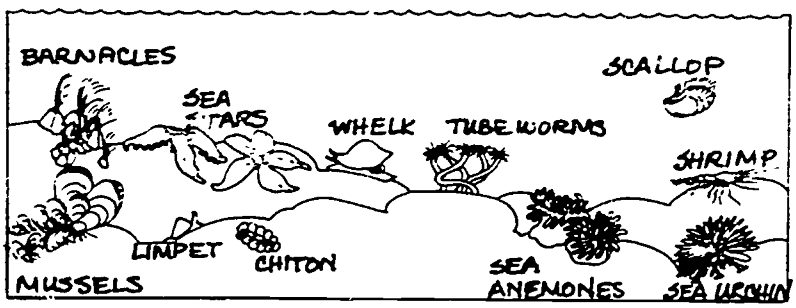
Directions: Study the following diagrams. These diagrams give you the information necessary to answer the questions. Work in groups of three.



MUD BEACH



SANDY BEACH



ROCKY BEACH

NAME ______________________

1. What is the major difference between animals that live on a rocky shore and the animals that live in sand or mud?

2. Compare the ways that animals in the three habitats avoid being washed away by strong waves or currents.

3. Waves and currents move sand and mud from place to place. Sand and mud can be piled up or washed away. What special problems might an animal face if it lives under sand or mud? What might it do to solve the problem?

4. What special problems might an animal face if it lives on exposed rocks where powerful waves crash over it? What are some ways it might solve the problem?

5. Most intertidal animals get oxygen directly from sea water.

   A. Why might this be difficult in a mud flat?

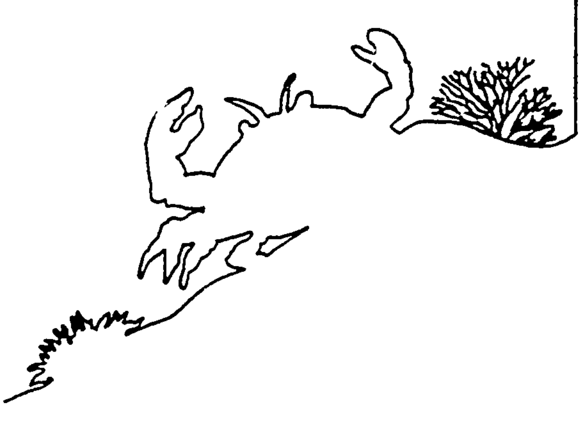
   B. What can an animal do to solve the problem?

NAME ____________________

QUIZ: Intertidal Habitats

Directions: Since space is limited, plan your answers carefully before starting to write. Do not go beyond the space provided.

NAME OF HABITAT	TWO KINDS OF ANIMALS, CHARACTERISTIC OF THE HABITAT	A DESCRIPTION OF ONE ADAPTATION FOR SURVIVAL IN THE HABITAT	LOCATIONS WHERE THE HABITAT IS LIKELY TO BE FOUND



ACTIVITY 3:

EXTENDED ACTIVITIES IN MARINE BIOLOGY

ACTIVITY 6: EXTENDED ACTIVITIES IN MARINE BIOLOGY

Extended Activities in Marine Biology

1. Tour the Seattle Aquarium. Telephone: 625-4357 (Seattle).

2. Tour the aquarium at the Point Defiance Park Zoo. Telephone: 759-0121 (Tacoma).

3. Tour the oceanographic ships of the National Oceanic and Atmospheric Administration (NOAA). Reservations are required. Telephone: 442-7657 (Seattle).

4. Tour the University of Washington Fisheries Department. Tours are available during the school year, but September and October are best when the fish are running and being harvested. Telephone: 543-9640 (Seattle).

5. Prepare a bouillabaisse or bake a salmon on the beach.

6. Take a census of organisms in various habitats or microhabitats on a given beach. What changes occur over a decade or more?

7. Give a classroom gourmet celebration. Serve octopus, squid, crab, oysters, sea urchin gonads, sea cucumber muscle strips, etc. See Edible? Incredible! for recipes.

8. Find shells of a particular species of clam that have been drilled by predatory snails. Plot the location of the drill hole on a diagram of clam internal anatomy. Is there a pattern to the holes? What part of the clam does the snail attack?

9. Set up a marine aquarium. See the bibliography for a publication that tells how.

10. Visit the Puget Sound model at the Pacific Science Center. Telephone: (206) 625-9333 (Seattle).

11. Make a survey of limpets to see if shell thickness changes with increased wave shock exposure (such as open coast vs. protected coast.

12. Make a herbarium collection of seaweed.

13. Investigate the Puget Sound Indians' use of marine life as a part of their culture. See Pacific Science Center/Sea Grant publication Early Fishing Peoples of Puget Sound.

14. Do a plankton tow, either from a boat, in the current passing under a dock or pier, or by a wader.

15. Do a night light field trip. Incredible forms of marine life move toward a bright light on a dock or pier.

EVALUATION

VOCABULARY

BIBLIOGRAPHY

VOCABULARY

Byssal threads - fibers produced by mussels for attachment to rocks

Cirri - barnacle legs modified for filter feeding

Dessication - drying out

Ecological - pertaining to the relationships among plants, animals, and their surroundings

Evisceration - discarding internal organs

Habitat - a place with a particular kind of environment inhabited by organisms

Marine - pertaining to the oceans

Nematocysts - stinging capsules found only in cnidarians

Organism - an individual of a species

Pedicellaria - a pincer-like organ used to keep dorsal surfaces of sea stars and sea urchins free of debris

Predator - an animal that feeds on other living animals

Taxis - movement toward or away from a stimulus

Toxin - a harmful chemical

Transect - a reference line drawn at right angles to a beach

Tube foot - hollow, extendable appendages of echinoderms

Water Vascular System - a water filled hydraulic system used by echinoderms for locomotion

NAME ______________________________

VOCABULARY

Byssal Threads

Cirri

Dessication

Ecological

Evisceration

Habitat

Marine

Nematocysts

Organism

Pedicellaria

Predator

Taxis

Toxin

Transect

Tube foot

Water Vascular System

Teacher Information Sheet

Quiz: Marine Biology

1. What is intertidal zonation?

   Intertidal zonation is the distribution of each species of marine organism according to tidal levels.

2. Give four reasons why intertidal organisms are limited to certain zones.

   Each kind of organism is limited to certain zones because of their
   1. *tolerance to drying,*
   2. *tolerance to solar radiation,*
   3. *tolerance to temperature extremes,*
   4. *competition for space, and*
   5. *relationship to other organisms as prey or predator.*

3. Compare the ways barnacles and sea anemones capture their food.

   Barnacles sweep the water with their "feathery feet" (cirri). They capture any small organisms or organic debris and transfer them to their mouths. Sea anemones must wait until the right combination of touch and chemical presence triggers their stinging cells (nematocysts). The tentacles close to bring the food to their "mouths."

4. Describe how marine organisms avoid being washed away from a rocky coast by waves.

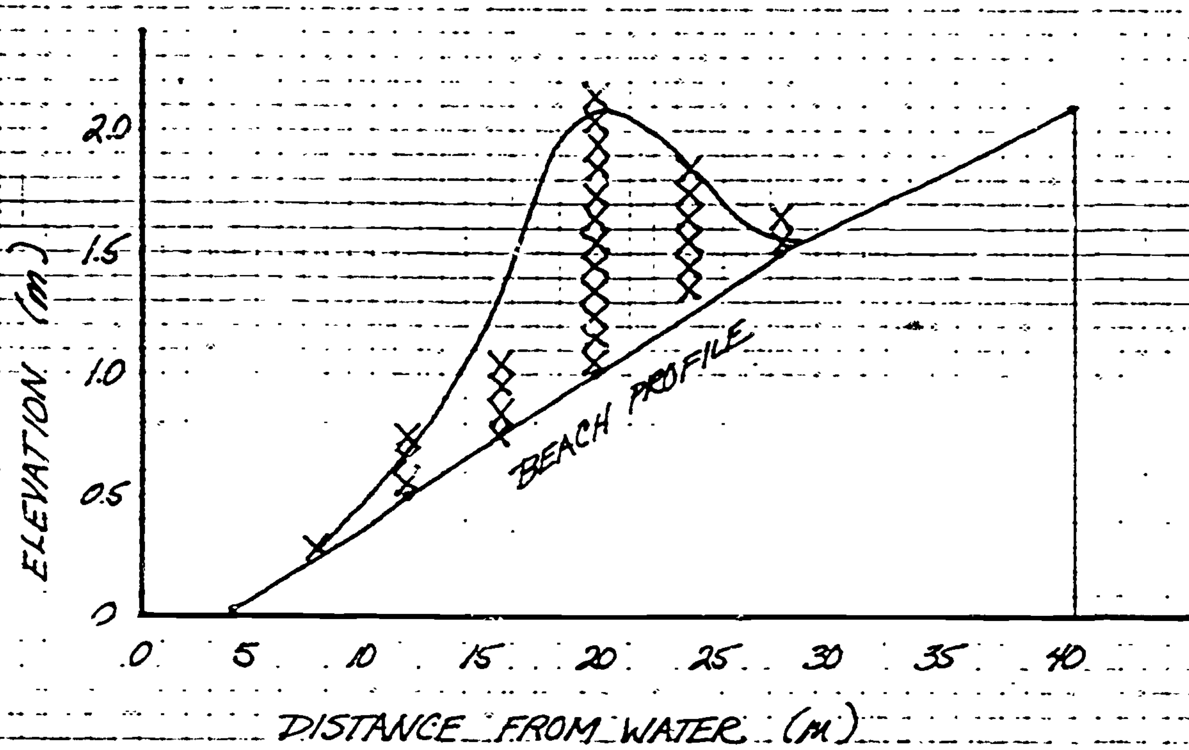
   To prevent waves from washing them away, marine organisms must hide under rocks or seaweed or they must firmly attach themselves to the bottom. Sea stars and sea urchins use tube feet, mussels use byssal threads, the octopus uses suckers on its arms, and barnacles are firmly cemented to the rock. Clams and worms bury themselves under seaweed or burrow into sand, rock, or wood.

Teacher Information Sheet
Key

5. Ten students counted all of a certain species of marine animals. Here are their data.

Student	1	2	3	4	5	6	7	8	9	10
Distance from water (m)	28	8	24	32	4	40	12	36	16	20
Elevation (m)	-	-	-	-	0	2	-	-	-	1
Number Counted	2	1	6	0	0	0	0	0	4	11

Graph the data below.

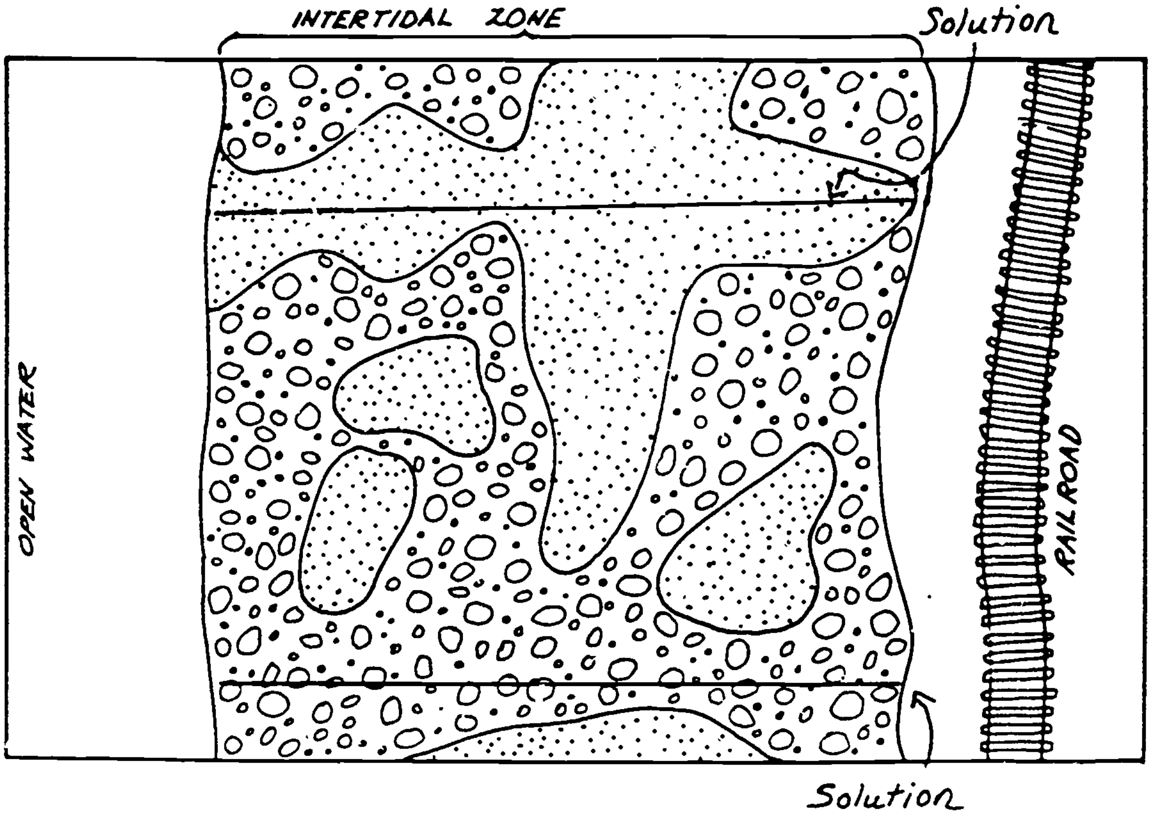


6. Sea stars move very slowly, How do they avoid being covered by sand or algae?

Sea stars have tiny jaw-like appendages (pedicellarias) which pinch and remove anything which might fall on the aboral surfaces.

Teacher Information Sheet
Key

7. A map of a beach is shown below. Draw a line that shows the <u>best</u> location for a transect that would show intertidal zonation.



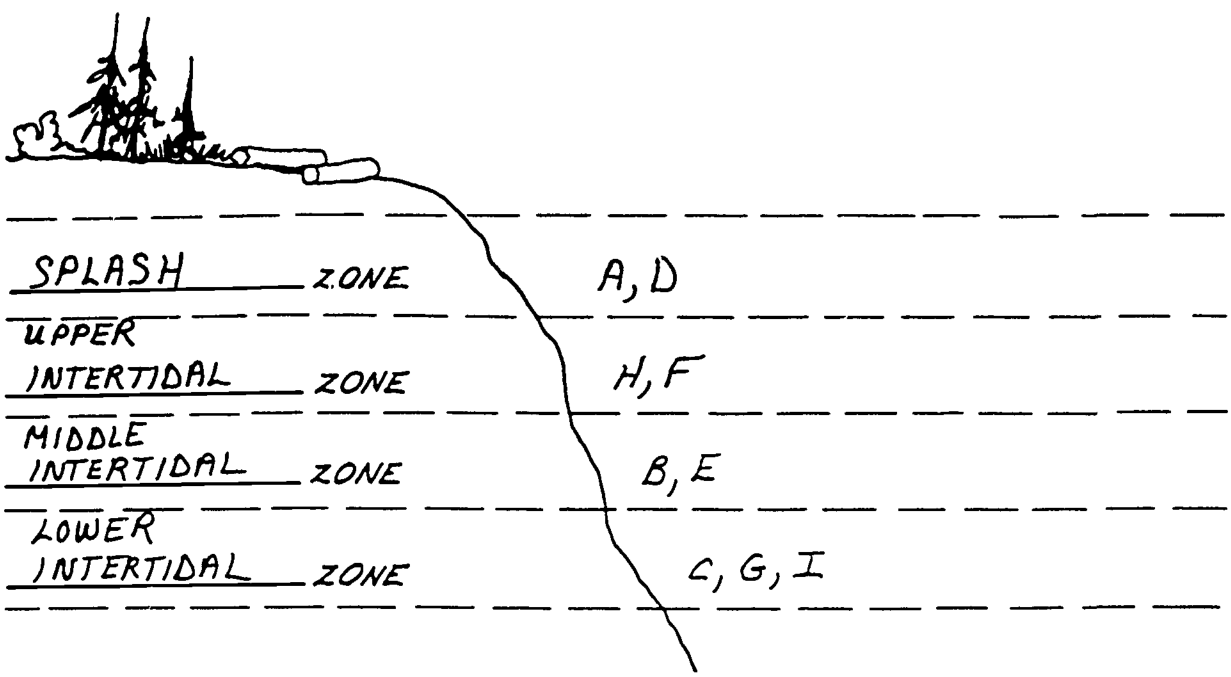
8. Compare the reaction to danger of octopuses, limpets, and sea cucumbers.

The octopus goes through a series of color changes and ink ejection which may camouflage it or may intimidate the predator. The limpet will attempt to seal itself tightly against the rock if it is threatened. It may, however, move away from a predator if it senses that the predator (such as a sea star) may be able to pry it loose from the rock. Sea cucumbers, otherwise defenseless, rely on distracting or discouraging predators by eviscerating (disgorging its internal organs). The organs are then regenerated.

Teacher Information Sheet
Key

9. A beach profile is drawn below. Label each of the intertidal zones in the spaces on the left. Then place the letter of the species listed below in the zone where it is most likely to be found.

   A. Periwinkles (Littorina sp)
   B. Mussels (Mytilus edulis)
   C. Eelgrass (Zostera sp)
   D. Finger Limpet (Acmaea digitalis)
   E. Purple sea star (Pisaster ochraceous)
   F. Hermit crab (Pagurus hirsutiusculus)
   G. Sea urchins (Stronglocentrotus spp)
   H. Rockweed (Fucus sp)
   I. Blood star (Henricia leviuscula)



Teacher Information Sheet
Key

10. What is a habitat?

A place where animals and plants live.

11. Describe how one animal has adapted to life in each habitat.

A. *answers will vary*

B.

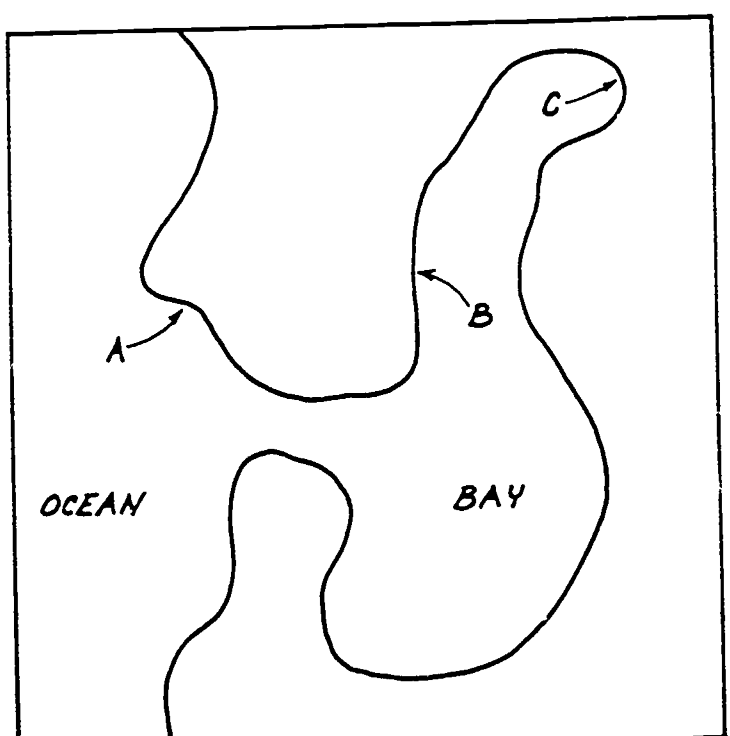
C.

12. What habitats would most likely be found at A, B, and C?

A. *Rocky Shore*

B. *Sandy Beach*

C. *Mud Flat*



NAME ______________________________

Quiz: Marine Biology

1. What is intertidal zonation?

2. Give four reasons why intertidal organisms are limited to certain zones.

3. Compare ways barnacles and sea anemones capture their food.

4. Describe how marine organisms avoid being washed away from a rocky coast by waves.

NAME ____________________

5. Ten students counted all of a certain species of marine animals. Here are their data.

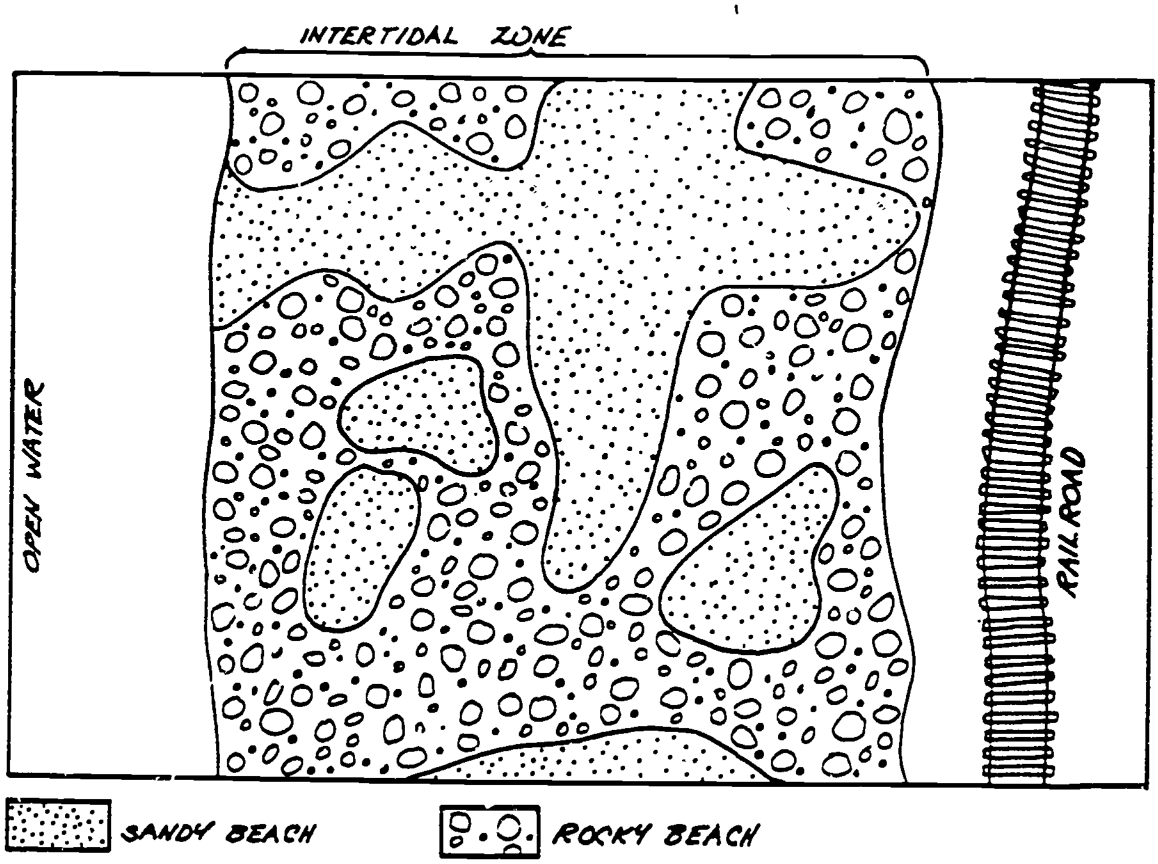
Student	1	2	3	4	5	6	7	8	9	10
Distance from water (m)	28	8	24	32	4	40	12	36	16	20
Elevation (m)	1.5	-	-	-	-	2	0.5	-	-	1
Number Counted	2	1	6	0	0	0	3	0	4	11

Graph the data below.

NAME ______________________

6. Sea stars move very slowly. How do they avoid being covered by sand or algae?

7. A map of a beach is shown below. Draw a line that shows the best location for a transect that would show intertidal zonation.

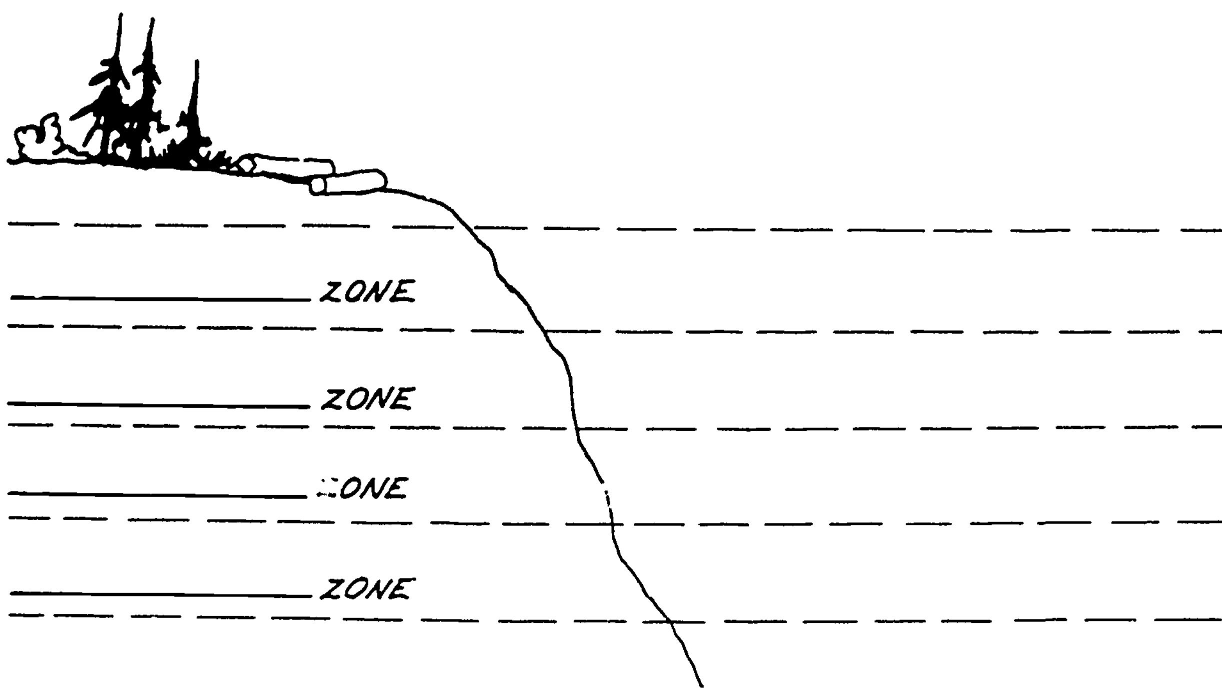


8. Compare the reaction to danger of octopuses, limpets, and sea cucumbers.

NAME ______________________

9. A beach profile is drawn below. Label each of the intertidal zones in the spaces on the left. Then place the <u>letter</u> of the species listed below in the zone where it is most likely to be found.

A. Periwinkles (<u>Littorina</u> sp)
B. Mussels (<u>Mytilus</u> <u>edulis</u>)
C. Eelgrass (<u>Zostera</u> sp)
D. Finger Limpet (<u>Acmaea</u> <u>digitalis</u>)
E. Purple sea star (<u>Pisaster</u> <u>ochraceous</u>)
F. Hermit crab (<u>Pagurus</u> <u>hirsutiusculus</u>)
G. Sea urchins (<u>Stronglocentrotus</u> spp)
H. Rockweed (<u>Fucus</u> sp)
I. Blood star (<u>Henricia</u> <u>leviuscula</u>)



NAME_______________________________

10. What is a habitat?

11. Describe how one animal has adapted to life in each habitat.

A.

B.

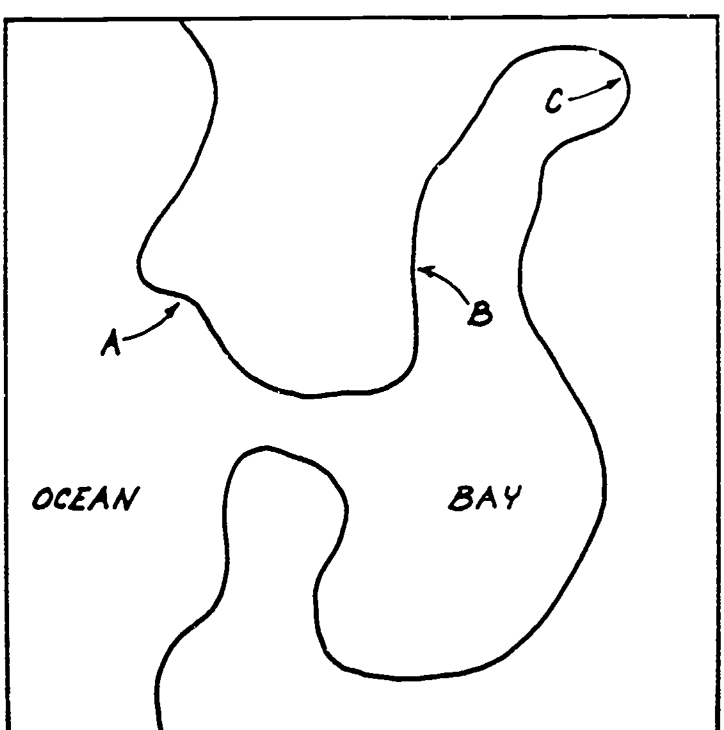
C.

12. What habitats would most likely be found at A. B, and C?

A.______________________________

B.______________________________

C.______________________________



BIBLIOGRAPHY

Brixius, Lyndal A. Constructing and Maintaining A Cold Salt Water Aquarium. Newport. Oregon State University. Marine Science Center.

Buchsbaum, Ralph. Animals Without Backbones. Chicage. University of Chicage Press. 1948.

Carefoot, Thomas. Pacific Seashores: A Guide to ıtertidal Ecology. Seattle. University of Washington Press. 1977.

Diehl, Fred A.; Feeley, James B.: and Gibson, Daniel G. Experiments Using Marine Animals. Eastlake, Ohio. Aquarium Systems, Inc. 1971.

Edmonds(Washington) School District No. 15. "Salt Water Beach Field Trips". Lynnwood. Undated. (Mimeographed).

Edmonds (Washington) School District No. 15. "Salt Water Community". Lynnwood. 1971. (Mimeographed.)

Flora, Charles J., and Fairbanks, Eugene. The Sound and the Sea. Olympia. Washington State Department of Printing. 1977.

Furlong, Marjorie, and Pill, Virginia. Edible? Incredible! Ellis Robinson Publishing Co. (city not given). 1972.

berlet, Muneı ewin. Animals of the Seashore. Portland. Binfords and Mort, Association. 1962.

Jones, Claire. Beach Profiles and Transects. Seattle, ORCA, Pacific Science Center. 1978.

Kirk, Ruth. The Olympic Seashore. Port Angeles. Olympic Natural History Association. 1962.

Kozloff, Eugene N. Seashore Life of Puget Sound, The Straits of Georgia, and the San Juan Archipelago. Seattle. University of Washington Press. 1974.

Light, S.F. Intertidal Invertebrates of the Central California Coast. Berkeley. University of California Press. 1961.

Marrett, Andrea. Beaches. Seattle, ORCA, Pacific Science Center. 1978.

Marrett, Andrea. Marshes, Estuaries, and Wetlands. Seattle, ORCA, Pacific Science Center. 1981.

Marrett, Andrea. Tides. Seattle. ORCA, Pacific Science Center. 1978.

Osis, Vicki. 4-H Advanced Marine Science Member's Book. Corvallis. Extension Service, Oregon State University. 1973.

Pauls, John E. Marine Biology Field Trip Sites. Seattle. ORCA, Pacific Science Center. 1981.

Ricketts, Edward F., and Calvin, Jack. revised by Hepgepeth, Joel W. Between Pacific Tides. Stanford. Stanford University Press. 1968.

Smith, Lynwood. Common Seashore Life of the Pacific Northwest. Healdsburge. Naturegraph Company. 1962.

Snively, Gloria. Exploring the Seashore. Vancouver. Gordon Soules. 1978.

Sumich, James L. An Introduction to the Biology of Marine Life. Dubuque. William C. Brown Company. 1976.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Tide Tables for the West Coast of North and South America. Published yearly.

Zim, Herbert S., and Ingle, Lester. Seashores: A Guide to Animals and Plants Along the Beaches. New York. Golden Press. 1955.