Estuary: an Ecosystem and a Resource

Teacher's Manual

Address correspondence to

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CONTENTS

Introduction 7

Integrating EER into the High School Science Program 7
EER Suggested Lesson Plan 9

Program Planning Form 13

Reading Guide: Introduction 17
Answer Key to EER Reading Guide 18
*Crossword Puzzle 23

Slide/Tape Show: Introduction 33
Slide/Tape Show Script 34
*Vocabulary and Key-Concept Review 47
Answer Key to Vocabulary and Key-Concept Review 53
Follow-up Discussion of the Slide/Tape Show 54

Laboratory Exercises 1-7: Introduction 57

*Laboratory Handouts 1-7 63
Answer Key to Laboratory Exercises 1-7 199

Field Trips: Introduction 213

Before the Field Trip 213
Sample Field Trip Schedule 214
Classroom Follow-up 214

*EER Student's Field Guide 217
Answer key to EER Student's Field Guide 277

Miscellaneous 281
*Curriculum Test 285
Answer Key to Curriculum Test 299
Additional Resources 300

Sanctuary Facilities 300
Other Points of interest in the Bay Area 300
Tours 301
Annotated Bibliography 302
Sea Grant Publications 304

*Asterisks indicate material that must also serve as master copy.

Introduction

The class is about to embark on an investigation of a special type of coastal ecosystem--estuaries. Estuaries are special resources, places where the fresh water of rivers and streams meets and mixes with the salt water of the ocean. This investigation will be conducted under the guidance of the Estuary: an Ecosystem and a Resource (EER) curriculum.

This guide is intended to provide the classroom teacher with

1. teaching strategies for incorporating EER into the high school science program,

2. answer keys,

3. classroom discussion guides, and

4. materials for evaluating student understanding of estuaries.

The staff at the South Slough Estuarine Sanctuary is willing to assist the teacher answering any questions regarding this curriculum and by helping the teacher organize field trips to the sanctuary. The sanctuary staff would greatly appreciate receiving any helpful suggestions, new materials that a class developed, and evaluations of this curriculum.

Integrating EER Into the High School Science Program

A Perspective -

Estuaries are one of the most productive and most used natural coastal resources on earth. Yet our citizens know little about how estuary systems function biologically or what relationships these systems ultimately have to people.

It was this realization that gave impetus to the creation of the National Estuarine Sanctuary Program in 1972. Through matching federal funds made available to the states, undisturbed estuaries are being protected from future development. These specially protected estuaries are to be used for research, education, and low-intensity recreation.

In 1974, a portion of the Coos Bay Estuary was set aside as the first National Estuarine Sanctuary in the United States. Today the South Slough Estuarine Sanctuary, administered by the state of Oregon, preserves some 4,400 acres of land and water and joins 14 other estuarine sanctuaries throughout the United States.

The "Estuary: an Ecosystem and a Resource" Curriculum

In 1982, through a grant from the Oregon State University Sea Grant College Program, the South Slough Sanctuary staff began work on a 9-12 grade curriculum of estuarine education. The resulting curriculum is defined largely by the following elements.

	Student Contact Hours
A student reading book	2
A slide/tape program	1
Laboratory activities	7
Field activities	5
Total	15

A copy of the student reading guide accompanies this manual. The books can be purchased from the South Slough Sanctuary at cost ($1.25 a copy). This manual also includes master copies of the laboratory and field activity sheets (to be used by the teacher in reproducing copies for the students) and a master of a vocabulary and key concept review activity for the slide/tape program.

A summary of the subjects presented in each element of the curriculum is outlined below.

I. Reading guide

A. How estuaries fit into the water cycle
B. Physical factors in estuaries
C. Estuarine habitats
D. How estuaries are used
E. Glossary

II. Slide/tape program

A. Importance of estuaries to people
B. Definition of an estuary
C. Physical factors
D. Habitats
E. Ecosystems, ecology, and population genetics

III. Laboratory activities

A. Tides
B. Sediments
C. Pollutants and dissolved oxygen
D. Plankton
E. Food webs
F. Productivity
G. Species distribution

IV. Field activities

A. Observe and interpret
B. Plankton tow
C. Vegetation transects in a salt marsh
D. Physical factors of the estuary
E. Creatures of the mud

V. Teacher's manual

The EER curriculum has been designed on the assumption that most students will be unfamiliar with the material it presents. The lesson plan outlined on pp. 4-6 is just a suggestion, but it does reflect a carefully conceived sequence of instruction.

The students should read the reading guide first. The short-answer questions at the end of each chapter introduce to the students the terms and concepts essential to a study of estuaries.

The slide/tape show should follow the reading of the guide. A vocabulary and key-concept review accompanies the show. The review is not intended as a test or quiz but as a tool for reinforcing the material presented in the slide/tape show and in the reading guide. The guide should be used both before and after the slide/tape show. When used prior to the show, it will draw the students' attention to main points they should look for. When used after the show, it will review concepts just presented and allow the students to check their original answers.

This sequence of instruction will prepare the students for the more complex lab and field portions of the curriculum.

EER Suggested Lesson Plan

Day	Time	Activity	Teacher Preparation
1	10 min.	Introduce "Estuary: an Ecosystem and a Resource" curriculum.	Distribute reading guides. Preview teacher's manual.
1	20 min.	Students organize notebooks with the following sections: -Assignments -Reading guide notes -Laboratory exercises -Field investigations -Articles	Have notebook materials on hand or see that students have purchased them ahead of time.
1	10 min.	Preview the reading guide. Assign Chapter 1 reading.	Understand the layout of the guide and its chapter contents.
1	10 min.	Give unit assignment to collect news items about estuaries (i.e., fisheries, salmon hatcheries, exports, oil spills, and estuary management). The long-term goal will be to apply student knowledge to current events.	

Day	Time	Activity	Teacher Preparation
2	15 min.	Review answers to Chapter 1.	Review questions and answers from teacher's manual.
2	5 min.	Assign Chapter 2 reading.	
2	30 min.	Begin Lab 1--Tides.	Copy labs from the master.
2	10 min.	Review answers to Chapter 2.	Review answers from manual.
3	15 min.	Review answers to Lab 1--Tides.	Review answers from manual.
3	25 min.	Begin Lab 2--Sediments.	Copy labs from master. Have needed supplies and materials on hand (see lab preparation section).
4	50 min.	Complete Lab 2--Sediments. Review results. Assign Chapter 3 reading.	Review answers from manual.
5	50 min.	Begin Lab 3--Pollutants and dissolved oxygen.	Copy lab from master. See lab preparation section for materials and supplies.
6	15 min.	Monitor Lab 3.	
6	15 min.	Review Chapter 3 Reading Guide answers.	Review questions and answers from teacher's manual.
6	20 min.	Begin field trip class planning and preview activities.	Copy field activities from master. See "Field Visit" section of manual for preparation tips. Confirm details of field visit.
		Assign Chapter 4 reading.	
7	15 min.	Monitor Lab 3.	
7	15 min.	Review Chapter 4 answers.	Review answers from manual.
7		Assign crossword puzzle.	Copy puzzle from master.
7	20 min.	Students complete slide/tape vocabulary and key-concept review.	Copy vocabulary and key-concept review from master.
8	15 min.	Complete monitoring of Lab 3.	
8	10 min.	Discuss results of Lab 3.	Review lab results from manual.

Day	Time	Activity	Teacher Preparation
8	18 min.	Review crossword puzzle result. View EER slide/tape presentation.	Set up projection equipment. Preview program.
8	7 min.	Discuss slide/tape guide. Correct answers. Continue field trip preparations.	Review answers from manual.
9	50 min.	Complete Lab 7. Final field trip preparation check.	Copy lab from master.
10	5-6 hours	Field investigations. Review results as soon as practical.	
11	50 min.	Begin Lab 4--Plankton.	Copy masters. See lab preparation section for materials and supplies.
12	50 min.	Complete Lab 4--Plankton.	
13	50 min.	Lab 5--Food Webs.	Copy lab from master.
14	25 min.	Lab 6--Productivity.	Copy lab from master.
14	25 min.	Class review for Unit Exam.	
15	50 min.	Unit Exam.	Copy exam from master.
16	50 min.	Review Exam. Classroom discussion of student articles and contemporary issues.	

SOUTH SLOUGH ESTUARINE SANCTUARY
Division of State Lands
P.O. BOX 5417, CHARLESTON, OREGON 97420 PHONE 888-9015

PROGRAM PLANNING FORM

Please use this form to coordinate the services that your class will require.

Field Program

______ I am interested in arranging a field program for ______ students (40 student maximum) on: ____________________ Primary date or

____________________ Alternate date.

________________________________ Course Title

________________________________ Grade Level

Slide/Tape Program

______ I am interested in arranging a showing of the slide/tape program on ____________________ Primary date or ____________________ Alternate date.

Sanctuary Housing

______ I am interested in reserving the Sanctuary headquarters for a group of __________ students (limit 20) on: _______________ to _______________ Primary dates or _______________ to _______________ Alternate dates.

Printed Materials

______	Student's Reading Book	$1.25 each
______	Teacher's Guide (includes one classroom master set for laboratory and field activities, slide show script, one student's reading book, and suggestions for successful classroom program use)	$5.00
	Total enclosed	$__________

OVER

Please submit this order blank and the following information for prompt response to your request. Confirmation of your request(s) will be provided.

Name: ______________________________ P.O. #__________________

Ship to: ______________________________

______________________________ Phone #__________

Please accompany this request with your check or purchase order made payable to: Division of State Lands-SSES. Thank you.

Reading Guide

Reading Guide: Introduction

(Estimated student contact time: 2 hours)

The reading guide is designed to increase the student's knowledge of what estuaries are, how estuaries function, and how people use estuaries. Each chapter ends with a series of questions with which the teacher can assess student comprehension of the reading material and help the students review specific discussion topics.

Reading guides can be purchased for $1.25 each from the South Slough Sanctuary. A copy of the guide is provided with this manual; answers to the chapter questions follow this introduction.

Answer Key to EER Reading Guide

Chapter 1. How Estuaries Fit into the Water Cycle

1. Fog is air saturated with moisture, a cloud in contact with the surface of the earth.

2. The east side of the Cascade mountain range is drier than the west side because the prevailing wind direction is from the west and the water-saturated air has lost much of its moisture crossing the Cascades.

3. The water cycle starts with the evaporation of water from the surface of the ocean. The moisture-laden air rises and moves with the prevailing winds. As the air moves over land masses, it is forced to rise over mountains and other high terrain features. This causes the air to cool, and as it does, moisture precipitates out of the air as rain, hail, or snow. The moisture ultimately finds its way back to the ocean as runoff. This completes the water cycle.

4. The size and shape of an estuary is influenced by the amount of fresh water entering the estuary and second, by the geologic history of the coastal area in which the estuary is located.

5. Scientists think that the primary cause of the prehistorical great change in sea level was the presence of huge ice caps over much of the surface of the earth during the Ice Age. These ice caps "robbed" the ocean of much of their water and therefore lowered the sea level drastically. A secondary cause is the movement of the earth's crust.

6. The types of estuaries discussed in this chapter were the drowned river valley and the glacier-formed types.

7. A delta is the fan-shaped mouth of certain estuaries and is formed by the accumulation of millions of tons of sediment from erosion occurring in the drainage basin.

8. An estuary is the place where the fresh water of a river or a stream meets and mixes with the salt water of the ocean.

Chapter 2. Physical Factors in Estuaries

1. The two features of the river having the greatest influence on the estuary are the fresh water and the fine sediments carried by the river. The three features of the ocean having the greatest influence on the estuary are the salt water, the tides, and the larger sediments of the ocean.

2. One tidal bulge is caused primarily by the gravitational attraction of the moon; the other tidal bulge is caused by the centrifugal force resulting from the motion of the earth around the center of mass of the earth/moon system.

3. The sun affects the tides by adding its gravitational attraction to that of the moon, which results in spring tides, and by reducing the heights of the tidal bulges, which results in neap tides.

4. Spring tides are higher than average tides caused when the earth, moon, and sun are in alignment, thereby increasing the height of the tidal bulges. Neap tides are lower than average tides caused when the sun is at a 90° angle to the earth and moon, thereby decreasing the height of the tidal bulges.

5. The river sediments are mainly very fine sediments, the silts and clays. The ocean sediments are mainly large-to-fine sand sediments.

6. The natural source of nitrates and phosphates is the breakdown of soil and rock into its chemical components.

7. The sediment gradient in an estuary is not always well defined, but in general the mouth of an estuary will have coarser sediments, usually sands. At the head of the estuary, where the streams enter, silts and clays will have precipitated to form a muddy bottom.

8. The salinity of sea water varies somewhat from ocean to ocean, but usually the salinity of sea water is about 35 parts per thousand (ppt or °/oo) or 3.5 percent.

9. Salinity is usually measured using a salinometer, a refractometer, or a hydrometer.

10. The two types of salinity gradients discussed in this chapter are the salt wedge salinity gradient and the homogeneous salinity gradient.

11. The three types of estuaries are the well-mixed, stratified, and partially mixed estuaries.

Chapter 3. Estuarine Habitats

1. Two types of tideflats are mud flats and sand flats.

2. Halophytes are plants that have adapted to living in salty soils.

3. The zones of a salt marsh are characterized by the plant species typically growing in them.

4. The zones of a salt marsh are determined by the amount of time they are covered with water.

5. Detritus is the dead bits and pieces of organic material found in the estuary.

6. In general the food web looks like the one found in Figure 16, page . There should be a source of primary productivity. If salt marsh plants are the primary producers, then detritus should be a part of the food web. There should be different levels of consumers representing the primary, secondary, and tertiary consumers.

7. The lower levels of a mud flat are black because of the lack of molecular oxygen in the mud.

8. Three advantages an organism gains by burrowing into the mud flats are that it is not as exposed to predators, it is not as subject to drying out because it is not exposed to the sun, and an organism burrowed into the mud is exposed to more consistent salinity than if it lived on the surface.

9. Burrowing mud flat animals frequently use filter feeding and deposit feeding strategies.

10. The three major sources of primary productivity on the mud flats are the algae that grow on them during the spring and summer months, the diatoms that coat the surface of the mud and other surfaces, and the eelgrass.

11. Plankton are aquatic plants or animals, usually microscopic, that are dependent upon water currents for movement.

12. Nekton are aquatic animals that are strong, active swimmers and so are independent of water currents for efficient movement.

13. The two general types of plankton are phytoplankton and zooplankton.

14. Two general types of plant plankton are the diatom and dinoflagellate plankton.

15. Two general types of animal plankton are the copepods and the jellyfish.

16. Estuaries are often called nursing grounds because many species of animals, such as the Pacific herring, migrate into the estuary to spawn and the estuary is where the young spend the first part of their life.

17. An anadromous species is one which lives as an adult in the ocean and then migrates into fresh water to spawn.

18. The three habitats of the estuary are the salt marshes, the mudflats, and the channels.

Chapter 4. How Estuaries are Used

1. Filling alters the estuary by reducing the amount of estuarine habitat present. Dredging alters the estuary by deepening the estuary and disrupting the bottom sediments. Dredging can also lead to a change in the salinity of the estuary by allowing greater saltwater intrusion into the estuary.

2. Log rafts can alter the productivity of the estuary by compacting and shading the mud flats beneath them. In addition, the organic material that leaches out of the logs and the bacteria that thrive on the wood and bark reduce the amount of oxygen in the water.

3. Filling in the estuary is often necessary to allow the positioning of shipping facilities and other structures near the estuary shoreline.

4. The overall effects of development of an estuary are the loss of estuarine habitat and a reduction in the productivity of the estuary.

5. The land used for agriculture must not be allowed to get too wet, and so tide gates are used to keep out the salt water during high tides and permit accumulated fresh water to drain out during low tides.

6. Aquaculture is the raising and harvesting of aquatic plants or animals for human use.

7. The two primary kinds of aquaculture in the Pacific Northwest are oyster culturing and salmon ranching.

8. The four basic kinds of oyster cultures are bottom culture, hanging culture, tray culture, and stake culture.

9. After an oyster larva has settled on a solid surface but before it metamorphoses into the adult form, it is called a spat.

10. A salmon ranching facility consists of concrete pens through which fresh water is continually flowing. Adults returning from the ocean to spawn are captured and their eggs and sperm removed. The eggs are fertilized and then allowed to hatch at the facility. The young fish are raised in water to which a special chemical has been added. The fish are raised to a predetermined size and then released into the estuary to migrate back into the ocean. The water flowing from the salmon ranch also contains the special chemical. Since salmon always return to the place where they spawned and since they can identify the water coming from the salmon ranch because of the chemical in the water, the adult salmon return to the ranch and the cycle is started again. Most of the adults are harvested and sold as food.

11. Stream conditions detrimental to trout and salmon include sedimentation of the stream, a water flow insufficient to allow salmon to move upstream to spawn, and overheating of the water caused by lack of shading by riparian vegetation.

12. The first change that led to the loss of the oyster industry at Great South Bay was the daily draining of millions of gallons of duck wastes into the bay from duck farms located along the shores.

13. The example of Great South Bay shows how all parts of an ecosystem are interrelated.

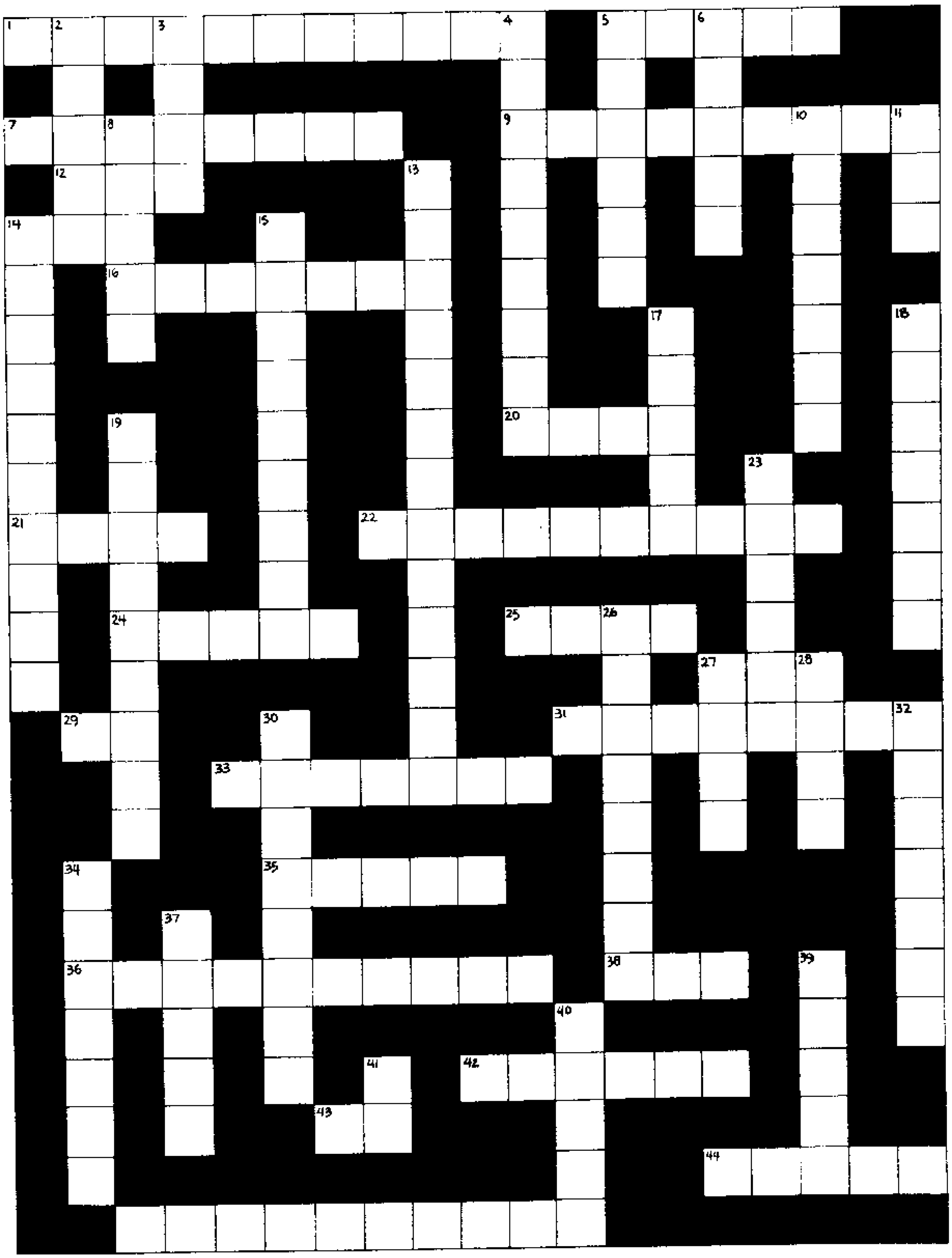
14. The key to the wise use of the estuary is cooperation among all the different users.

15. The South Slough Sanctuary was developed to help find the answers to questions about estuaries and to provide protection for the estuarine habitats and the plants and animals living there.

Note

The following pages are master copies: 23, 25, 27. One copy per student will be required.

Estuary Crossword Puzzle



Estuary Crossword Puzzle

Use the glossary in the back of your reading guide to find the solutions for this crossword puzzle.

Across:

1. Planktonic animals
5. Fan-shaped mouth of an estuary
7. Dead bits and pieces of organic material
9. Organisms that can live in the absence of oxygen
12. A gaseous mixture that surrounds the earth
14. Added to; plus
16. A place where fresh water mixes with salt water
20. The larva of oysters after it has settled on a solid surface and before it has metamorphosed
21. Mud flats consist primarily of ________, silts, and clays.
22. Flowering plants that live in salty soil conditions
24. A portion of the estuary covered with perennial vegetation is known as a salt ________.
25. The tide when the greatest amount of ocean water is in the estuary is known as the _______ tide.
27. The tide when the least amount of ocean water is in the estuary is known as the _______ tide.
29. The opposite of out
31. The amount of salt dissolved in water
33. The area of the estuary that is always covered by water
35. The periodic rise and fall of the level of the sea each 24 hours and 50 minutes is known as the tide ________.
36. A material which improves the growth of plants
38. Crustaceans have ________ pair of antennae.
42. Animals that obtain their food by filtering it from water currents are known as ________ feeders.
43. The chemical equation for water is ____2____.
44. An instrument that measures the electrical conductivity of a solution is known as a salino____________.
45. The upward rise of the surface of the ocean caused by the gravitational force of the moon and the centrifugal force of the earth rotating around the moon is known as ____________ ____________.

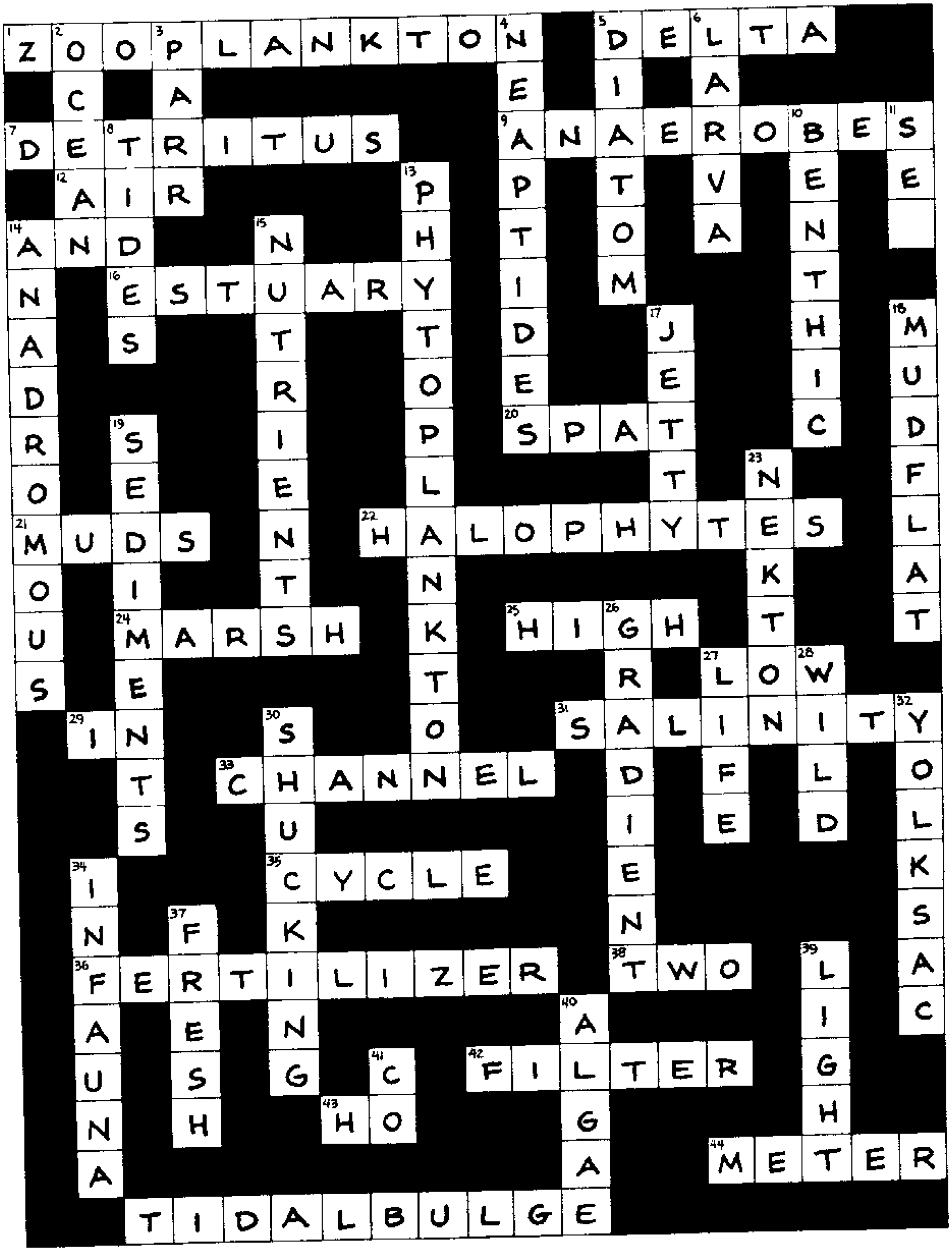
Down:

2. The entire body of salt water that covers about 72 percent of the earth's surface
3. A stage in the life cycle of salmon after it has hatched and emerged from the gravel
4. Tides with a less than average difference between high and low tides that occur when the sun is at a 90 degree angle from the moon as seen from earth (two words)
5. A microscopic golden brown alga
6. An early form of an animal which is fundamentally unlike its parent and must metamorphose
8. The periodic rising and falling of the level of the sea
10. Occurring on the bottom of a body of water

Down, cont'd.

11. A relatively large body of salt water, completely or partially landlocked
13. Planktonic plants
14. A species that hatches in fresh water, spends most of its life in the ocean, and returns to fresh water to spawn
15. Organic food materials
17. A structure extending into and above a body of water to protect a portion of shoreline from wave action
18. Tide flat composed of muds, silts, and clays (two words)
19. Particulate materials that are kept suspended in a fluid only by the motion of the fluid; if the motion stops, the materials fall to the bottom.
23. Aquatic animals independent of water currents
26. Regularly ascending and descending change in a variable in a specified direction
27. The interval between birth and death
28. Not domesticated
30. The process of removing the adult oyster from its shell for food processing
32. An alevin depends upon its ________ ________ for nourishment.
34. Animals that live burrowed in sediments
37. Water having less than 0.2 part per thousand salt in it is known as ________ water.
39. Refractometers measure how much a solution bends ________.
40. Diatoms are microscopic golden-brown ________.
41. Primary productivity depends upon ________ ________2 from which organic carbon is produced.

Key to Estuary Crossword Puzzle



Slide/Tape Show

Slide/Tape Show: Introduction

The South Slough Sanctuary will lend teachers an eighteen-minute production that examines the physical, biological, and recreational uses of estuaries. The last part of the slide/tape show emphasizes the importance of genetic variability in natural Oregon fish populations, using a well-documented case history from the Willamette River.

The slide/tape show is free. The South Slough Sanctuary will pay the cost of shipment, and the teacher will be responsible for shipping the show back. To avoid scheduling problems, the teacher should contact the sanctuary at least two weeks before he or she plans to present the show.

The presentation consists of a cassette tape and a slide set in a 140-slide carousel tray. The cassette tape contains inaudible cues that provide automatic control of a Wollensak tape player and the carousel projector. For manual systems, the slide-change cues are noted on a copy of the slide show script supplied with the slides. The teacher is urged to preview the presentation regardless of the playback method used.

This section of the teacher's manual contains the following material:

1. a copy of the slide/tape script
2. a reproduction master of the student vocabulary and key-concept review guide
3. an answer key for the review guide
4. a teacher's guide to the follow-up discussion

The reproduction master can be found in this section of the manual.

Slide/Tape Show Script

(Title) Estuary: An Ecosystem and a Resource

"All rivers run to the sea: yet the sea is not full; unto the place whence the rivers cometh, thither they must return again."

I often come to the estuary to read and watch the morning fog. I value this place for its ever changing beauty. And I continue to be amazed by the way all its living things work together in a fierce sort of harmony. I don't think it's important whether a barnacle or tube-worm is of any use to humankind; what's important is that they have as much right to live on this earth as we do.

(Construction worker's wife) "My husband's found work again! This boat basin is exactly what our community has been needing. There must be 50 people working on the job. And it will help out the fishermen who need places to tie up their boats. Now if we can only get the permits to let us go ahead on the airport runway extension, we can put that many more workers on the job. Sure, it will fill a little chunk of the estuary, but it's only 12 acres we're talking about."

(Duck Hunter) "I've been hunting ducks on this slough a long time. This is where my son learned how to hunt and fish. Of course, there aren't as many ducks as there used to be and the environmentalists are tying up too much of the good hunting and fishing spots. I want my grandkids to be able to go hunting and fishing just like we've always done!"

(Mill Worker) "I think the most important thing about Coos Bay is that it's the biggest exporter of wood products in the world.

That means jobs for loggers, mill workers, longshoremen, and other Oregonians. But we've got to develop other aspects of this port, too! We need to develop our coal export facilities and containerized cargo capabilities. This port has a lot of potential!"

(Research Biologist) "When I chose to study an undisturbed estuary for my Ph.D. thesis, I was afraid I might not be able to find a suitable estuary for my research. Most of the estuaries are being dredged, diked, filled, or altered in other ways. I believe it is of vital importance to quickly gain an understanding of the biology of estuaries, so that we can manage our land and water resources intelligently. To develop this understanding we need to compare developed and undeveloped estuaries. Some of these studies will have to be conducted over many years, and this type of research will be increasingly hard to do as our estuaries continue to be developed."

(First commercial fisherman) "Hey man! Did you hear that last year's catch for Oregon's fishermen was valued at $50 million dollars?"

(Second commercial fisherman) "You wouldn't know it by looking at my bank account! It seems like all we get is more regulations and shorter seasons. Pretty soon I'm just going to have to sell my boat and look for some other kind of work."

****

(Narrator) Estuaries...they're important to people for many different reasons. Some people have strong feelings about estuaries because they value them in their natural state. Others have little concern for them except for mooring boats and supporting commercial facilities.

Conflicts in the use of estuaries are inevitable. The purpose of this program is to help you, as voters and future voters, to gain a better understanding of estuaries and their uses. This will help you make more responsible decisions about managing our natural resources.

The theme of this program is science education for better citizenship and richer lives.

The Oregon coast has 21 estuaries, most of which are small. The Coos Bay Estuary is a good example for learning what an estuary is, how it functions, and how we use it.

What is an estuary? It's a protected place where the fresh water of rivers and streams meets and mixes with the salt water of the ocean. Here is where the runoff from a watershed completes its journey to the sea. The Columbia River Estuary accepts runoff from a very large watershed which includes parts of Oregon, Washington, Montana, Idaho, and Canada.

Estuaries are defined in physical terms; however, they are best known for the amazing amount of life they support. In fact, estuaries are among the most productive areas in the world. This productivity is measured as primary productivity, which is the amount of carbon converted into plant tissue by photosynthesis, in a measured area, in a given amount of time.

The Coos Bay Estuary is an ecosystem, that is, a group of living organisms that interact with each other and their environment. An ecosystem can be as small as a pond or meadow, or as big as a whole watershed, depending on what we wish to study.

First let us consider the nonliving, environmental conditions of the estuarine ecosystem. The ocean provides two tidal surges of salt water into and out of the estuary daily. Scientists have determined that 60 million tons of sea water enter the Coos Bay Estuary with each tide. Sixty million tons is equivalent to the weight of 991 of these huge ships fully loaded with wood chips. Of course, all of that water returns to the sea again, six hours later, with the next low tide.

Coos Bay, the second largest estuary in Oregon, covers 19 square miles at high tide and extends 28 miles up the Coos River.

The height difference between high and low tides in a single day averages 5.2 feet or 1.6 meters. The flooding tides carry sediments in a variety of sizes. As tidewater moves into the estuary, the water slows down and the sediments fall to the bottom with the heavier particles falling first. This action distributes the sediments along the bottom and sorts them according to size. The end result is a sediment gradient along the bottom of the estuary with a gradual decrease in sediment size as we move inland from the ocean. The mouth of the estuary near the ocean has a sandy bottom, and the water is almost as salty as seawater most of the year. In the midregions of the estuary, we find a mixture of sand and mud. The amount of salt in the water, that is, the salinity of the water, changes rapidly with the tides and so the midregion of the estuary in highly variable each day.

In the upper part of the estuary where the river enters, we find the finest sediments. These are the muddy sediments carried mainly by the river water. We find the upper reaches of the estuary dominated by the river. Here the seawater is almost always very dilute. We call diluted seawater brackish water. The river also carries nutrients into the estuary. In short, we see that physically the estuary is the result of the effects of the ocean, and the river, and the interactions between them. This makes the estuary dynamic, very changeable, and in many ways a rather difficult place for organisms to live and thrive.

Besides environmental conditions, the estuarine ecosystem consists of organisms that live in three major habitats: the salt marshes, the tideflats, and the open water or channels.

Salt marshes consist mainly of grasslike plants growing between the drier upland areas and the tideflats. They are found at the highest tidal elevations and are submerged only by the highest tides. Salt marsh plants have become adapted to tolerate occasional submersion in brackish water and to grow in soggy soil. The marsh helps protect the shoreline from storm wave erosion, slows the movement of the tidewater that washes over it, and traps fine sediments and nutrients. With its rapid plant growth, it produces tons of plant material each year, which dies and breaks down into microscopic particles called detritus. The energy that's still stored in detritus, in the form of carbon bonds, provides large amounts of food for animals, such as the bentnosed clam and the tiny crustaceans Corophium. The Corophium then serves as a main food source for young salmon and other animals.

The marsh areas are also important for human uses such as ship and boat docks, farm pastures, stores, and parking lots. For these important economic uses, the marsh must be dredged, diked, or filled. In the process, plants and animals lose their homes. For centuries this whole valley was filled by marshes and mud flats, until these two dikes were built, one with a road on top.

The city of Coos Bay was originally named Marshfield because it was built on filled marshlands. Most of downtown Coos Bay seen in this slide was once an extensive salt marsh. It's hard to believe, but 90 percent of the bay's marshes have been lost to dredging and filling since white settlers arrived in 1851. The red areas shown in this picture indicate marshlands that have been eliminated from the Coos Bay Estuary.

The second habitat of importance in an estuary is the tideflats. They are alternately covered and then exposed by the tides and usually consist of sand, mud, or both. Mud flats support a surprising abundance and variety of life because food is very plentiful. Lush beds of eelgrass grow on the fringes of the mud flats along the channel edges. Minute plants called diatoms coat the surface of the mud flats and the leaves of the eelgrass. The tides carry detritus and tiny plants and animals called plankton from the ocean and other parts of the estuary to the many filter feeders living in the mud. This barnacle is a filter feeder.

Millions of bacteria living in the mud produce a gas, hydrogen sulfide, which forms the stinking black mud that made the settlers think the mud flats were foul places only to be filled or dredged for other uses. We now know that they are an important part of the estuary. Most mud flat animals are buried in the mud. Softshell clams and cockles are only two examples of edible clams that live here. Commercial oyster beds are commonly located on the mud flats as well.

Large areas of the Coos Bay Estuary are used to store log rafts until they can be towed to the lumber mills. It is an economical method of handling them. Unfortunately the log rafts shade the mud flats at high tide and settle heavily onto them at low tide, reducing the number of plants and animals living beneath. Over the years dredging and filling of the mud flats have resulted in the loss of about 15 percent of the Coos Bay mud flats.

The third habitat is the channel, or open water, portion of the estuary. A major food source is microscopic plants called phytoplankton. They may be carried in passively by the tides from the ocean, or they may live in the estuary itself. These little plants are very abundant and can double their numbers every two days during the growing season. They represent a very significant part of the primary productivity in the estuary.

Zooplankton are microscopic animals that live in the water and feed on the phytoplankton. Zooplankton are in turn fed upon by larger animals. The open water is important to us because it is the site where fish populations, shipping channels, and docks are located, and where sewage and other wastes end up. Pollution can be a serious problem in the open water, especially when you consider that 80 percent of Oregon's commercially harvested fish and shellfish depend upon estuaries for their lives.

The uplands that surround an estuary and form its drainage basin are not usually considered a part of the estuarine ecosystem, but they can have a profound impact on it. Poor logging and road building practices can result in a very rapid filling of the estuary. This not only causes increased dredging costs, but the sediments smother fish spawning grounds in the rivers, and clam beds in the mud flats.

The history of San Francisco Bay provides a documented case of the influence of upland areas on an estuary. In the distant Sierra Nevada Mountains, starting in the year 1850, hydraulic gold mining methods sent a deluge of sediments into the bay. In the next 34 years, 1 trillion cubic yards of sediment were deposited in the bay. If 1 trillion cubic yards of sediment could be neatly stacked in an area the size of a football field, it would reach nearly halfway to the moon.

The most important aspects of an estuary are not visible to casual observation. The organisms in an ecosystem are linked together in many ways, ways we may not even be aware of. It is difficult to conceive of the hundreds of years it took the organisms of an estuary to adapt to the conditions found there. It is also difficult to grasp the tremendous changes humans can make in just a few years. There are a couple of major ecological concerns to keep in mind when making decisions about using natural resources. These ideas may be new to you, but you'll need to understand them to be able to make better informed decisions. One concern is genetic variability. And the other is adaptation.

First we'll look at genetic variability. Genes are pieces of information in the cells of the body that tell your body what to do. This boy's genes told his body to grow black hair. This girl has genes for brown hair.

Scientists have learned that it is very important for each species of plant and animal to have many types of genes among its members. This is called genetic variability.

The need to maintain genetic variability makes running a salmon hatchery very ticklish business. If you get eggs and sperm from only a few types of salmon, you end up with fewer kinds of genes, and the genetic variability among the hatchery stock is reduced. This is dangerous because the fish are then vulnerable to changes in their environment, like higher water temperature or a new, introduced fish they may have to compete with. If all the members of a species with low genetic variability are subjected to new environmental pressures at the same time, the species can become extinct. Some scientists feel this may have happened to the dinosaurs and woolly mammoths that once roamed the earth.

Now let's look at the idea of adaptation by examining a case history about steelhead in the Willamette River. Between 1966 and 1975, over 1 million steelhead trout were transplanted from one coastal river, the Siletz River, into the Willamette River watershed.

Essentially none of the Siletz River fish survived. Research has begun to find out why.

Biologists found that the Willamette River system contains a tiny parasite that lives in trout. Apparently, thousands of years ago the parasite came into contact with the steelhead in the Willamette River system. They must have had high genetic variability among all of their members, high enough that there were a few fish with genes that gave them resistance to the parasite. The offspring of these fish also carried the gene for resistance to the parasite, and they had a better chance to survive and reproduce than the other fish. Eventually all of the Willamette steelhead were resistant. In other words, they had adapted to the presence of the parasite.

Continued research showed that the parasite did not live in the Siletz River, so the Siletz steelhead didn't have a chance to become adapted to it. A species adapts only to its own environment. Because the transplanted fish were suddenly exposed to a different environment, there was no time to adapt, so they died. Perhaps you can think of examples of changes in the environment where plants and animals must either adapt or die.

We have looked at the Coos Bay Estuary as an example of a typical estuary, demonstrating the many ways we use estuaries and pointing out biological concerns we should keep in mind when planning for these uses. We have seen that the Coos Bay Estuary is used for hunting, fishing, clamming, mooring boats, storing logs, shipping, and much more. To do many of these things requires dredging and filling of parts of the estuary. The estuary also provides habitats for many species of plants and animals.

And the Coos Bay Estuary is also being used to help us better manage our estuaries in the future. The South Slough Sanctuary, operated by the state of Oregon, is there to help find the answers to questions about estuaries, provide protection for typical estuarine habitats, and preserve the plant and animal species found in the sanctuary.

The key to the wise use of the estuary is cooperation among all of its users: those people who value its natural beauty, its economic development, and its recreational potential. We hope that with the information you have gained from this program you will be better able to understand and participate in the planning decisions being made about estuaries and their resources. We can have a healthy estuary and still use its resources. We must work in harmony with nature in meeting our needs, for it is ultimately in our best interests.

Note

The following pages are master copies: 47, 49, 51. One copy per student will be required.

Name: ____________________

Instructor: __________ Period: ____

Vocabulary and Key-Concept Review

Instructions: In the left column, below, are commonly used estuarine ecology terms. In the right column are definitions which define the terms. Match the definitions to the terms by placing the appropriate letter in the spaces provided.

____ 1. estuary

____ 2. tideflats

____ 3. salt marsh

____ 4. watershed

____ 5. channel

____ 6. detritus

____ 7. salinity

____ 8. brackish

____ 9. dredge

____ 10. sediments

____ 11. ecosystem

____ 12. habitat

____ 13. erosion

____ 14. productivity

____ 15. gradient

A. to remove rock, mud, and sand in order to deepen harbors and waterways

B. aquatic plants or animals, usually microscopic, that are dependent upon water currents for movement

C. an area always covered with water, where shipping lanes and fish populations are located.

D. minute unicellular algea with glass-like walls

E. a wet area supporting grasses and grass-like plants, which is occasionally covered by very high tides

F. fish which resulted from the artificial breeding of parents selected by hatchery personnel

G. a measurement of the saltiness of water

H. microscopic particles of dead plants and animals

I. the wearing away of rock or soil by wind, water, or ice

J. an area which is exposed at low tide and consists of mud, sand, or both

K. a regular change in a variable in a specific direction, such as the increasing amount of snow encountered as you travel farther up a mountain

L. passively floating or weakly swimming minute animals

M. the amount of carbon converted into plant tissue by photosynthesis, in a given area, over a given amount of time

_____ 16. plankton

_____ 17. zooplankton

_____ 18. diatoms

_____ 19. parasites

_____ 20. phytoplankton

_____ 21. adaptation

_____ 22. gene

_____ 23. genetic variability

_____ 24. hatchery stock

N. water which is somewhat salty

O. a region whose rainfall drains into a particular body of water

P. a place where fresh water from the land mixes with the salt water of the ocean

Q. the particles that settle to the bottom of a liquid

R. a group of living organisms that interact with each other and their environment

S. organisms living in or on other organisms and often causing some harm to them

T. any genetic change in a group of organisms that makes them better suited to live and reproduce in their environment

U. a part of a cell that passes genetic characteristics along from generation to generation

V. the wide range of genetic characteristics seen within a group of organisms

W. the place where an organism naturally lives and grows

X. minute plants carried passively by water currents

Instructions: There are many facts about the estuaries of Oregon that you should know. The following multiple choice questions will help bring to your attention some of the most important ones. Place the letter of the answer you choose in the spaces provided.

_____ 1. The average vertical distance between high and low tides in a single day at Coos Bay is

A. 5.2 feet
B. 3.0 feet
C. 12.1 feet

_____ 2. The Oregon coast has

A. 13 estuaries
B. 21 estuaries
C. 50 estuaries

_____ 3. Coos Bay is

A. the largest estuary on the Oregon coast
B. the thirteenth largest estuary on the Oregon coast
C. the second largest estuary on the Oregon coast

_____ 4. During high tide the Coos Bay estuary extends

A. 5 miles up the Coos River
B. 28 miles up the Coos River
C. 12 miles up the Coos River

_____ 5. The percentage of the original Coos Bay estuary salt marshes that have been lost due to human activities is

A. 55
B. 10
C. 90

Answer Key to
Vocabulary and Key-Concept Review

Matching the Terms

P	1.	I	13.
J	2.	M	14.
E	3.	K	15.
O	4.	B	16.
C	5.	L	17.
H	6.	D	18.
G	7.	S	19.
N	8.	X	20.
A	9.	T	21.
Q	10.	U	22.
R	11.	V	23.
W	12.	F	24.

Multiple Choice Questions

A	1.	B	4.
B	2.	C	5.
C	3.		

Follow-up Discussion of the Slide/Tape Show

After the students view the show, they should look over the review guide and correct any wrong answers. Make sure the students record all of the right answers. Some potential areas of confusion may exist with the vocabulary words. Here are some further explanations that may help.

Question	Discussion
14	Productivity as defined in the review guide is really primary productivity. Other kinds of productivity can be studied, such as the amount of carbon assimilated by the animals of a community. This is secondary productivity.
15	The concept of a gradient is abstract and may possibly be difficult for the students to learn. The concept may best be defined using examples, such as A. the decreasing amount of oxygen present as you ascend Mt. Everest B. the increasing soil moisture content found as you move closer to a lake
21	A person from Seattle can adapt to the weather in Arizona, but that is not genetic adaptation. Genetic adaptation is a change in the genetic material of an organism that leads to an alteration of the organism's ability to cope with its environment. This alteration of ability can then be transmitted to its offspring, and if the adaptation is generally advantageous over many generations, the gene or genes containing the changed genetic material become more common in the population because the individuals carrying the gene(s) are better suited to their environment.

Here are a few topics for classroom follow-up discussion.

A. The narrator talks about the economic importance of dredging and filling which allows for ship and boat docks, stores, and parking lots. Which of these activities really need to take place in or along the estuary? In which of the following locations should filling of salt marshes and mud flats be allowed?

homes hotels fish packing plants shopping malls

roads dumping dredge spoils

B. List on the blackboard all of the conflicting uses of the estuary the class can think of.

C. Identify some ways in which citizens can participate in decisions about how our estuarine resources are to be used.

Laboratory Exercises

Laboratory Exercises: Introduction

A series of seven lab exercises has been developed to provide classroom experience for the students, even if a field trip is not possible. Listed below, for planning purposes, are the primary characteristics of each lab.

Lab	Key Concepts	Teacher Preparation Time	Comments
1	Tides	None	Especially useful prior to a coast field trip
2	Sediments	Up to two weeks if sediment samples are requested	This lab is useful for other aquatic ecosystems; considerable preparation required
3	Pollutants	One-half day and time required to obtain Hach kits	Also useful for other aquatic ecosystems; moderate preparation required
4	Plankton	A prior field trip is required	Lab must be begun immediately after a field trip because live specimens are used
5	Food webs	None	A field trip is recommended but not mandatory; this lab is useful for various ecosystems
6	Energy transfer	None	This lab is useful for other ecosystems as well
7	Population distribution	None	A field trip is recommended; this lab is mainly useful for estuarine ecosystem study

The material which follows provides information about the estimated student contact time, preparation considerations prior to the lab, equipment and supplies needed, and comments pertaining to follow-up discussions for each lab. Reproduction masters of student handout materials are found in this section of the manual.

LABORATORY 1

The Wet Blanket: Understanding the Tides
(Estimated student contact time: 30 minutes)

Preparation Prior to the Lab. Have the students read the appropriate section of the reading book.

Equipment and Supplies Needed. The classroom will need to be equipped with scotch tape, scissors, and perhaps straight edges.

Exercise Follow-up. The important topics for discussion are the numbers of tides each tide period, the basic tidal cycle pattern for the Pacific coast of North America, and the variation in the height of tides from place to place. A good exercise for illustrating the way tides vary from place to place is to have the students compare their graphs with the example of the tides at Seattle as graphed in the reading book. In dealing with question 3, it is important to note that it takes time for the tidal bulge to move into an estuary, and this accounts for the time difference between ebb tides at the mouth and at the head of the estuary.

LABORATORY 2

Mud Mixer: Exploring the Bottom Sediments of an Estuary
(Estimated student contact time: 1 hour 15 minutes)

Preparation Prior to the Lab. Have the students read the appropriate section of the reading book. You will need to obtain the South Slough samples and samples of dirt and sand about one week before the lab. Samples other than those from the South Slough can be used. Use powder-fine dirt and fine sand to prepare the standard curves. The sand and dirt should be dried and large organic particles sieved out or otherwise removed.

The South Slough samples can be gathered in the field, or you can request them from the sanctuary. Samples sent to you will be dried and ready for analysis. Any samples gathered in the field will need to be dried and any material caked together broken up. This will facilitate measuring out the samples to be tested. Be careful to break up only caked material and not grind up the sample so that the larger particles are broken down, thereby altering the sample.

The wooden blocks should also be prepared in advance of the lab.

Equipment and Supplies Needed. All equipment and supplies needed are listed in the lab. The cadmium sulfide photocells cost about $1.30 each. The ohmmeter will need to have adjustable levels of sensitivity so that the reading from the muddiest sample is near the upper end of the meter scale.

Exercise Follow-up. It is important to note that whether the water is salt water or fresh water, the same principle applies: the faster the water movement, the larger the particles that can be carried along. However, the salinity does alter the sedimentation rate of clay particles because of the effects of salt ions on the particles. One experiment you can do is to compare the sedimentation rate of a sample in seawater and one in fresh water. It is also important to note that colonies of bacteria live on the surface of the particles. Since the finer particles have more total surface area, the fine sediments are particularly rich in bacteria.

LABORATORY 3

Wasting Away: The Effects of Pollutants on Dissolved Oxygen
(Estimated student contact time: 50 minutes, day 1, and 15 minutes days 2, 3, and 4; total time 1 hour 30 minutes)

Preparation Prior to the Lab. You will need to collect enough fine, wet mud from a stream, pond, or some other water course for the activities outlined in the lab. You will also need a supply of animal manure, fish wastes, and wood. When this lab was piloted, only fish entrails were used as fish wastes. These organic materials were chosen because they frequently find their way into estuaries and other bodies of water.

The glass tubing should be bent prior to the lab. The lab instructions are written as if the students will be inserting the tubing into the stoppers, but for safety, inserting the tubing could also be done prior to starting the lab.

Equipment and Supplies Needed. All equipment and supplies needed are listed in the lab handouts.

Exercise Follow-up. This lab includes a recent newspaper article and a copy of a letter which together constitute an excellent discussion vehicle. The students should understand that the oxygen is dissolved in the water and that bacteria, because of their rapid metabolic rate, can quickly deplete the oxygen supply. The latter is especially true when very little flushing action occurs. It should be pointed out that just because a portion of an estuary empties out each low tide, a new supply of oxygen-rich water does not necessarily return: the water coming back in again may be the water that was previously there. In other words, no significant exchange with oxygenated water is occurring.

LABORATORY 4

The Phyto and Zoo of Plankton
(Estimated student contact time: 50 minutes, days 1 and 2; total time 1 hour 40 minutes)

Preparation Prior to the Lab. This lab is designed to complement Field Study 2, so you should have conducted a field trip to the South Slough Sanctuary or a similar field trip to gather plankton samples. You will need to reproduce transparencies of the counting grids used for the plankton counts made in this lab.

Equipment and Supplies Needed. All equipment and supplies needed are listed in the lab handout, except for the counting grids referred to above.

Exercise Follow-up. The idea behind this lab is to use the sample preserved in the field to get an idea of the plankton populations at the time of sampling. The sample of living plankton is used for making behavioral observations and for continuing to observe changes in the plankton after sampling.

Unless the students are careful, it will be difficult to obtain any quantitative data. However, the purposes of this lab are (1) to introduce students to the basic tools and methods for studying plankton, (2) to gain an appreciation of the interesting life forms completely invisible upon casual observation, and (3) to impress upon the student that even though plankton are individually very small, collectively they constitute a major food source in the estuary.

A question which may arise is "Why are there so few phytoplankton and so many zooplankton?" One part of the answer is that the plankton net is not equally efficient at sampling the very small phytoplankton and the relatively large zooplankton. A second part to the answer, though, is that the plankton often do not conform to the classical pyramid in which the biomass of the primary producers is greater than the biomass of the consumers. Often there is a greater biomass of zooplankton than of phytoplankton. This is possible because the rate of reproduction of phytoplankton is high enough to sustain a turnover rate of biomass sufficient to support the primary consumers present. This high rate of reproduction results in an inverted pyramid base. Succeedingly higher trophic levels, however, do conform to the classic pyramid idea.

LABORATORY 5

The Consumer Connection: Food Webs of an Estuary
(Estimated student contact time: 50 minutes)

Preparation Prior to the Lab. Have the students read the appropriate sections of the reading book. A field trip to the South Slough Sanctuary or other estuary is strongly recommended.

Equipment and Supplies Needed. All equipment and supplies needed are listed in the lab handout.

Exercise Follow-up. This lab is designed to be a self-contained pencil-and-paper study of food webs. Any field trip experience to an estuary is strongly recommended. For teachers not able to conduct a field trip before this lab, a follow-up field trip to the South Slough Sanctuary, where on-site staff assistance is available, would be very beneficial for the students.

LABORATORY 6

Inefficiency Experts: Productivity in the Estuary
(Estimated student contact time: 25 minutes)

Preparation Prior to the Lab. Have the students read the appropriate sections of the reading book. The students should also have a firm understanding of the concept of trophic levels and should have completed Lab 5, "The Consumer Connection."

Equipment and Supplies Needed. All materials needed are included with the lab.

Exercise Follow-up. This lab is designed to be a self-contained pencil-and-paper exercise for studying the concept of productivity. This is an excellent general biology exercise as well.

LABORATORY 7

Who, Where, and Why in an Estuary: Predicting the Distribution of Plants and Animals
(Estimated student contact time: 50 minutes)

Preparation Prior to the Lab. Have the students read the appropriate sections of the reading book. It is strongly recommended that the students have completed this lab before they take a field trip to an estuary.

Equipment and Supplies Needed. All materials needed are included with the lab.

Exercise Follow-up. After the students have completed this lab and scheduled a field trip to an estuary, a good follow-up exercise is to obtain a map of the field trip area and predict the environmental conditions and organisms you expect to find at two or three sites in the field trip area. Then use samples, field observations, and lab tests to confirm, refute, and modify your predictions as much as possible.

Note

Laboratory handouts one through seven (odd-numbered pages 63-197) are master copies. One copy per student will be required.

ACKNOWLEDGEMENTS

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LABORATORY 1

Name:______________________

Instructor:__________ Period:____

The Wet Blanket: Understanding the Tides

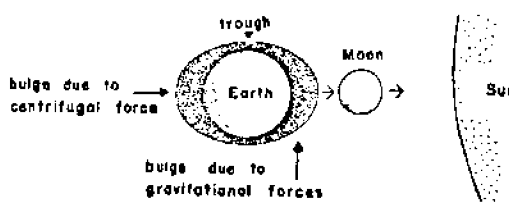
Purpose:

The purpose of this exercise is to learn to use tide tables. Looking at tide tables for a coastal area you expect to visit will help familiarize you with the tables as well as with the patterns of the tides for that area. That way you won't be trapped on a rock by the incoming tide while tidepooling, or have your canoe float away while you are clamming on the mud flats of an estuary. One question to ask yourself while doing this exercise is, "If I lived there, would I need to keep a tide table handy or could I just look at it once and then forget it?"

Materials: Tide tables with lunar phases (one per pair of students)
Pencils and fine-point marking pens
Graph paper
Scissors, tape
Ruler

Introduction:

The thin blanket of water that surrounds the earth is pulled by the gravitational force of the moon and sun, and it is also affected by the centrifugal force of the earth rotating around the sun. These forces create "bulges" in the water blanket with "troughs" in between as illustrated below. The earth turns under these bulges and troughs, creating high and low tides.



Although the basic causes for the tides are the same everywhere, different factors combine to produce tides characteristic of a given area. For example, in some places low tide is followed ten minutes later by a high tide. Along the Oregon coast we have two high tides and two low tides every 24 hours and 50 minutes. Since there are two highs and two lows per day, along the Oregon coast the low tide is followed about six hours later by a high tide. Also, in some areas of the world, for example the Caribbean, there is only one high and one low tide each day. Oregon has two highs and two lows, as we've already noted.

Procedure:

1. You and your teacher will briefly discuss "How to read the tide tables," instructions accompanying the tide tables included with this exercise. Make sure you know which part of the tables is for high tides and which part is for low tides.

2. Look through the tide tables you have been given. Turn to today's date.

   a. What is the height of the lowest tide today at Humboldt Bay, California? ______________

   b. At what time did it occur? ______________

   c. How long after it does the next high tide occur? ______________

3. Included with the tide tables is a "correction" table. Find the time and tide height correction factors for the Coos Bay Docks, Coos Bay Entrance, and Port Orford. Write the correction factors below.

Location	Height Correction	Time Correction
Coos Bay Docks	______________	______________
Coos Bay Entrance	______________	______________
Port Orford	______________	______________

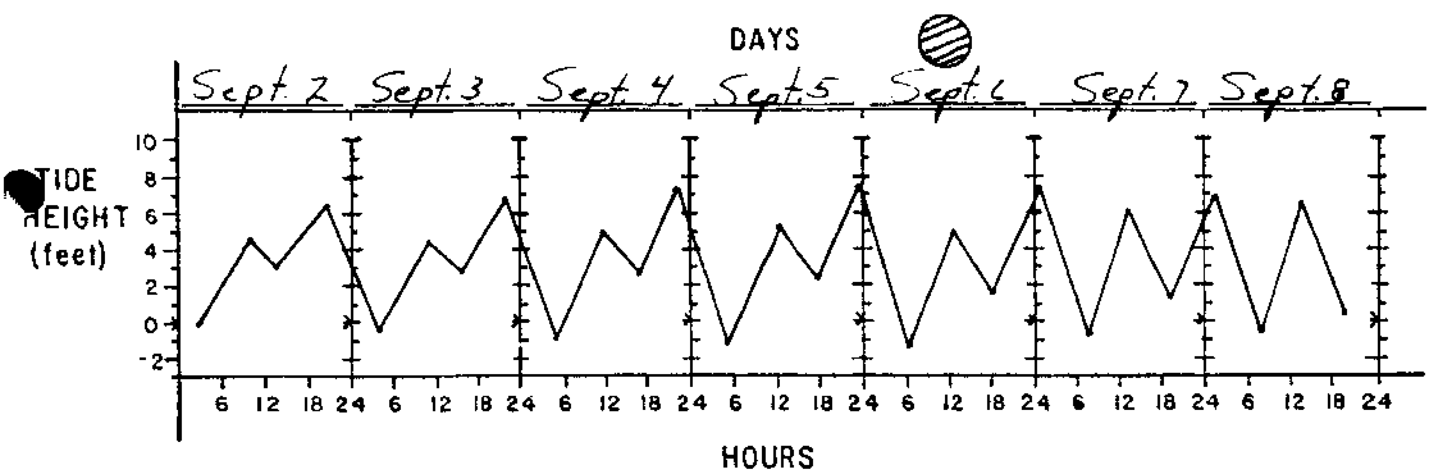
   a. Can you explain why there is such a large difference in correction times for Coos Bay Docks and Coos Bay Entrance?

   b. Give at least one good reason a person must demonstrate a working knowledge of tide table correction factors before receiving a ship captain's license?

4. Using the attached graph paper, graph the tides for a seven-day period your instructor will assign to you. Also indicate the phase of the moon appropriate to that period of time along the top of the graph. (See example below.) The phases of the moon are

First Quarter | Full Moon | Third Quarter | New Moon

When graphing the tides, remember to use the appropriate correction factors.



5. Now look at the tide curve over a several-week period by combining your graph with those of your classmates. Do this by taping all of the tide graphs end to end in the proper order on a wall. You should have several months of tide curves to look at. You can now see several patterns in the curve. Using your own graph paper, draw a tide graph approximating the curve of one month. Add the phases of the moon to this curve as you did before.

6. How does the cycle of the moon follow the cycle of the tide heights?

Conclusion:

From this exercise we have been able to visualize some of the important patterns in the rise and fall of the tides. We have also been able to determine that the moon is a very important cause of the patterns we see. In fact, it has been shown that the moon is the primary cause of the tide patterns we see. We have also learned something of practical importance. We have learned how to use a tide book, and we need to know that every time we're around the ocean.

How to Read the Tide Tables

1. "HIGH" indicates that this part of the tide table gives ebb high tide times and elevation.

2. "LOW" indicates that this part of the tide table gives ebb low tide times and elevations.

3. "A.M." indicates those ebb tides occurring between 12:00 midnight and 12:00 noon.

4. "P.M." indicates those ebb tides occurring between 12:00 noon and 12:00 midnight.

5. "h.m." indicates the time in hours and minutes that the ebb tide is expected to occur, without any consideration for conditions such as increased rainwater runoff during the winter, and storm conditions.

6. "ft." indicates the expected elevation of the ebb tide in feet and tenths of a foot.

7. A minus sign before the expected elevation indicates a tide expected to be below zero. The zero tide level is the average tide height of the lower low tides observed over a specified time interval. Mean sea level is the average observed tide level based upon observations taken over several years at a number of tide stations along the west coast of the United States and Canada. The height of mean sea level is about 4.11 ft.

Correction Table for the Humboldt Bay District

	Location	Correction for high water times		Correction for high water heights
1.	Arcata Wharf	+0 hr	40 min	+0.6 ft.
2.	Bandon	-0	05	+0.5
3.	Bodega Head	-0	45	-0.8
4.	Brookings	-0	30	+0.6
5.	Bucksport	+0	05	+0.1
6.	Cape Mendocino	-0	45	-0.6
7.	Coos Bay Docks	+1	30	+1.0
8.	Coos Bay Entrance	+0	05	+0.7
9.	Crescent City	-0	30	+0.6
10.	Eureka	+0	30	+0.3
11.	Fields Landing	+0	05	+0.1
12.	Fort Bragg	-0	55	-0.5
13.	Hookton Slough	+0	10	+0.3
14.	Humboldt Bay Entrance	-0	10	-0.2
15.	Humboldt Bay South Jetty Landing	0	00	0.0

	Location	Correction for high water times		Correction for high water heights
16.	Monterey	-1	30	-1.1
17.	Moss Landing	-1	30	-1.1
18.	Point Arena	-1	00	-0.6
19.	Point Reyes	-1	15	-0.6
20.	Port Orford	-0	25	+0.9
21.	San Francisco	-0	25	-0.6
22.	Shelter Cove	-1	00	-0.3
23.	Trinidad Harbor	-0	40	+0.1
24.	Wedderburn	+0	05	0.0

"+" indicates time or elevation to be added to the tide table.
"-" indicates time or elevation to be subtracted from the tide table.

JANUARY

HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

HIGH Date	A.M. h m	ft	P.M. h m	ft
1 Sat	1:58	5.8	**12:41**	**7.9**
2 Sun	2:46	5.9	**1:31**	**7.5**
3 Mon	3:35	6.0	**2:29**	**6.8**
4 Tue	4:24	6.2	**3:32**	**6.0**
5 Wed	5:13	6.4	**4:44**	**5.3**
6 Thu	6:02	6.5	**6:10**	**4.7**
7 Fri	6:49	6.7	**7:44**	**4.4**
8 Sat	7:36	6.8	**9:08**	**4.5**
9 Sun	8:21	6.9	**10:17**	**4.6**
10 Mon	9:03	7.0	**11:13**	**4.9**
11 Tue	9:42	7.1	**11:57**	**5.0**
12 Wed	10:18	7.1	....	...
13 Thu	0:36	5.1	....	...
13 "	10:57	7.1	....	...
14 Fri	1:09	5.2	....	...
14 "	11:29	7.0	....	...
15 Sat	1:41	5.3	**12:04**	**6.9**
16 Sun	2:13	5.3	**12:38**	**6.8**
17 Mon	2:41	5.4	**1:15**	**6.5**
18 Tue	3:13	5.5	**1:57**	**6.1**
19 Wed	3:44	5.7	**2:42**	**5.6**
20 Thu	4:16	5.8	**3:41**	**5.1**
21 Fri	4:55	6.1	**4:50**	**4.6**
22 Sat	5:37	6.3	**6:23**	**4.3**
23 Sun	6:24	6.6	**7:58**	**4.3**
24 Mon	7:17	7.0	**9:24**	**4.6**
25 Tue	8:10	7.4	**10:28**	**4.9**
26 Wed	9:06	7.7	**11:19**	**5.3**
27 Thu	10:00	8.0	....	...
28 Fri	0:08	5.6	....	...
28 "	10:52	8.1	....	...
29 Sat	0:50	5.8	....	...
29 "	11:44	8.1	....	...
30 Sun	1:32	6.0	**12:36**	**7.7**
31 Mon	2:11	6.2	**1:28**	**7.2**

JANUARY

HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

LOW Date	A.M. h m	ft	P.M. h m	ft
1 Sat	6:51	3.1	**7:58**	**-1.5**
2 Sun	7:50	3.1	**8:44**	**-1.0**
3 Mon	8:53	3.0	**9:32**	**-0.4**
4 Tue	10:01	2.8	**10:21**	**0.3**
5 Wed	11:17	2.5	**11:11**	**1.0**
6 Thu	....	...	**12:31**	**2.0**
7 Fri	0:03	1.7	**1:42**	**1.5**
8 Sat	0:56	2.3	**2:42**	**0.9**
9 Sun	1:53	2.8	**3:38**	**0.4**
10 Mon	2:45	3.1	**4:23**	**0.1**
11 Tue	3:38	3.3	**5:02**	**-0.2**
12 Wed	4:23	3.4	**5:40**	**-0.4**
13 Thu	5:05	3.5	**6:15**	**-0.4**
14 Fri	5:42	3.5	**6:51**	**-0.4**
15 Sat	6:21	3.5	**7:23**	**-0.3**
16 Sun	7:00	3.4	**7:56**	**-0.1**
17 Mon	7:42	3.4	**8:28**	**0.1**
18 Tue	8:28	3.3	**9:01**	**0.5**
19 Wed	9:21	3.1	**9:35**	**0.9**
20 Thu	10:21	2.8	**10:14**	**1.4**
21 Fri	11:28	2.4	**10:57**	**2.0**
22 Sat	....	...	**12:41**	**1.8**
22	....	...	**11:48**	**2.5**
23 Sun	....	...	**1:46**	**1.1**
24 Mon	0:50	2.9	**2:45**	**0.3**
25 Tue	1:53	3.2	**3:41**	**-0.4**
26 Wed	2:59	3.3	**4:33**	**-1.0**
27 Thu	3:58	3.2	**5:22**	**-1.4**
28 Fri	4:54	3.0	**6:08**	**-1.5**
29 Sat	5:50	2.8	**6:53**	**-1.4**
30 Sun	6:44	2.5	**7:36**	**-1.1**
31 Mon	7:39	2.3	**8:18**	**-0.5**

FEBRUARY

HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

HIGH Date	A.M. h m	ft	P.M. h m	ft
1 Tue	2:53	6.4	**2:22**	**6.5**
2 Wed	3:35	6.5	**3:21**	**5.8**
3 Thu	4:17	6.5	**4:29**	**5.0**
4 Fri	5:04	6.5	**5:52**	**4.5**
5 Sat	5:53	6.5	**7:30**	**4.3**
6 Sun	6:46	6.5	**8:59**	**4.4**
7 Mon	7:39	6.5	**10:08**	**4.6**
8 Tue	8:32	6.6	**10:54**	**4.8**
9 Wed	9:21	6.7	**11:37**	**5.0**
10 Thu	10:03	6.8	....	...
11 Fri	0:08	5.2	....	...
11 "	10:42	6.8	....	...
12 Sat	0:36	5.3	....	...
12 "	11:20	6.8	....	...
13 Sun	1:04	5.4	....	...
13 "	11:53	6.7	....	...
14 Mon	1:27	5.5	**12:31**	**6.6**
15 Tue	1:52	5.7	**1:06**	**6.3**
16 Wed	2:20	5.8	**1:48**	**5.9**
17 Thu	2:46	6.0	**2:36**	**5.5**
18 Fri	3:18	6.1	**3:33**	**5.0**
19 Sat	3:56	6.3	**4:42**	**4.5**
20 Sun	4:43	6.4	**6:14**	**4.3**
21 Mon	5:36	6.6	**7:55**	**4.3**
22 Tue	6:40	6.8	**9:15**	**4.6**
23 Wed	7:46	7.0	**10:15**	**5.0**
24 Thu	8:52	7.3	**10:57**	**5.3**
25 Fri	9:51	7.5	**11:39**	**5.7**
26 Sat	10:46	7.6	....	...
27 Sun	0:18	6.0	....	...
27 "	11:42	7.4	....	...
28 Mon	0:53	6.3	**12:32**	**7.1**

FEBRUARY

HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

LOW Date	A.M. h m	ft	P.M. h m	ft
1 Tue	8:37	2.1	**9:01**	**0.2**
2 Wed	9:39	1.9	**9:43**	**0.9**
3 Thu	10:43	1.8	**10:27**	**1.7**
4 Fri	11:54	1.5	**11:16**	**2.4**
5 Sat	....	...	**1:07**	**1.3**
6 Sun	0:12	2.9	**2:10**	**0.9**
7 Mon	1:18	3.3	**3:08**	**0.6**
8 Tue	2:23	3.5	**3:57**	**0.3**
9 Wed	3:19	3.5	**4:39**	**0.0**
10 Thu	4:08	3.4	**5:17**	**-0.1**
11 Fri	4:49	3.2	**5:52**	**-0.2**
12 Sat	5:31	3.1	**6:24**	**-0.2**
13 Sun	6:07	2.9	**6:55**	**-0.1**
14 Mon	6:46	2.7	**7:24**	**0.1**
15 Tue	7:27	2.5	**7:56**	**0.5**
16 Wed	8:09	2.3	**8:25**	**0.9**
17 Thu	8:57	2.1	**8:57**	**1.4**
18 Fri	9:50	1.8	**9:31**	**1.9**
19 Sat	10:52	1.5	**10:15**	**2.4**
20 Sun	....	...	**12:01**	**1.1**
20	....	...	**11:12**	**2.9**
21 Mon	....	...	**1:14**	**0.6**
22 Tue	0:21	3.2	**2:19**	**0.1**
23 Wed	1:41	3.3	**3:19**	**-0.4**
24 Thu	2:50	3.2	**4:15**	**-0.8**
25 Fri	3:53	2.8	**5:01**	**-1.1**
26 Sat	4:50	2.4	**5:46**	**-1.0**
27 Sun	5:44	1.9	**6:29**	**-0.8**
28 Mon	6:34	1.5	**7:08**	**-0.3**

MARCH

HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

HIGH Date	A.M. h m	ft	P.M. h m	ft
1 Tue	1:32	6.4	**1:23**	**6.6**
2 Wed	2:06	6.5	**2:16**	**6.0**
3 Thu	2:42	6.5	**3:14**	**5.4**
4 Fri	3:21	6.4	**4:16**	**4.8**
5 Sat	4:02	6.3	**5:35**	**4.4**
6 Sun	4:51	6.1	**7:08**	**4.2**
7 Mon	5:49	5.9	**8:34**	**4.3**
8 Tue	6:54	5.8	**9:38**	**4.6**
9 Wed	7:58	5.9	**10:21**	**4.8**
10 Thu	8:55	6.0	**10:57**	**5.0**
11 Fri	9:44	6.2	**11:24**	**5.2**
12 Sat	10:27	6.3	**11:51**	**5.4**
13 Sun	11:08	6.3	....	...
14 Mon	0:15	5.6	....	...
14 "	11:45	6.2	....	...
15 Tue	0:37	5.7	**12:22**	**6.1**
16 Wed	1:03	5.9	**1:04**	**5.8**
17 Thu	1:27	6.1	**1:49**	**5.5**
18 Fri	1:56	6.2	**2:36**	**5.1**
19 Sat	2:29	6.3	**3:36**	**4.8**
20 Sun	3:11	6.4	**4:49**	**4.4**
21 Mon	3:58	6.3	**6:17**	**4.3**
22 Tue	5:02	6.3	**7:48**	**4.4**
23 Wed	6:18	6.3	**8:55**	**4.8**
24 Thu	7:34	6.3	**9:45**	**5.1**
25 Fri	8:47	6.5	**10:25**	**5.5**
26 Sat	9:49	6.6	**11:03**	**5.9**
27 Sun	10:48	6.6	**11:40**	**6.2**
28 Mon	11:40	6.5	....	...
29 Tue	0:12	6.5	**12:32**	**6.2**
30 Wed	0:46	6.6	**1:22**	**5.8**
31 Thu	1:19	6.6	**2:12**	**5.4**

MARCH

HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

LOW Date	A.M. h m	ft	P.M. h m	ft
1 Tue	7:27	1.2	**7:47**	**0.2**
2 Wed	8:19	1.0	**8:25**	**0.9**
3 Thu	9:11	0.9	**9:06**	**1.6**
4 Fri	10:07	0.9	**9:48**	**2.3**
5 Sat	11:09	0.9	**10:37**	**2.8**
6 Sun	....	...	**12:18**	**0.9**
6 "	....	...	**11:36**	**3.2**
7 Mon	....	...	**1:24**	**0.8**
8 Tue	0:52	3.4	**2:29**	**0.6**
9 Wed	2:02	3.4	**3:19**	**0.4**
10 Thu	3:03	3.2	**4:05**	**0.2**
11 Fri	3:53	2.9	**4:45**	**0.1**
12 Sat	4:37	2.6	**5:17**	**0.1**
13 Sun	5:15	2.3	**5:49**	**0.2**
14 Mon	5:53	1.9	**6:19**	**0.4**
15 Tue	6:29	1.6	**6:49**	**0.6**
16 Wed	7:08	1.3	**7:18**	**1.0**
17 Thu	7:50	1.0	**7:48**	**1.4**
18 Fri	8:35	0.7	**8:24**	**1.9**
19 Sat	9:26	0.6	**9:02**	**2.4**
20 Sun	10:27	0.4	**9:49**	**2.8**
21 Mon	11:35	0.3	**10:57**	**3.2**
22 Tue	....	...	**12:45**	**0.1**
23 Wed	0:17	3.3	**1:54**	**-0.2**
24 Thu	1:41	3.1	**2:54**	**-0.4**
25 Fri	2:52	2.6	**3:47**	**-0.5**
26 Sat	3:52	2.0	**4:36**	**-0.5**
27 Sun	4:48	1.4	**5:19**	**-0.3**
28 Mon	5:37	0.8	**5:59**	**0.1**
29 Tue	6:23	0.4	**6:38**	**0.6**
30 Wed	7:11	0.1	**7:13**	**1.1**
31 Thu	7:57	-0.1	**7:49**	**1.7**

APRIL

HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

HIGH Date	A.M. h m	ft	P.M. h m	ft
1 Fri	1:52	6.5	**3:08**	**5.0**
2 Sat	2:27	6.2	**4:08**	**4.6**
3 Sun	3:05	6.0	**5:20**	**4.3**
4 Mon	3:52	5.7	**6:42**	**4.3**
5 Tue	4:49	5.4	**7:55**	**4.4**
6 Wed	6:05	5.2	**8:52**	**4.6**
7 Thu	7:17	5.2	**9:32**	**4.8**
8 Fri	8:23	5.3	**10:03**	**5.1**
9 Sat	9:19	5.4	**10:32**	**5.3**
10 Sun	10:07	5.5	**10:57**	**5.6**
11 Mon	10:52	5.5	**11:20**	**5.8**
12 Tue	11:35	5.5	**11:46**	**6.1**
13 Wed	....	...	**12:18**	**5.4**
14 Thu	0:10	6.3	**1:03**	**5.3**
15 Fri	0:40	6.4	**1:53**	**5.1**
16 Sat	1:14	6.5	**2:46**	**4.9**
17 Sun	1:51	6.5	**3:47**	**4.6**
18 Mon	2:37	6.4	**5:01**	**4.5**
19 Tue	3:21	6.2	**6:17**	**4.6**
20 Wed	4:40	5.9	**7:28**	**4.8**
21 Thu	6:03	5.7	**8:23**	**5.1**
22 Fri	7:25	5.6	**9:09**	**5.5**
23 Sat	8:42	5.6	**9:48**	**5.9**
DAYLIGHT TIME BEGINS				
24 Sun	10:48	5.6	**11:24**	**6.2**
25 Mon	11:49	5.6	**11:59**	**6.3**
26 Tue	....	...	**12:43**	**5.5**
27 Wed	0:31	6.6	**1:33**	**5.3**
28 Thu	1:03	6.6	**2:22**	**5.1**
29 Fri	1:33	6.5	**3:12**	**4.9**
30 Sat	2:07	6.4	**4:05**	**4.7**

APRIL

HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

LOW Date	A.M. h m	ft	P.M. h m	ft
1 Fri	8:44	0.0	**8:30**	**2.3**
2 Sat	9:34	0.1	**9:13**	**2.7**
3 Sun	10:27	0.3	**10:01**	**3.1**
4 Mon	11:28	0.5	**11:10**	**3.4**
5 Tue	....	...	**12:35**	**0.6**
6 Wed	0:27	3.4	**1:36**	**0.6**
7 Thu	1:42	3.2	**2:31**	**0.5**
8 Fri	2:43	2.8	**3:17**	**0.4**
9 Sat	3:35	2.3	**3:58**	**0.4**
10 Sun	4:17	1.8	**4:33**	**0.5**
11 Mon	4:57	1.3	**5:08**	**0.7**
12 Tue	5:35	0.8	**5:40**	**1.0**
13 Wed	6:11	0.4	**6:12**	**1.3**
14 Thu	6:51	-0.1	**6:44**	**1.6**
15 Fri	7:31	-0.4	**7:16**	**2.0**
16 Sat	8:17	-0.6	**7:58**	**2.4**
17 Sun	9:09	-0.6	**8:44**	**2.8**
18 Mon	10:07	-0.6	**9:43**	**3.1**
19 Tue	11:10	-0.5	**10:59**	**3.2**
20 Wed	....	...	**12:16**	**-0.4**
21 Thu	0:27	3.0	**1:23**	**-0.3**
22 Fri	1:45	2.5	**2:23**	**-0.2**
23 Sat	2:52	1.9	**3:14**	**0.0**
DAYLIGHT TIME BEGINS				
24 Sun	4:51	1.1	**4:59**	**0.3**
25 Mon	5:40	0.4	**5:45**	**0.6**
26 Tue	6:28	-0.2	**6:23**	**1.1**
27 Wed	7:13	-0.6	**7:03**	**1.5**
28 Thu	7:56	-0.8	**7:41**	**2.0**
29 Fri	8:35	-0.8	**8:19**	**2.4**
30 Sat	9:20	-0.7	**8:58**	**2.8**

MAY

HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

HIGH Date	A.M. h.m	ft	P.M. h.m	ft
1 Sun	2:42	6.1	4:58	4.5
2 Mon	3:19	5.8	6:01	4.4
3 Tue	4:04	5.5	7:06	4.4
4 Wed	5:00	5.1	8:05	4.5
5 Thu	6:09	4.8	8:54	4.7
6 Fri	7:28	4.6	9:30	5.0
7 Sat	8:44	4.6	10:03	5.3
8 Sun	9:47	4.6	10:32	5.6
9 Mon	10:45	4.7	11:01	5.9
10 Tue	11:36	4.8	11:27	6.2
11 Wed	....	...	12:28	4.9
11 "	....	...	11:57	6.5
12 Thu	....	...	1:17	5.0
13 Fri	0:30	6.7	2:05	5.0
14 Sat	1:04	6.9	2:58	4.9
15 Sun	1:45	6.9	3:54	4.8
16 Mon	2:28	6.8	4:53	4.8
17 Tue	3:20	6.5	5:55	4.8
18 Wed	4:19	6.1	6:57	5.0
19 Thu	5:31	5.6	7:53	5.3
20 Fri	6:54	5.1	8:45	5.6
21 Sat	8:20	4.8	9:28	6.0
22 Sun	9:39	4.7	10:08	6.3
23 Mon	10:48	4.7	10:45	6.6
24 Tue	11:51	4.8	11:20	6.7
25 Wed	....	...	12:47	4.8
25 "	....	...	11:54	6.7
26 Thu	....	...	1:37	4.8
27 Fri	0:25	6.7	2:23	4.8
28 Sat	0:57	6.5	3:09	4.7
29 Sun	1:32	6.4	3:54	4.6
30 Mon	2:08	6.1	4:40	4.6
31 Tue	2:43	5.8	5:32	4.6

MAY

HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

LOW Date	A.M. h.m	ft	P.M. h.m	ft
1 Sun	10:04	-0.5	9:41	3.1
2 Mon	10:51	-0.2	10:34	3.3
3 Tue	11:43	0.0	11:43	3.4
4 Wed	....	...	12:40	0.3
5 Thu	1:02	3.3	1:37	0.4
6 Fri	2:12	2.9	2:31	0.6
7 Sat	3:15	2.4	3:18	0.7
8 Sun	4:07	1.8	4:02	0.9
9 Mon	4:51	1.2	4:40	1.1
10 Tue	5:33	0.5	5:19	1.3
11 Wed	6:13	-0.1	5:54	1.6
12 Thu	6:52	-0.7	6:33	2.0
13 Fri	7:34	-1.1	7:12	2.3
14 Sat	8:19	-1.4	7:54	2.6
15 Sun	9:04	-1.5	8:40	2.8
16 Mon	9:57	-1.4	9:36	3.0
17 Tue	10:50	-1.2	10:43	3.1
18 Wed	11:49	-0.9	....	...
19 Thu	0:04	3.0	12:49	-0.5
20 Fri	1:28	2.5	1:47	-0.1
21 Sat	2:44	1.9	2:44	0.3
22 Sun	3:47	1.1	3:35	0.7
23 Mon	4:42	0.4	4:24	1.2
24 Tue	5:31	-0.3	5:09	1.6
25 Wed	6:16	-0.8	5:52	2.0
26 Thu	6:58	-1.0	6:31	2.4
27 Fri	7:37	-1.2	7:12	2.7
28 Sat	8:16	-1.1	7:50	2.9
29 Sun	8:57	-1.0	8:29	3.1
30 Mon	9:36	-0.8	9:14	3.3
31 Tue	10:19	-0.5	10:09	3.3

JUNE

HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

HIGH Date	A.M. h.m	ft	P.M. h.m	ft
1 Wed	3:28	5.5	6:21	4.6
2 Thu	4:20	5.1	7:06	4.8
3 Fri	5:23	4.7	7:48	5.0
4 Sat	6:35	4.3	8:25	5.3
5 Sun	7:56	4.1	8:58	5.6
6 Mon	9:15	4.1	9:31	6.0
7 Tue	10:22	4.2	10:05	6.3
8 Wed	11:25	4.4	10:40	6.7
9 Thu	....	...	12:21	4.6
9 "	....	...	11:17	7.0
10 Fri	....	...	1:12	4.7
10 "	....	...	11:57	7.2
11 Sat	....	...	2:03	4.9
12 Sun	0:41	7.3	2:53	5.0
13 Mon	1:27	7.3	3:45	5.0
14 Tue	2:16	7.0	4:36	5.1
15 Wed	3:11	6.6	5:29	5.3
16 Thu	4:10	6.0	6:22	5.5
17 Fri	5:23	5.3	7:14	5.8
18 Sat	6:45	4.7	8:00	6.1
19 Sun	8:12	4.3	8:45	6.4
20 Mon	9:37	4.2	9:29	6.6
21 Tue	10:52	4.3	10:09	6.7
22 Wed	11:55	4.4	10:46	6.8
23 Thu	....	...	12:47	4.5
23 "	....	...	11:24	6.8
24 Fri	....	...	1:36	4.6
25 Sat	0:00	6.7	2:19	4.7
26 Sun	0:35	6.6	2:57	4.7
27 Mon	1:10	6.4	3:35	4.7
28 Tue	1:45	6.2	4:11	4.7
29 Wed	2:24	5.9	4:49	4.8
30 Thu	3:06	5.6	5:25	4.9

JUNE

HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

LOW Date	A.M. h.m	ft	P.M. h.m.	ft
1 Wed	11:05	-0.2	11:13	3.3
2 Thu	11:51	0.1	....	...
3 Fri	0:24	3.1	12:37	0.4
4 Sat	1:37	2.7	1:28	0.7
5 Sun	2:39	2.1	2:17	1.1
6 Mon	3:34	1.4	3:02	1.4
7 Tue	4:23	0.7	3:48	1.7
8 Wed	5:09	-0.1	4:30	2.0
9 Thu	5:51	-0.8	5:15	2.3
10 Fri	6:33	-1.3	6:01	2.5
11 Sat	7:18	-1.7	6:46	2.7
12 Sun	8:04	-2.0	7:35	2.8
13 Mon	8:53	-2.0	8:29	2.9
14 Tue	9:40	-1.8	9:33	2.9
15 Wed	10:32	-1.4	10:42	2.8
16 Thu	11:23	-0.9	11:57	2.5
17 Fri	....	...	12:16	-0.2
18 Sat	1:18	2.0	1:11	0.4
19 Sun	2:32	1.3	2:03	1.0
20 Mon	3:35	0.6	2:57	1.6
21 Tue	4:30	0.0	3:48	2.0
22 Wed	5:19	-0.5	4:37	2.4
23 Thu	6:02	-0.9	5:22	2.7
24 Fri	6:43	-1.1	6:05	2.9
25 Sat	7:21	-1.1	6:47	3.0
26 Sun	8:00	-1.1	7:28	3.1
27 Mon	8:35	-1.0	8:07	3.2
28 Tue	9:11	-0.8	8:53	3.2
29 Wed	9:48	-0.5	9:44	3.2
30 Thu	10:26	-0.2	10:39	3.1

JULY

HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

HIGH Date	A.M. h.m	ft	P.M. h.m	ft.
1 Fri	3:51	5.2	6:03	5.1
2 Sat	4:47	4.7	6:41	5.3
3 Sun	5:56	4.2	7:17	5.6
4 Mon	7:16	3.9	7:54	5.9
5 Tue	8:44	3.8	8:35	6.3
6 Wed	10:04	4.0	9:17	6.6
7 Thu	11:12	4.2	10:03	7.0
8 Fri	....	...	12:11	4.5
8 "	....	...	10:49	7.3
9 Sat	....	...	1:02	4.8
9 "	....	...	11:37	7.6
10 Sun	....	...	1:49	5.0
11 Mon	0:26	7.6	2:34	5.2
12 Tue	1:18	7.5	3:20	5.4
13 Wed	2:10	7.1	4:05	5.6
14 Thu	3:06	6.6	4:51	5.8
15 Fri	4:05	5.9	5:39	6.0
16 Sat	5:14	5.1	6:25	6.2
17 Sun	6:36	4.5	7:14	6.4
18 Mon	8:07	4.1	8:03	6.5
19 Tue	9:37	4.0	8:53	6.6
20 Wed	10:51	4.2	9:39	6.6
21 Thu	11:52	4.4	10:22	6.6
22 Fri	....	...	12:42	4.6
22 "	....	...	11:04	6.6
23 Sat	....	...	1:23	4.7
23 "	....	...	11:41	6.6
24 Sun	....	...	1:56	4.8
25 Mon	0:19	6.6	2:28	4.9
26 Tue	0:55	6.4	3:00	4.9
27 Wed	1:30	6.3	3:25	5.0
28 Thu	2:05	6.0	3:57	5.1
29 Fri	2:47	5.6	4:25	5.3
30 Sat	3:33	5.2	4:56	5.4
31 Sun	4:21	4.7	5:32	5.6

JULY

HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

LOW Date	A.M. h.m.	ft	P.M. h.m	ft.
1 Fri	11:03	0.2	11:45	2.8
2 Sat	11:43	0.6	....	...
3 Sun	0:51	2.4	12:29	1.1
4 Mon	1:59	1.9	1:14	1.5
5 Tue	2:55	1.2	2:03	2.0
6 Wed	3:51	0.4	2:59	2.3
7 Thu	4:40	-0.3	3:51	2.6
8 Fri	5:29	-1.0	4:46	2.7
9 Sat	6:15	-1.6	5:36	2.8
10 Sun	7:02	-1.9	6:31	2.7
11 Mon	7:47	-2.0	7:26	2.6
12 Tue	8:34	-1.9	8:23	2.5
13 Wed	9:20	-1.6	9:23	2.3
14 Thu	10:06	-1.0	10:29	2.1
15 Fri	10:54	-0.3	11:40	1.8
16 Sat	11:43	0.4	....	...
17 Sun	0:54	1.4	12:33	1.1
18 Mon	2:07	0.9	1:24	1.8
19 Tue	3:11	0.4	2:23	2.3
20 Wed	4:11	0.0	3:19	2.7
21 Thu	5:00	-0.4	4:16	2.9
22 Fri	5:45	-0.6	5:04	3.0
23 Sat	6:26	-0.8	5:49	3.0
24 Sun	7:03	-0.8	6:32	3.0
25 Mon	7:37	-0.8	7:11	3.0
26 Tue	8:11	-0.7	7:50	2.9
27 Wed	8:43	-0.5	8:35	2.8
28 Thu	9:15	0.2	9:18	2.7
29 Fri	9:47	0.2	10:07	2.5
30 Sat	10:19	0.6	11:06	2.3
31 Sun	10:54	1.1	....	...

AUGUST

HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

HIGH Date	A.M. h.m	ft	P.M. h.m	ft
1 Mon	5:31	4.3	6:11	5.8
2 Tue	6:52	[illegible]	6:56	6.1
3 Wed	8:27	[illegible]	7:46	6.4
4 Thu	9:54	[illegible]	8:42	6.7
5 Fri	11:02	4.3	9:37	7.1
6 Sat	11:54	4.7	10:33	7.4
7 Sun	....	...	12:41	5.0
7 "	....	...	11:25	7.6
8 Mon	....	...	1:23	5.3
9 Tue	0:18	7.6	2:02	5.6
10 Wed	1:13	7.4	2:41	5.8
11 Thu	2:05	7.0	3:23	6.0
12 Fri	3:01	6.3	4:05	6.2
13 Sat	4:01	5.6	4:47	6.3
14 Sun	5:08	4.9	5:33	6.3
15 Mon	6:28	4.4	6:23	6.3
16 Tue	7:59	4.1	7:18	6.2
17 Wed	9:31	4.1	8:15	6.2
18 Thu	10:39	4.3	9:12	6.2
19 Fri	11:31	4.6	10:01	6.3
20 Sat	....	...	12:13	4.8
20 "	....	...	10:47	6.4
21 Sun	....	...	12:48	4.9
21 "	....	...	11:30	6.4
22 Mon	....	...	1:17	5.0
23 Tue	0:07	6.4	1:45	5.1
24 Wed	0:43	6.3	2:07	5.3
25 Thu	1:21	6.1	2:35	5.4
26 Fri	1:57	5.8	2:57	5.5
27 Sat	2:35	5.5	3:25	5.6
28 Sun	3:21	5.1	3:54	5.8
29 Mon	4:15	4.7	4:29	5.9
30 Tue	5:21	4.3	5:12	6.0
31 Wed	6:45	4.0	6:05	6.1

AUGUST

HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

LOW Date	A.M. h.m	ft	P.M. h.m.	ft.
1 Mon	0:05	2.0	....	...
1 "	11:33	1.6	....	...
2 Tue	1:11	1.5	12:21	2.1
3 Wed	2:16	0.9	1:20	2.5
4 Thu	3:19	0.2	2:23	2.8
5 Fri	4:16	-0.4	3:29	2.9
6 Sat	5:07	-1.0	4:31	2.8
7 Sun	5:57	-1.4	5:27	2.6
8 Mon	6:43	-1.7	6:23	2.3
9 Tue	7:27	-1.6	7:16	2.0
10 Wed	8:09	-1.4	8:13	1.7
11 Thu	8:55	-0.9	9:09	1.5
12 Fri	9:37	-0.2	10:10	1.3
13 Sat	10:19	0.5	11:15	1.1
14 Sun	11:05	1.3	....	...
15 Mon	0:22	0.9	....	...
15 "	11:56	2.0	....	...
16 Tue	1:33	0.7	12:52	2.5
17 Wed	2:40	0.4	1:55	2.9
18 Thu	3:42	0.1	3:03	3.1
19 Fri	4:35	-0.1	4:02	3.1
20 Sat	5:20	-0.3	4:53	3.0
21 Sun	6:00	-0.4	5:38	2.8
22 Mon	6:35	-0.4	6:18	2.6
23 Tue	7:07	-0.3	6:57	2.4
24 Wed	7:39	-0.2	7:33	2.2
25 Thu	8:08	0.1	8:14	2.1
26 Fri	8:36	0.4	8:56	1.9
27 Sat	9:08	0.8	9:38	1.7
28 Sun	9:36	1.3	10:29	1.5
29 Mon	10:11	1.8	11:26	1.2
30 Tue	10:51	2.3	....	...
31 Wed	0:31	0.9	....	...
31 "	11:42	2.7	....	...

SEPTEMBER
HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

HIGH Date	A.M. h m	ft	P.M. h m	ft
1 Thu	8:20	4.0	**7:08**	**6.3**
2 Fri	9:42	4.3	**8:15**	**6.5**
3 Sat	10:40	4.6	**9:22**	**6.8**
4 Sun	11:27	5.0	**10:24**	**7.1**
5 Mon	....	...	**12:09**	**5.4**
5	....	...	**11:21**	**7.2**
6 Tue	....	...	**12:48**	**5.8**
7 Wed	0:15	7.2	**1:23**	**6.1**
8 Thu	1:11	6.9	**1:58**	**6.3**
9 Fri	2:03	6.5	**2:37**	**6.5**
10 Sat	2:59	6.0	**3:13**	**6.5**
11 Sun	3:54	5.4	**3:54**	**6.4**
12 Mon	5:03	4.8	**4:38**	**6.3**
13 Tue	6:18	4.4	**5:27**	**6.0**
14 Wed	7:51	4.3	**6:27**	**5.8**
15 Thu	9:13	4.4	**7:34**	**5.7**
16 Fri	10:13	4.6	**8:43**	**5.7**
17 Sat	11:01	4.8	**9:42**	**5.8**
18 Sun	11:33	5.0	**10:32**	**5.9**
19 Mon	....	...	**12:05**	**5.2**
19	....	...	**11:17**	**6.0**
20 Tue	....	...	**12:29**	**5.4**
20	....	...	**11:55**	**6.0**
21 Wed	....	...	**12:52**	**5.6**
22 Thu	0:34	5.9	**1:18**	**5.7**
23 Fri	1:13	5.8	**1:39**	**5.9**
24 Sat	1:52	5.6	**2:04**	**6.0**
25 Sun	2:33	5.3	**2:30**	**6.1**
26 Mon	3:20	5.0	**3:02**	**6.2**
27 Tue	4:15	4.7	**3:41**	**6.2**
28 Wed	5:25	4.4	**4:27**	**6.2**
29 Thu	6:48	4.3	**5:27**	**6.1**
30 Fri	8:17	4.4	**6:38**	**6.1**

SEPTEMBER
HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

LOW Date	A.M. h m	ft	P.M. h m	ft
1 Thu	1:41	0.5	**12:49**	**3.0**
2 Fri	2:49	0.1	**2:07**	**3.1**
3 Sat	3:48	-0.4	**3:21**	**3.0**
4 Sun	4:44	0.8	**4:24**	**2.6**
5 Mon	5:33	-1.0	**5:24**	**2.1**
6 Tue	6:19	1.1	**6:16**	**1.6**
7 Wed	7:02	-0.9	**7:08**	**1.1**
8 Thu	7:41	-0.4	**7:59**	**0.7**
9 Fri	8:22	0.1	**8:52**	**0.5**
10 Sat	9:02	0.8	**9:48**	**0.4**
11 Sun	9:43	1.5	**10:44**	**0.4**
12 Mon	10:29	2.2	**11:46**	**0.4**
13 Tue	11:21	2.7	....	...
14 Wed	0:52	0.5	**12:23**	**3.1**
15 Thu	2:01	0.5	**1:39**	**3.3**
16 Fri	3:05	0.4	**2:52**	**3.2**
17 Sat	4:00	0.3	**3:50**	**3.0**
18 Sun	4:45	0.2	**4:42**	**2.7**
19 Mon	5:24	0.1	**5:24**	**2.3**
20 Tue	6:00	0.2	**6:02**	**2.0**
21 Wed	6:31	0.3	**6:40**	**1.6**
22 Thu	7:00	0.5	**7:16**	**1.3**
23 Fri	7:29	0.8	**7:55**	**1.1**
24 Sat	7:58	1.2	**8:30**	**0.8**
25 Sun	8:29	1.6	**9:12**	**0.6**
26 Mon	9:01	2.1	**10:01**	**0.5**
27 Tue	9:36	2.5	**10:57**	**0.4**
28 Wed	10:21	2.9	**11:59**	**0.3**
29 Thu	11:24	3.2	....	...
30 Fri	1:11	0.1	**12:46**	**3.4**

OCTOBER
HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

HIGH Date	A.M. h m	ft	P.M. h m	ft
1 Sat	9:24	4.7	**7:57**	**6.1**
2 Sun	10:12	5.1	**9:13**	**6.3**
3 Mon	10:55	5.6	**10:19**	**6.5**
4 Tue	11:30	6.0	**11:18**	**6.5**
5 Wed	....	...	**12:07**	**6.4**
6 Thu	0:15	6.5	**12:42**	**6.6**
7 Fri	1:09	6.3	**1:16**	**6.8**
8 Sat	2:02	5.9	**1:51**	**6.9**
9 Sun	2:56	5.5	**2:27**	**6.8**
10 Mon	3:54	5.2	**3:03**	**6.5**
11 Tue	4:54	4.8	**3:45**	**6.2**
12 Wed	6:08	4.6	**4:33**	**5.8**
13 Thu	7:29	4.6	**5:32**	**5.5**
14 Fri	8:42	4.7	**6:48**	**5.3**
15 Sat	9:32	4.9	**8:04**	**5.2**
16 Sun	10:11	5.1	**9:10**	**5.2**
17 Mon	10:43	5.4	**10:09**	**5.4**
18 Tue	11:12	5.6	**10:56**	**5.4**
19 Wed	11:38	5.9	**11:43**	**5.5**
20 Thu	....	...	**12:00**	**6.1**
21 Fri	0:25	5.5	**12:23**	**6.3**
22 Sat	1:07	5.4	**12:50**	**6.5**
23 Sun	1:50	5.3	**1:17**	**6.6**
24 Mon	2:36	5.2	**1:47**	**6.7**
25 Tue	3:25	5.0	**2:23**	**6.7**
26 Wed	4:25	4.8	**3:06**	**6.6**
27 Thu	5:29	4.7	**3:56**	**6.4**
28 Fri	6:43	4.7	**5:03**	**6.1**
29 Sat	7:56	5.0	**6:19**	**5.8**
DAYLIGHT TIME ENDS				
30 Sun	7:51	5.3	**6:45**	**5.7**
31 Mon	8:37	5.8	**8:08**	**5.7**

OCTOBER
HUMBOLDT BAY DISTRICT TIDES
DAYLIGHT TIME

LOW Date	A.M. h m	ft	P.M. h m	ft
1 Sat	2:17	-0.1	**2:11**	**3.2**
2 Sun	3:21	-0.3	**3:24**	**2.7**
3 Mon	4:14	-0.4	**4:24**	**2.0**
4 Tue	5:03	-0.4	**5:21**	**1.3**
5 Wed	5:48	-0.1	**6:10**	**0.7**
6 Thu	6:29	0.2	**6:59**	**0.1**
7 Fri	7:11	0.7	**7:48**	**-0.2**
8 Sat	7:50	1.3	**8:34**	**-0.4**
9 Sun	8:29	1.9	**9:22**	**-0.4**
10 Mon	9:11	2.4	**10:15**	**-0.2**
11 Tue	9:56	2.9	**11:07**	**0.1**
12 Wed	10:48	3.3	....	...
13 Thu	0:09	0.3	....	...
13	11:57	3.5	....	...
14 Fri	1:12	0.5	**1:19**	**3.5**
15 Sat	2:15	0.6	**2:33**	**3.3**
16 Sun	3:11	0.6	**3:34**	**2.8**
17 Mon	3:57	0.6	**4:22**	**2.3**
18 Tue	4:38	0.7	**5:05**	**1.8**
19 Wed	5:13	0.9	**5:43**	**1.3**
20 Thu	5:47	1.1	**6:19**	**0.8**
21 Fri	6:19	1.3	**6:57**	**0.4**
22 Sat	6:49	1.7	**7:33**	**0.1**
23 Sun	7:21	2.0	**8:13**	**-0.2**
24 Mon	7:53	2.4	**8:56**	**-0.3**
25 Tue	8:29	2.8	**9:42**	**-0.4**
26 Wed	9:14	3.1	**10:36**	**-0.3**
27 Thu	10:09	3.4	**11:37**	**-0.2**
28 Fri	11:22	3.5	....	...
29 Sat	0:42	-0.1	**12:53**	**3.4**
DAYLIGHT TIME ENDS				
30 Sun	0:46	0.0	**1:14**	**2.9**
31 Mon	1:45	0.1	**2:25**	**2.2**

NOVEMBER
HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

HIGH Date	A.M. h m	ft	P.M. h m	ft
1 Tue	9:17	6.2	**9:17**	**5.7**
2 Wed	9:53	6.6	**10:23**	**5.8**
3 Thu	10:28	7.0	**11:19**	**5.7**
4 Fri	11:03	7.2	....	...
5 Sat	0:12	5.6	....	...
5	11:39	7.2	....	...
6 Sun	1:05	5.5	**12:11**	**7.1**
7 Mon	1:59	5.3	**12:46**	**6.9**
8 Tue	2:49	5.1	**1:22**	**6.6**
9 Wed	3:44	4.9	**2:01**	**6.3**
10 Thu	4:47	4.9	**2:45**	**5.9**
11 Fri	5:52	4.9	**3:40**	**5.5**
12 Sat	6:48	5.0	**4:49**	**5.1**
13 Sun	7:38	5.2	**6:12**	**4.8**
14 Mon	8:15	5.5	**7:31**	**4.8**
15 Tue	8:47	5.8	**8:37**	**4.8**
16 Wed	9:16	6.1	**9:37**	**4.9**
17 Thu	9:43	6.4	**10:29**	**5.0**
18 Fri	10:09	6.7	**11:16**	**5.1**
19 Sat	10:38	6.9	....	...
20 Sun	0:01	5.2	....	...
20	11:09	7.1	....	...
21 Mon	0:50	5.2	....	...
21	11:42	7.3	....	...
22 Tue	1:37	5.2	**12:17**	**7.3**
23 Wed	2:27	5.2	**12:59**	**7.2**
24 Thu	3:23	5.1	**1:47**	**7.0**
25 Fri	4:19	5.2	**2:42**	**6.6**
26 Sat	5:22	5.3	**3:48**	**6.1**
27 Sun	6:17	5.6	**5:07**	**5.6**
28 Mon	7:09	6.0	**6:37**	**5.2**
29 Tue	7:57	6.4	**8:06**	**5.1**
30 Wed	8:39	6.8	**9:22**	**5.1**

NOVEMBER
HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

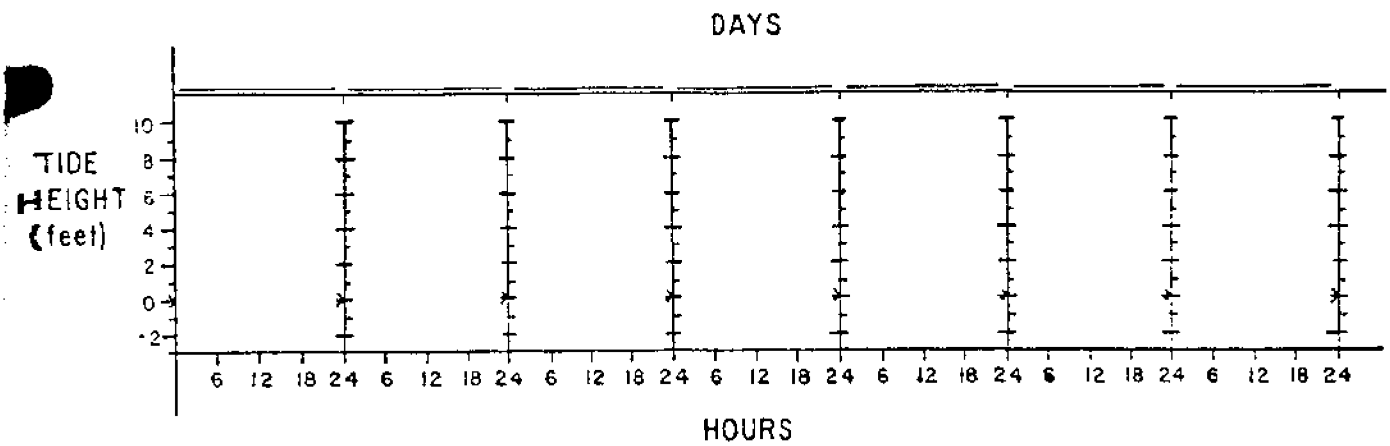
LOW Date	A.M. h m	ft	P.M. h m	ft
1 Tue	2:42	0.3	**3:24**	**1.4**
2 Wed	3:29	0.6	**4:16**	**0.6**
3 Thu	4:15	1.0	**5:05**	**-0.1**
4 Fri	4:57	1.4	**5:51**	**-0.6**
5 Sat	5:36	1.9	**6:33**	**-0.9**
6 Sun	6:18	2.3	**7:18**	**-0.9**
7 Mon	6:57	2.8	**8:00**	**-0.8**
8 Tue	7:38	3.1	**8:46**	**-0.5**
9 Wed	8:24	3.5	**9:33**	**-0.2**
10 Thu	9:21	3.7	**10:27**	**0.2**
11 Fri	10:27	3.8	**11:21**	**0.5**
12 Sat	11:47	3.6	....	...
13 Sun	0:19	0.7	**1:05**	**3.3**
14 Mon	1:12	1.0	**2:05**	**2.7**
15 Tue	2:00	1.2	**2:57**	**2.1**
16 Wed	2:42	1.4	**3:43**	**1.5**
17 Thu	3:24	1.6	**4:21**	**0.8**
18 Fri	3:59	1.9	**5:00**	**0.2**
19 Sat	4:35	2.2	**5:39**	**-0.3**
20 Sun	5:13	2.5	**6:17**	**-0.7**
21 Mon	5:49	2.8	**6:58**	**-0.9**
22 Tue	6:27	3.0	**7:41**	**-1.0**
23 Wed	7:09	3.3	**8:27**	**-1.0**
24 Thu	8:02	3.5	**9:18**	**-0.8**
25 Fri	9:05	3.6	**10:15**	**-0.5**
26 Sat	10:23	3.5	**11:11**	**-0.1**
27 Sun	11:47	3.1	....	...
28 Mon	0:11	0.3	**1:07**	**2.5**
29 Tue	1:07	0.7	**2:17**	**1.7**
30 Wed	2:01	1.2	**3:16**	**0.8**

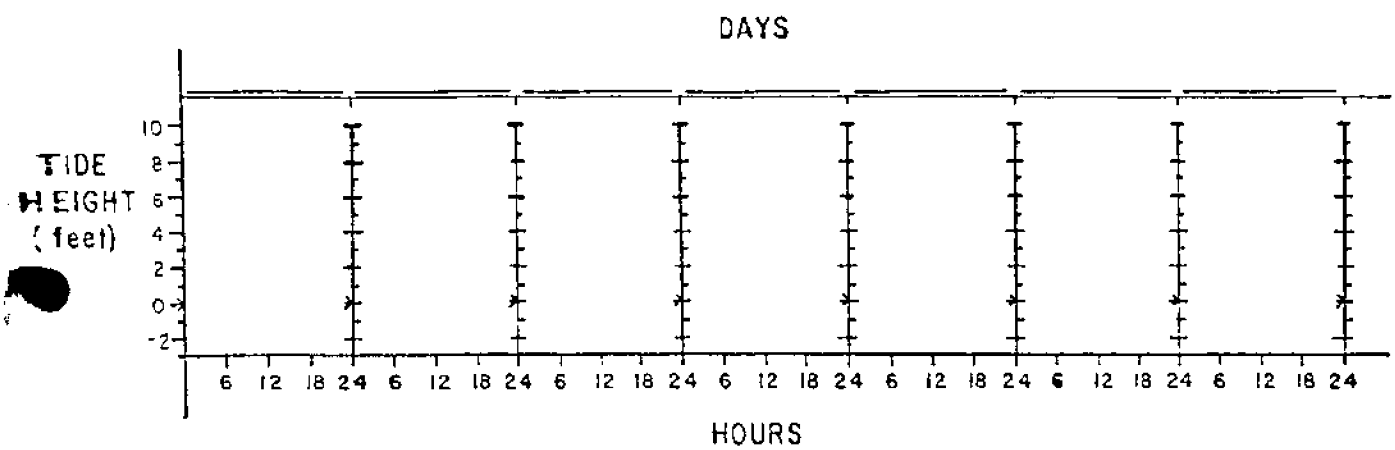
DECEMBER
HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

HIGH Date	A.M. h m	ft	P.M. h m	ft
1 Thu	9:17	7.1	**10:28**	**5.2**
2 Fri	8:56	7.4	**11:26**	**5.3**
3 Sat	10:31	7.5	....	...
4 Sun	0:17	5.3	....	...
4	11:07	7.4	....	...
5 Mon	1:07	5.3	....	...
5	11:42	7.3	....	...
6 Tue	1:55	5.3	**12:19**	**7.1**
7 Wed	2:38	5.2	**12:54**	**6.8**
8 Thu	3:27	5.2	**1:30**	**6.5**
9 Fri	4:12	5.1	**2:12**	**6.1**
10 Sat	5:01	5.2	**3:01**	**5.6**
11 Sun	5:46	5.3	**3:57**	**5.1**
12 Mon	6:28	5.5	**5:15**	**4.7**
13 Tue	7:07	5.8	**6:39**	**4.4**
14 Wed	7:41	6.1	**8:02**	**4.4**
15 Thu	8:16	6.4	**9:15**	**4.5**
16 Fri	8:50	6.7	**10:15**	**4.7**
17 Sat	9:24	7.1	**11:09**	**4.9**
18 Sun	10:00	7.4	**11:57**	**5.1**
19 Mon	10:38	7.6	....	...
20 Tue	0:45	5.3	....	...
20	11:18	7.8	....	...
21 Wed	1:29	5.4	**12:01**	**7.8**
22 Thu	2:19	5.5	**12:49**	**7.6**
23 Fri	3:05	5.6	**1:41**	**7.3**
24 Sat	3:55	5.7	**2:37**	**6.7**
25 Sun	4:45	6.0	**3:43**	**6.0**
26 Mon	5:34	6.2	**4:59**	**5.3**
27 Tue	6:23	6.5	**6:32**	**4.8**
28 Wed	7:12	6.8	**8:05**	**4.6**
29 Thu	8:00	7.1	**9:27**	**4.7**
30 Fri	8:45	7.3	**10:34**	**4.9**
31 Sat	9:27	7.4	**11:31**	**5.1**

DECEMBER
HUMBOLDT BAY DISTRICT TIDES
STANDARD TIME

LOW Date	A.M. h m	ft	P.M. h m	ft
1 Thu	2:54	1.7	**4:07**	**0.1**
2 Fri	3:43	2.1	**4:57**	**-0.5**
3 Sat	4:25	2.5	**5:39**	**-0.8**
4 Sun	5:10	2.8	**6:21**	**-1.0**
5 Mon	5:52	3.1	**7:02**	**-1.0**
6 Tue	6:31	3.4	**7:40**	**-0.8**
7 Wed	7:16	3.6	**8:20**	**-0.5**
8 Thu	7:59	3.7	**9:02**	**-0.2**
9 Fri	8:53	3.8	**9:45**	**0.1**
10 Sat	9:52	3.8	**10:31**	**0.5**
11 Sun	11:06	3.6	**11:17**	**0.9**
12 Mon	....	...	**12:20**	**3.2**
13 Tue	0:06	1.3	**1:26**	**2.7**
14 Wed	0:54	1.7	**2:24**	**2.0**
15 Thu	1:39	2.1	**3:14**	**1.3**
16 Fri	2:28	2.4	**3:56**	**0.6**
17 Sat	3:13	2.7	**4:38**	**-0.1**
18 Sun	3:56	2.9	**5:19**	**-0.6**
19 Mon	4:41	3.1	**6:01**	**-1.1**
20 Tue	5:23	3.2	**6:43**	**-1.3**
21 Wed	6:09	3.3	**7:29**	**-1.4**
22 Thu	7:01	3.3	**8:12**	**-1.2**
23 Fri	7:59	3.3	**9:01**	**-0.9**
24 Sat	9:04	3.2	**9:50**	**-0.4**
25 Sun	10:16	3.0	**10:40**	**0.2**
26 Mon	11:36	2.6	**11:34**	**0.9**
27 Tue	....	...	**12:54**	**2.0**
28 Wed	0:30	1.5	**2:05**	**1.2**
29 Thu	1:26	2.1	**3:04**	**0.5**
30 Fri	2:21	2.6	**3:56**	**-0.1**
31 Sat	3:17	2.9	**4:44**	**-0.5**


DAYS
TIDE HEIGHT (feet)
10
8
6
4
2
0
-2
6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24
HOURS


DAYS
TIDE HEIGHT (feet)
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8
6
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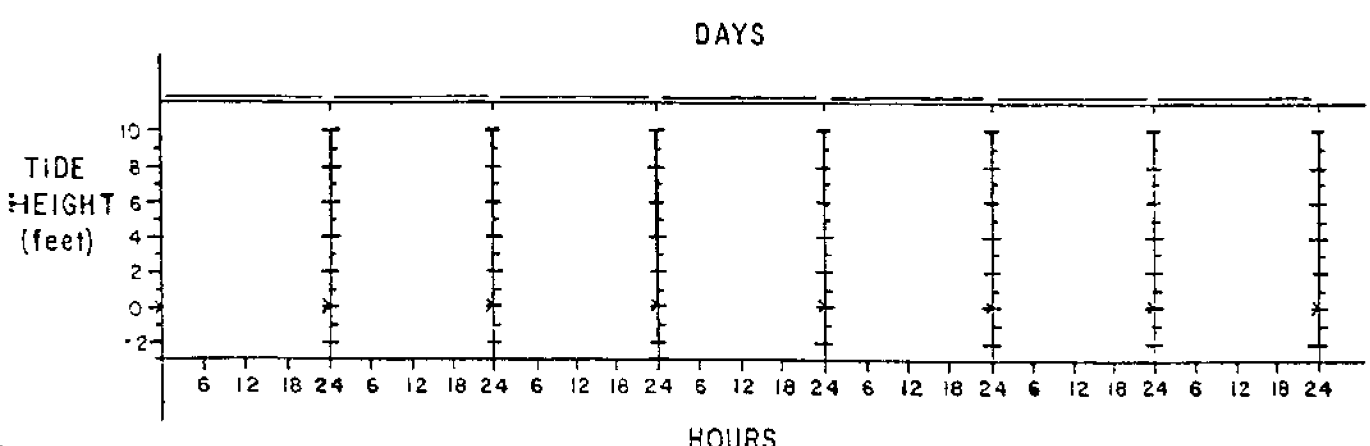
2
0
-2
6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24
HOURS


DAYS
TIDE HEIGHT (feet)
10
8
6
4
2
0
-2
6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24
HOURS

LABORATORY 2 Name: ____________________

Instructor: ______________ Period: ____

Mud Mixer: Exploring the Bottom Sediments of an Estuary

Purpose:

The purpose of this lab is to construct a simple instrument for measuring the relative amount of sediment suspended in water and to use this information to compare the sediments in a series of samples.

Materials: This list is for each student group.

1 photometer kit consisting of
- 1 - 90-mm x 90-mm x 150-mm block of wood with predrilled holes
- 1 - 15-mm-diameter x 7-mm-thick cadmium sulfide photocell
- 1 - 20-mm x 40-mm length of green or yellow cellophane
- 1 - ohmmeter with test leads
- 1 - 2-in. strip of 3/4-in.-wide black vinyl electrical tape
- 2 - thumb tacks
- 1 - light source with 60-watt bulb

6 - 15-mm-diameter x 125-mm-long test tubes
1 - test tube rack
1 - 20-cc (approximately) sample of dried fine sand
1 - 20-cc (approximately) sample of dried fine soil
1 - 5-cc (approximately) dried sediment sample marked South Slough #1
1 - 5-cc (approximately) dried sediment sample marked South Slough #2
1 - sheet of millimeter divided linear graph paper per student
1 - glass marking pencil or 6 labels
1 - 1/4-teaspoon measure
1 - light source with 60-watt bulb

Introduction:

Most sediment is carried into an estuary by the ocean and by rivers or streams. The size of the particles suspended in water depends on the speed of the current. List below the maximum sediment size (small, medium, large) that can be held in suspension by each class of current speed given.

Current Speed	Maximum Sediment Size
Fast	____________
Moderate	____________
Slow	____________

In an estuary such as Coos Bay, we find different combinations of sediment particle sizes in different parts of the bottom of the estuary. It is important to have a general idea of the composition of the sediments in an area because the type of sediment determines to a large degree the environmental conditions found there. These conditions, in turn, have a strong influence on the types of organisms found there.

In this lab you will be constructing a simple instrument to measure the sediments suspended in water. Using the instrument, you will then develop a set of standard curves and use those curves to analyze two sediment samples from the South Slough fo the Coos Bay Estuary.

Procedure: A. Constructing a simple photometer (refer to Figure 1)

1. Punch two small holes in the center of the electrical tape. Pass the wire leads from the photocell through the holes so that the back of the photocell is stuck to the tape.

2. Now tape the photocell into one end of the horizontal hole, which was drilled completely through the wooden block, so that the electrical leads protrude from the side of the block.

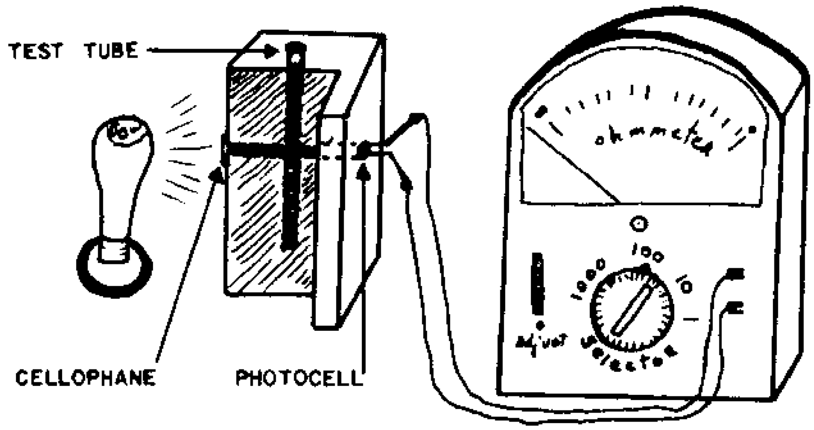
3. Over the end of the hole opposite the photocell, thumbtack into place the strip of cellophane so that the hole is completely covered. Do not block the hole with the heads of the thumbtacks.

4. If the ohmmeter does not have alligator clips on the test leads, secure one lead to one lead of the photocell by tape or some other means. There is no need to worry about getting an electrical shock.

5. Place the light source so it faces the cellophane-covered opening and is about 1 1/2 in. away from the block. This will allow the cellophane to stay cool while the sample is being illuminated.

6. This completes construction of your photometer. Remember that the amount of light passing through the cellophane and the sample and into the photocell must be constant in order to obtain good results. Be careful not to move the apparatus while you are using it. It may be a good idea to mark the location of the block and light source before beginning to analyze the samples.

    a. Light detecting electrical devices, such as the cadmium sulfide photocell used here, do not detect all colors of light with the same efficiency. What two colors of light are most efficiently detected by a cadmium sulfide photocell? ____________________.



THE PHOTOMETER IN USE

FIGURE I

Procedure: B. Preparing the sediment samples for analysis

1. Next you will develop a set of four standard curves with which your South Slough samples will be compared. Begin by marking one test tube "sand," one "sandy mud," one "muddy sand," and one "mud." If there are no other markings on the tubes, use a marking pencil to place a mark on the tube near the top so you can see the mark when the tube is in the photometer.

2. Into the labelled test tubes, place the following amounts of sand and dirt.

Test Tube Labelled	Number of 1/8 Teaspoon Measures	
	Sand	Dirt
Sand	3	0
Muddy sand	2	1
Sandy mud	1	2
Mud	0	3

3. Add enough tap water to each of the four labelled test tubes to bring the surface of the water to within about 15 millimeters of the top of the tube. Cap the tubes with your thumb or a stopper and invert the tubes three or four times to thoroughly mix the sediment. Now add enough water so that all tubes are filled to the same level and there is an air space present. These samples are ready for analysis.

4. Take two more test tubes and mark one "South Slough #1" and the other "South Slough #2." Into the first tube add three 1/8-teaspoon measures of South Slough #1 sample. Into the second tube add three 1/8-teaspoon measures of South Slough #2 sample.

5. Add water, invert, and fill both tubes with the same amount of water as you did before. These samples are now ready for analysis.

Procedure: C. Constructing standard curves and analyzing the South Slough samples

1. Begin by first setting the dial on the ohmmeter to the x100 setting. Now inspect the ohmmeter dial. One end of the dial reads "0." Take one lead of the ohmmeter and touch it to the second lead of the meter. The needle should swing to the "0" reading. If it does not, adjust the dial to read "0."

2. The other end of the dial will read ∞ (infinity). Your instructor will explain how to read the ohmmeter scale.

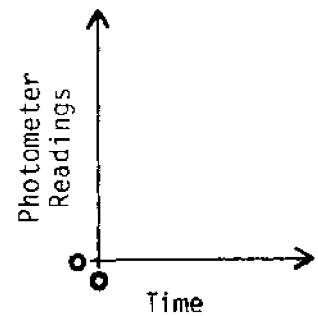
3. Begin the analysis by first noting the time, and call this "0" time. Then rapidly take each tube, cap it, invert it, and shake the tube to get the sediment off the bottom of the tube. Once that is done, invert the tube three or four times to thoroughly mix the sediment. Let the tubes set.

4. Five minutes after "0" time take each tube, place it into the photometer, and complete the circuit to the ohmmeter. The needle will rise from oo. Record the scale reading where the needle appears to stop moving. Try to get all the samples read within a 1 ½-minute time span. Just record the scale reading without multiplying x100 as the ohmmeter selector switch indicates. The data will not be difficult to graph if you do that. Also, do not shake the tubes.

5. Continue to take one series of readings at each five-minute interval until readings have been obtained over a 30-minute period. Record the data in the spaces provided below.

	Time Intervals (minutes)						
Sample Labelled	0	0+5	0+10	0+15	0+20	0+25	0+30
sand							
muddy sand							
sandy mud							
mud							
S. Slough #1							
S. Slough #2							

Procedure: D. Graphing the data and estimating the proportion of sand and mud in the South Slough samples



1. On your graph paper use the "x" axis to scale the time and the "y" axis to scale the photometer readings. (See example.)

2. First plot the data and draw the curves for the "sand," "sandy mud," "muddy sand," and "mud" samples. These curves are STANDARD CURVES against which you can compare the South Slough samples.

3. Now plot and draw the curves of the "South Slough #1" and "South Slough #2" samples. Draw these curves on the same graph as the STANDARD CURVES. By comparing the location of the South Slough curves at the 0+30-minute mark with the locations of the STANDARD CURVES at the same time, you can estimate the proportion of sand to mud in the South Slough samples.

   a. Briefly explain why the term BASELINE is sometimes applied to a standard curve.

   b. Place the South Slough samples in one of the categories below.

      sand ____________________

      muddy sand ____________________

      sandy mud ____________________

      mud ____________________

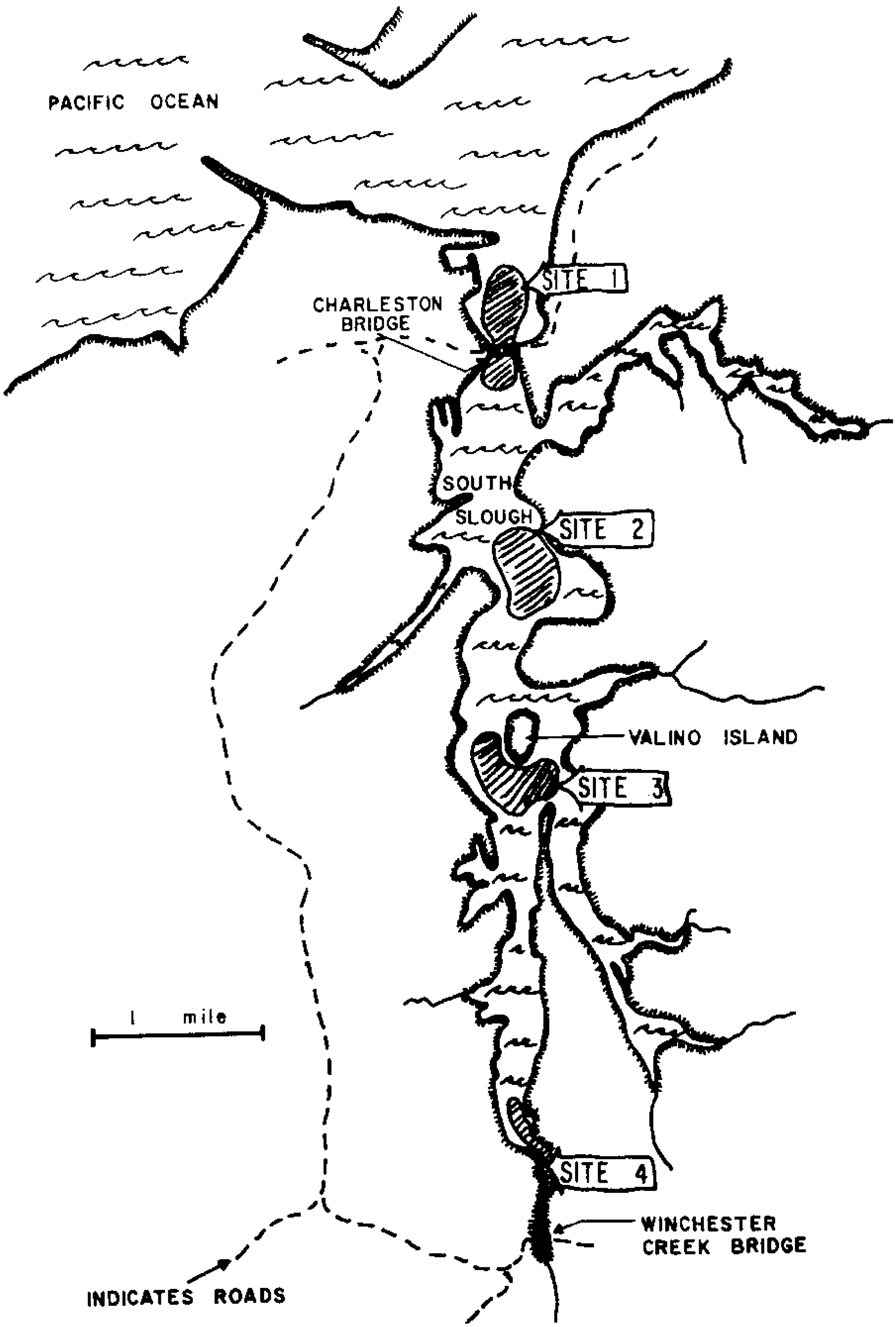
   c. Figure 2 is a sketch of the South Slough. Indicated on this sketch are four areas labelled as listed below. Using the information on sediment distribution in estuaries from the reading booklet, on the first line of the chart below fill in the boxes for the sites where you estimate the two South Slough samples came from. One line two, fill in the boxes for the sites where you estimate a "sand," "sandy mud," "muddy sand," and "mud" sample would most likely be gathered.

SITE 1	SITE 2	SITE 3	SITE 4

d. Briefly explain why the sedimentation curves are shaped the way they are.

Conclusion:

The sediments in an estuary form a gradient from large particles, sand, at one end and small particles, mud and clay, at the other end. These sediments determine the environmental conditions beneath the surface of the tideflats. A simple photometer can be constructed and used to analyze the sediment characteristics of tideflats.



A SKETCH OF SOUTH SLOUGH

FIGURE 2

LABORATORY 3

Name: ____________________

Instructor: ______________ Period: _____

Wasting Away: The Effects of Pollutants on Dissolved Oxygen

Purpose:

The purpose of this lab is to understand the effects of pollutants on the estuary. When you think of pollutants that enter the estuary, you may typically think of chemicals. Organic materials (materials derived from living organisms) that are disposed of in the estuary also can become pollutants. Through this experiment you will discover the effect of animal manure and fish and wood wastes on the dissolved oxygen in water.

Materials: This list is for each group of one to four students.

- 4 - 500-ml Erlenmeyer flasks
- 4 - single-hole stoppers for the flasks
- 4 - pieces of glass tubing bent at more than a 90° angle
- 1 - Hach kit for measuring dissolved oxygen
- 4 - tablespoons of fine mud from a stream, pond, or drainage ditch
- 1 - tablespoon each of animal manure, fish wastes, and SHREDDED WATERLOGGED wood
- 1 - sheet of graph paper per student
- Marking pens
- Glycerine
- Cotton

Lab Safety:

Follow all pertinent school district safety instructions. Eye goggles should be worn when using the chemicals found in the Hach kit. In case of contact with the skin, wash all affected areas thoroughly with soap and water. Obviously, DO NOT INGEST any of the materials found in the kit. SPECIFIC FIRST AID INSTRUCTIONS ARE FOUND ON EACH OF THE CHEMICAL CONTAINERS!

Introduction:

The estuary is an important nursery environment for many commercially harvested animals such as crabs, clams, fish, and shellfish. The larvae of many of these animals are planktonic; they live floating in the water eating each other as well as phytoplankton and other zooplankton. The reason that the estuary is such an ideal place for them to begin their lives or live year around is because of the large amounts of detritus (microscopic dead organic particles) found there. The detritus forms the basis of a food chain that supplies nutrients for the plankton to survive. Phytoplankton can grow at an incredible rate, thus providing a rich food source for juvenile fish and shellfish.

The estuary is also a tough environment for animals to cope with. Salinity and temperature change many times daily in any given area. To compound the problem, oxygen, which all animals need to live, can be scarce. Most bacteria also depend on dissolved oxygen. Since liquid oxygen can only exist at -183°C or lower, animals and bacteria that live in the water depend on oxygen dissolved in the water as molecules. Oxygen is commonly measured in milligrams of oxygen per liter of water (mg/l). Your Hach kit measures dissolved oxygen in mg/l.

Since oxygen is used by almost all animals and bacteria, the amount of dissolved oxygen present in an environment is extremely important. One factor that greatly influences the amount of oxygen present is the movement of oxygen-rich water into the estuary with the incoming tides and the removal of excess waste pollutants from the estuary by the outgoing tides. An estuary or portion of an estuary with a lot of waste pollutants dumped into it, like animal manure and fish and wood wastes, is a perfect place for bacteria to dominate. Bacteria reproduce very quickly, and the large populations that result consume a lot of dissolved oxygen. This reduces the dissolved oxygen available for animals, including commercially important ones, to survive.

Procedure: Day 1

1. Label the flasks Control, Manure, Fish, and Wood.

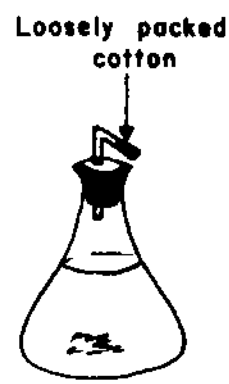
2. Fill each flask with 400-ml of tap water.

3. Add 1 tablespoon of wet, fine mud to each flask. The mud introduces bacteria to the water.

4. Stopper the flask, cover the hole in the stopper with your finger, and shake the flask to mix the mud with the water and to saturate the water with oxygen.

5. Leave the control flask as it is. Into the others put about 1 teaspoon of the contents indicated by the label.

6. Put the bent glass tubing into the stoppers as indicated in the diagram (at right). Use glycerine to lubricate the tubing. ALWAYS PROTECT YOUR HANDS BY GRIPPING THE TUBING WITH SEVERAL LAYERS OF PAPER TOWELING OR OTHER MATERIAL IN CASE THE TUBING BREAKS!



7. Using the Hach kit, measure the dissolved oxygen in the control flask. SEE SPECIAL NOTES BELOW REGARDING DISSOLVED OXYGEN TESTS! Mark the amount of dissolved oxygen on the graph sheets.

8. Now test for dissolved oxygen in the other three flasks.

Procedure: Day 2, 3, 4

1. You will be measuring and recording the amount of dissolved oxygen in each flask once each day for the next three days.

Special Notes on Measuring Dissolved Oxygen Using the Hach Kits

1. Follow the instructions found in your Hach kit CAREFULLY to obtain accurate results.
2. Make sure that all glassware is thoroughly washed between tests.
3. DO NOT fill the dissolved oxygen bottle two or three times with your sample. Fill it only once with the sample you are testing. (You will not have enough water to do the experiment if you use the repeated fillings.)
4. Be as exact as you possibly can when doing the titration (using the eye-dropper to drop the PAO--phenylarsine oxide--solution into the tube).
5. AVOID SHAKING, JIGGLING, AND MIXING OXYGEN INTO THE FLASKS WHEN POURING OR HANDLING THEIR CONTENTS!

Discussion Questions:

1. a. Which organic material caused the highest consumption of dissolved oxygen in your experiment?

   ____

   b. Which caused the least consumption of dissolved oxygen?

   ____

2. What do you think is the most likely explanation for the difference in consumption of dissolved oxygen you observed?

   ____

   ____

3. Name one method that could be used to prevent each of the organic materials you tested from entering the estuary?

   ____

   ____

   ____

Conclusion:

From this experiment we have been able to see the effects of various organic pollutants on dissolved oxygen. We have seen that the bacteria feed on organic pollutants. The growth of the bacteria initially requires the consumption of oxygen which lowers the amount of dissolved oxygen in the water. Attached to this lab is a newspaper article concerning an experiment to find new ways of disposing of fish wastes. Also attached to this lab is a letter stating some concerns the National Marine Fisheries Service have about that experiment. Read these over, keeping in mind the experiment you just conducted.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
7600 Sand Point Way N.E.
BIN C15700
Seattle, WA 98115

F/NWR5:JWW

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SO. SLOUGH SANCTUARY

Mr. William H. Young
Director,
Department of Environmental Quality
P.O. Box 1760
Portland, Oregon 97207

Dear Mr. Young:

Thank you for providing us with the opportunity to review and comment on two draft proposals for general permits under the National Pollution Discharge Elimination System (NPDES) which we received from Mr. Baton of the Water Quality Division. These proposals relate to (1) adequately treated discharges from seafood processing facilties and (2) disposal of waste water from gravel mining and/or processing facilities.

We have no comments at this time regarding the disposal of waste water from gravel mining and/or processing facilities. The comments that follow relate to a general permit for the discharge of adequately treated seafood processing wastes and a specific NPDES permit proposed for the Oregon Department of Fish and Wildlife.

GENERAL PERMIT

General Comments

It is generally recognized that there is a legitimate concern with the disposal of seafood processing wastes along the west coast. We deduced from the information provided that the proposal for a general permit does not constitute a reduction in your agency's level of concern with such waste disposal, but is merely a proposal to streamline the NPDES permit process. This being the case, we would like to know what benefits would accrue to the seafood processor by issuance of a general permit. Does your agency expect a general permit to result in a lowering of water quality through the discharge of more wastes than would be provided for if individual permits continued to be a requirement? We support efforts to address the disposal of processing wastes so long as water quality required by aquatic organisms is not impaired. Reduced water quality in estuaries, especially reduced dissolved oxygen levels and bacterial pollution, could impact fish and shellfish resources, including clam resources and commercial oyster beds.

If this general permit system is implemented, we suggest that it be evaluated periodically to determine if there has been any significant negative impact on water quality in the respective estuaries. This would is especially important if monitoring of processing plants or other discharges would be less frequent under a general permit.

Specific Comments

Schedule A: A mixing zone has been identified in the proposal as an area not to extend beyond a radius of 30 meters from the point of discharge, and is a designated area of a receiving water where waste waters and receiving waters mix and water quality criteria do not need to be met. We do not support the exemption of areas around a discharge from water quality criteria if the discharge is in very shallow or poorly flushed waters, or in areas of fish (e.g. herring) spawning, in areas having high clam densities, etc. These factors and communities are relatively common near shorelines in Oregon estuaries. For this reason we suggest mixing zone water quality exemptions only in deep waters and areas where rapid flushing is documented. Monitoring should be designed to assure proper compliance.

We suggest that mixing zone water quality exemptions not be allowed where discharge points would be in areas designated in local estuary plans as natural management units, or in estuaries designated by the State (through the Oregon Coastal Zone Management Program) as natural estuaries. Otherwise, a 30-meter mixing zone radius would surrender from 0.3 to 0.7 acres per discharge site (depending upon the distance from shore) to deregulation. This is not acceptable in natural estuarine areas.

Paragraph three describes a bypass allowance of the facility treatment process if excessive storm drainage or runoff would damage the facility. This language seems inappropriate for seafood processing plants although it may be appropriate for other water treatment facilities (e.g., sewage treatment facilities).

NPDES PERMIT FOR THE OREGON DEPARTMENT OF FISH AND WILDLIFE

We support the general concept proposed by the Oregon Department of Fish and Wildlife of enhancing fisheries through the introduction of organic matter to bodies of water. Our major concern with the subject permit is that it lacks sufficient detail to allow a critical evaluation of the proposal's environmental impacts. For example, since the draft NPDES permit does not indicate how many outfalls will be used or their locations (except as "various"), we cannot determine whether any are proposed in natural management units, in poorly flushed areas, etc.

It is not clear what level of treatment, if any, is proposed prior to disposal. The public notice merely lists "shrimp and crab shells and fish carcasses" as the wastes to be discharged. Will there be any pretreatment or residue size requirements?

The monitoring requirements do not appear adequate. Neither underwater observations nor a record of quantities deposited will indicate whether there are violations of several Water Quality Standards as adopted in OAR 340 Division 41. Without requiring the monitoring of dissolved oxygen, bacterial pollution, etc., it is not evident how violations of standards would be detected. Since there is no requirement to monitor such parameters there may be limited value in citing these standards in Schedule A, "Discharge Limitations of Permit." Are standard water quality parameters routinely monitored at existing seafood waste outfalls?

It would be useful to document the value of seafood processing wastes in enhancing local fisheries. However, "periodic underwater observations" may not provide a sufficient basis for judging whether fisheries have been enhanced. Ideally, a more extensive and quantitative approach to measuring the benefits of the release of seafood wastes should be used. If this is not feasible, an exceptionally careful interpretation of the data acquired by observations will be necessary.

If your staff would like to discuss our concerns, you may wish to direct their inquiries to personnel in our Environmental Assessment Branch: Dr. Jacqueline Wyland or Mr. James Bybee. They are in our Portland office and may be reached at 230-5432 and 5427, respectively.

Sincerely yours,

Thomas E. Kruse

for H. A. Larkins
Regional Director

cc: Jim Haas, Oregon Department of Fish & Wildlife

Fish waste at Winchester Bay

Experiment launched

By JOHN KIRKLAND
Staff Writer

WINCHESTER BAY — What began two years ago as an idea to eliminate a smelly problem was transformed Monday into action when hundreds of pounds of unusable fish parts were ground and dumped into the Umpqua River estuary.

Although the fish parts were trucked in Sunday from a processing plant in Bandon, the project is hoped to become a way in which Winchester Bay processors can get rid of processing byproducts without having to take them to a Douglas County dump.

The Port of Umpqua last year declared an emergency after Douglas County and Department of Environmental Quality officials informed the processors they could no longer use a Reedsport landfill.

The emergency prompted port officials to study the prospect of disposing the fish garbage into the estuary, where it would act as a nutrient for marine life.

Port Commissioner Merv Cloe said the project, being performed at Inner Tidal Seafoods, is still in the experimental stage. Biologists from the Oregon Deparmtne of Fish and Wildlife were on hand in Winchester Bay Monday to examine the disposal system for possible problems.

"We're trying to gear up so we can handle a lot of volume. I hope the assessment will prove that there are no problems with the estuary," said Cloe.

Much of the actual work time at the Winchester Bay processing plant Monday was taken up with working out bugs in the system, including repairing a faulty pump.

Port officials last fall approved the spending of $50,000 from a bond sale to buy equipment needed for studies of the fish waste proposal.

Preliminary studies for the project's permits were performed by port commissioner and biology teacher Bill Karcher and ODFW biologist John Johnson.

Original plans were to dry the fish waste, but Monday the material was ground and diluted with water before being pumped into the estuary.

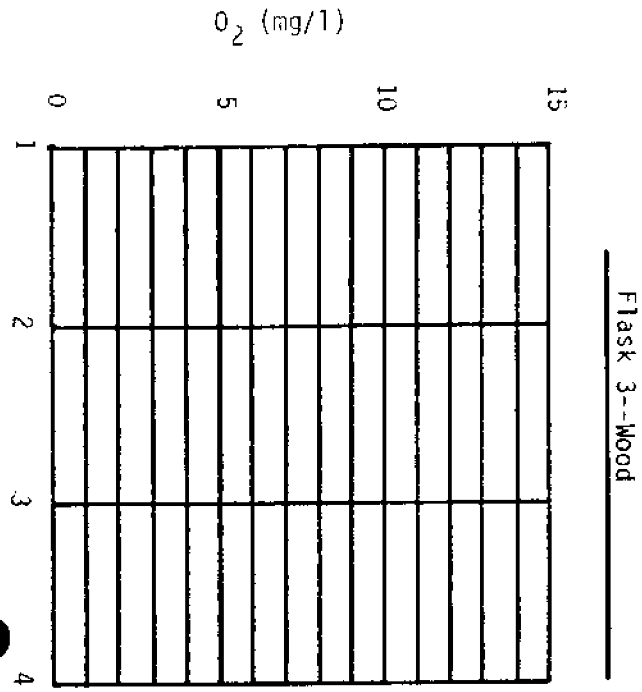
Cloe said fish processors in Bandon are considering using a similar method in Coos County.

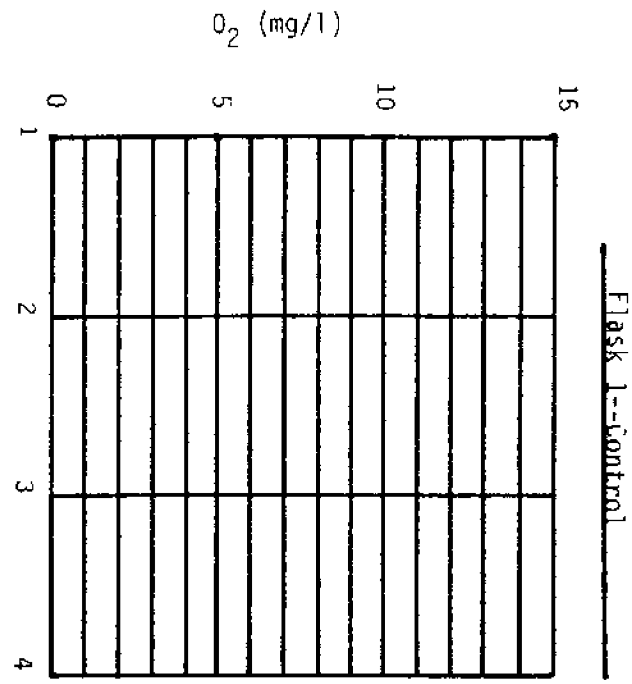
Bob Wellman, an employee at Inner Tidal Seafoods in Winchester Bay, lends a hand with a fish waste disposal project launched yesterday. The project is designed to eliminate a dumping problem at a Douglas County landfill by sending unusable fish parts from processing plants into the Umpqua River estuary instead of to the dump. The project is still in the experimental stage, according to a Port of Umpqua official. — World photo by John Kirkland.

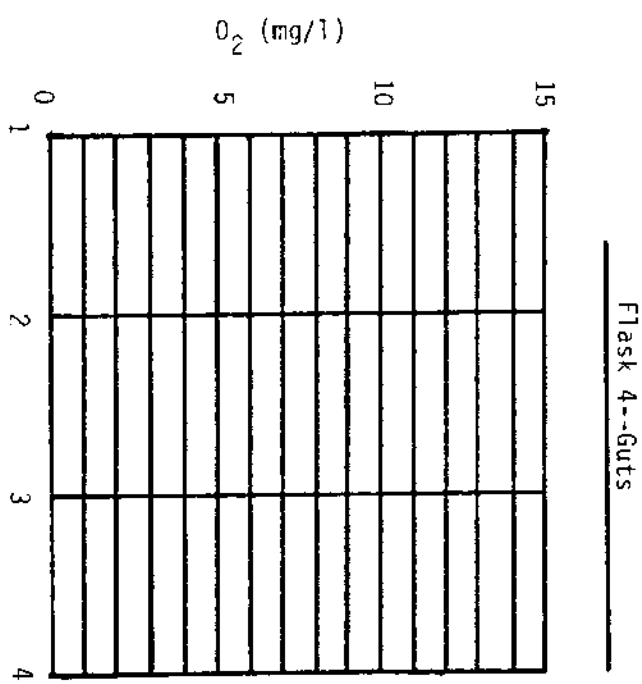
Laboratory 3

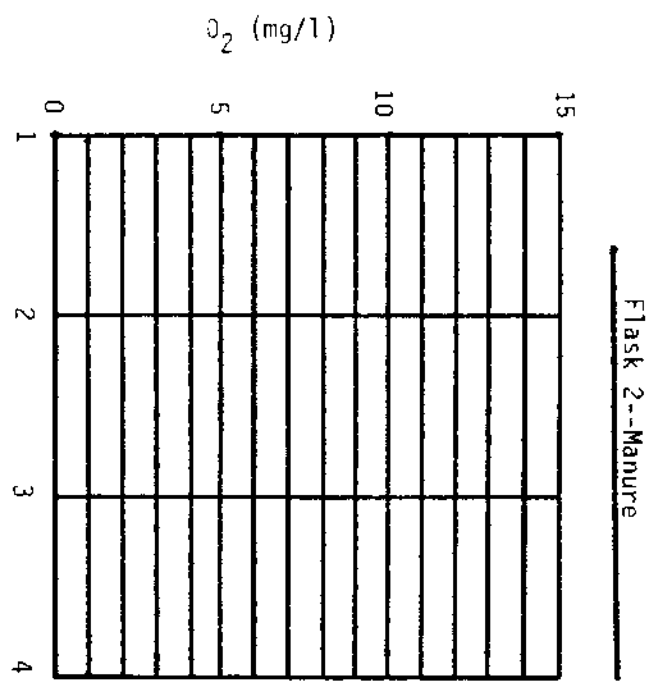
	Date
Day 1	
Day 2	
Day 3	
Day 4	

Measure the d.o. in each flask every day for four consecutive days and record the data.









LABORATORY 4

Name: ______________________

Instructor: ____________ Period: ____

The Phyto and Zoo of Plankton

Purpose:

To observe the different organisms that live part or all of their lives as plankton and to watch the changes that take place over time in a plankton community.

Materials: This list is for every six students.

1 - liter of water from South Slough
1 - plankton sample marked "live"
1 - plankton sample marked "preserved"
1 - 50-ml beaker
3 - dissecting microscopes (1 per pair of students)
3 - compound microscopes (1 per pair of students)
Microscope lights
Regular slides
Supply of 22-mm-square cover slips
3 - 150-mm-long test tubes with corks
Eye droppers
6 - 9-cm-diameter petri dishes
3 - 9-cm-square transparent grid marked off in 1-cm-square cells
3 - 9-cm-square piece of black construction paper
Scotch tape
"Protoslo" or glycerin
(There should also be a sample of living plankton for the whole class to use for obtaining live specimens for observation.)

Introduction:

Although the detritus is an important source of energy in an estuary, there is also a very substantial contribution by the plankton. "Plankton" is a term used to describe the small microscopic plants and animals that float in the water. Some lead a wandering lifestyle, drifting with the currents, living only as deep as light can penetrate. Other plankton live on the surface of the mud and other surfaces such as the leaves of eelgrass. The phytoplankton consist of microscopic plants. Diatoms are one example of phytoplankton. Zooplankton (animal plankton) eat the phytoplankton and each other. The zooplankton are in turn eaten by larger animals like shrimp, clams, and fish. Most of the larger animals that eat plankton do so by filtering them out of the water. For this reason they are called filter feeders.

Procedure: (First lab period)

1. Pour the sample of living plankton your group collected into a 50-ml beaker.

2. Label the beaker with the same information as that on the field collection bottle.

3. Place the sample in a refrigerator (NOT A FREEZER). Cover the beaker with a loose-fitting cover, like the top of a petri dish. Samples can be kept satisfactorily on ice as long as there is enough ice or ice water present to keep the samples cool.

4. Now take a 0.5- to 1-ml sample from the class live sample, place it in a petri dish, and add 9-ml of South Slough water. Observe the plankton in this sample with a dissecting microscope.

   a. Look for different forms of locomotion such as the jerky swimming motions of copepods.

   b. Look for various feeding activities.

   c. Look for various species or types of plankton. Compare the specimens you have with the Identification Charts included with this lab. Draw examples of all of the various zooplankton and phytoplankton you can find.

   d. Compare the relative sizes of zooplankton and phytoplankton.

5. To see structural details of the specimens, place a sample in a drop of water on a flat slide and add a drop of protoslo or glycerin. Place a coverslip on the slide. If you have added too much fluid, remove some by drawing it from beneath the slide using a piece of tissue or other absorbant paper. Place the slide on a compount microscope and use the lowest power of magnification to make your observations. Keep the lighting at an intermediate level of brightness. Ask your instructor to assist you if you have difficulty making these observations.

Procedure: (Second lab period)

1. Take the plankton sample you preserved in the field and add 12 ml of South Slough water to it. Mix the sample thoroughly by inverting the sample container several times. What is the total sample volume?

   ____

2. Use a 10-ml graduated cylinder to divide the sample into thirds. Pour each subsample into a clean 9-cm-diamaeter petri dish. Each pair of students will have their own subsample. What is the subsample volume?

   ____

3. Each pair of students can now prepare their sample for analysis. Tape a 9 x 9-cm-square clear grid to a piece of black construction paper the same size as the grid. Place the grid on the dissecting microscope stage.

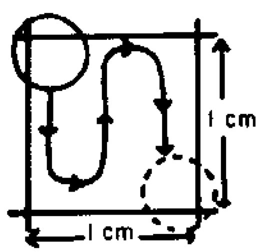
4. Center the petri dish containing the sample on the grid. Distribute the sample evenly over the bottom of the dish by gently shaking the sample first side to side and then back and forth. Do not swirl the dish because that only concentrates the plankton in the center of the dish.

5. The grid divides the petri dish into square-centimeter cells. The surface area of the bottom of the dish is determined by the formula $SA = \pi r^2$, where SA = surface area in square centimeters, π = 3.14, and r = the radius of the dish in centimeters.

   a. What is the surface area of the bottom of the dish? __________

   b. What proportion of the total surface area of the bottom of the dish is represented by each square-centimeter cell? __________

6. Now each pair of students will estimate the concentration of plankton in the South Slough waters on the day the samples were collected. To do this, each student will count all of the plankton in one square centimeter. Each student should count the specimens in a different square. Do the counts by centering the square to be counted in the field of view, set the microscope to the highest level of magnification, and then move the dish until the top left corner of the square is visible in the field of view. At that starting point, slowly move the dish so that you can scan all of the area in the cell. As diagrammed below, keep a count of all of the specimens you see. Keep the area of overlap between fields of view as small as possible to prevent counting the same specimens twice, and if you cannot identify some specimens by name, use a sketch of them or give them a number. Each student pair will have to agree on the identification of each type of plankton present.



A diagram showing the pattern to follow when counting the specimens in each one-centimeter-square area.

7. After each student has counted all of the plankton in their cell, determine the average number of each type of plankton per cell and list those numbers on the attached worksheet.

8. Now estimate the total number of each type of plankton present in the dish and record this on the worksheet. To do this, divide the average number of each type of plankton by the proportion of surface area represented by each cell you calculated in item 5, above.

9. Next, estimate the number of each type of plankton in the original field sample. Remember that the original sample was first split into halves and then further subdivided into thirds. Therefore, to estimate the number of each type in the original sample, multiply the estimated total in the dish by six and record that data.

10. The last step is to estimate the concentration of plankton in the waters of South Slough at the time of sampling. To do that, divide the estimated total number in the original sample by the volume of water filtered through the plankton net. Record that data for each type of plankton.

11. Now take the sample of living plankton you previously set aside. Preserve the sample by adding alcohol as you did in the field. Add 12 ml of South Slough water, mix, and subdivide this sample, as before.

12. Now follow steps 3-10 above. Record all of the data on the worksheet as before.

13. Compare the data from the sample preserved immediately after sampling. What major differences are there, and what is the most likely cause or causes of these differences?

PLANKTON DATA SHEETS

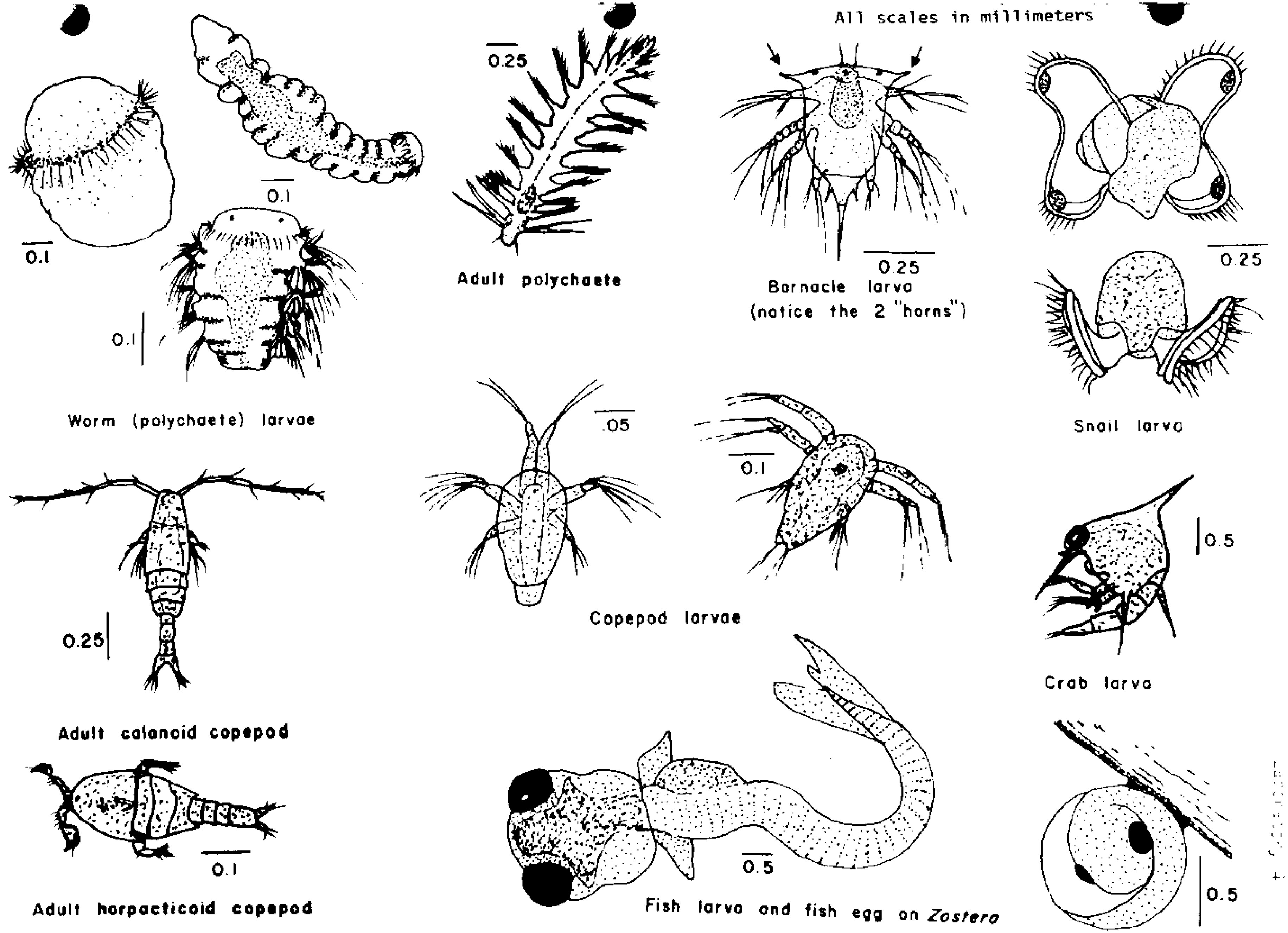
Field Preserved Sample

Specimen	Average no. per sq cm	Estimated Total no. in the dish	Estimated Total in original smpl.	Concentration (in no./l)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PLANKTON DATA SHEETS

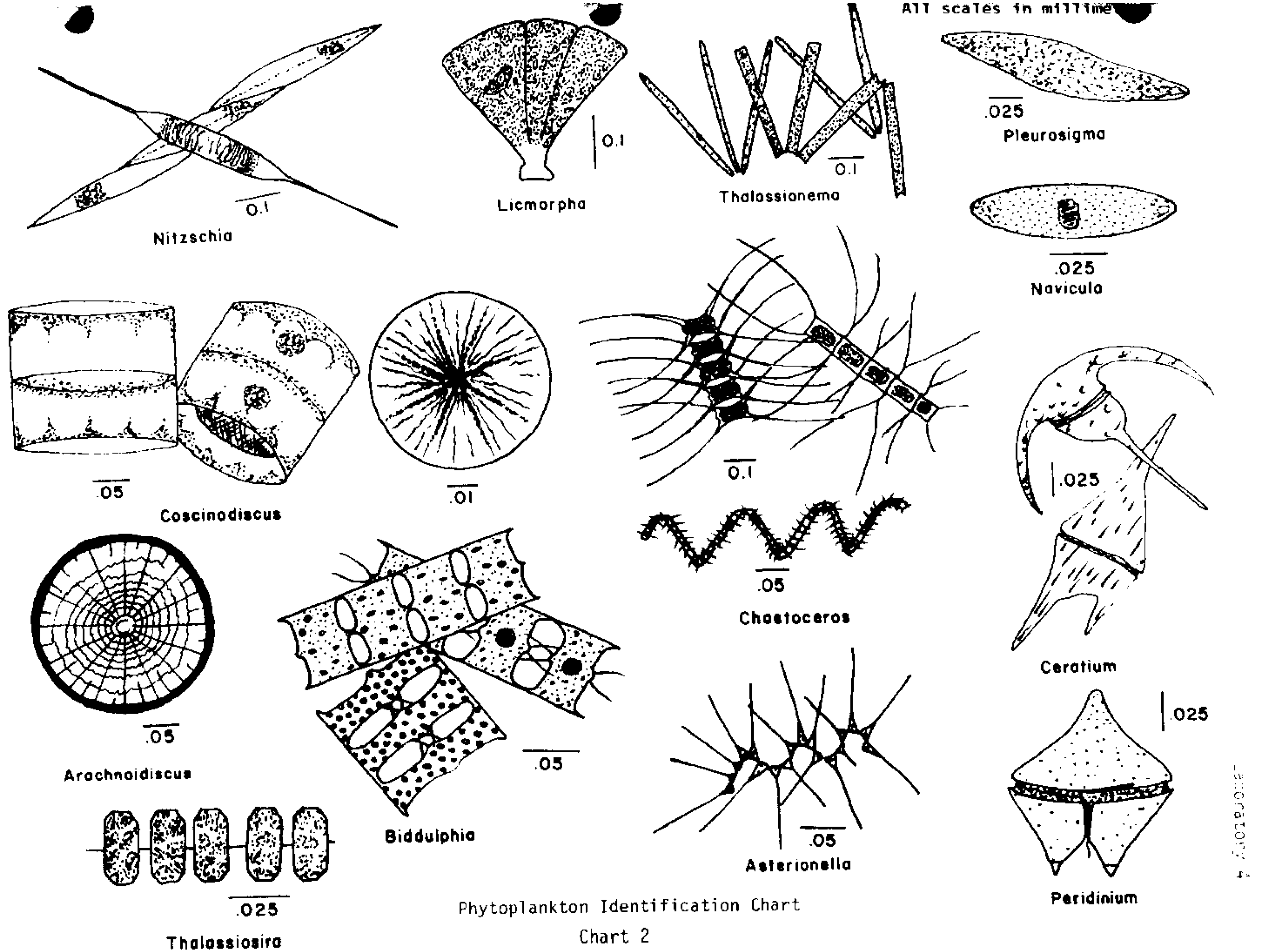
Stored Preserved Sample

Specimen	Average no. per sq cm	Estimated Total no. in the dish	Estimated Total in original smpl.	Concentration (in no./l)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				



Zooplankton Identification Chart

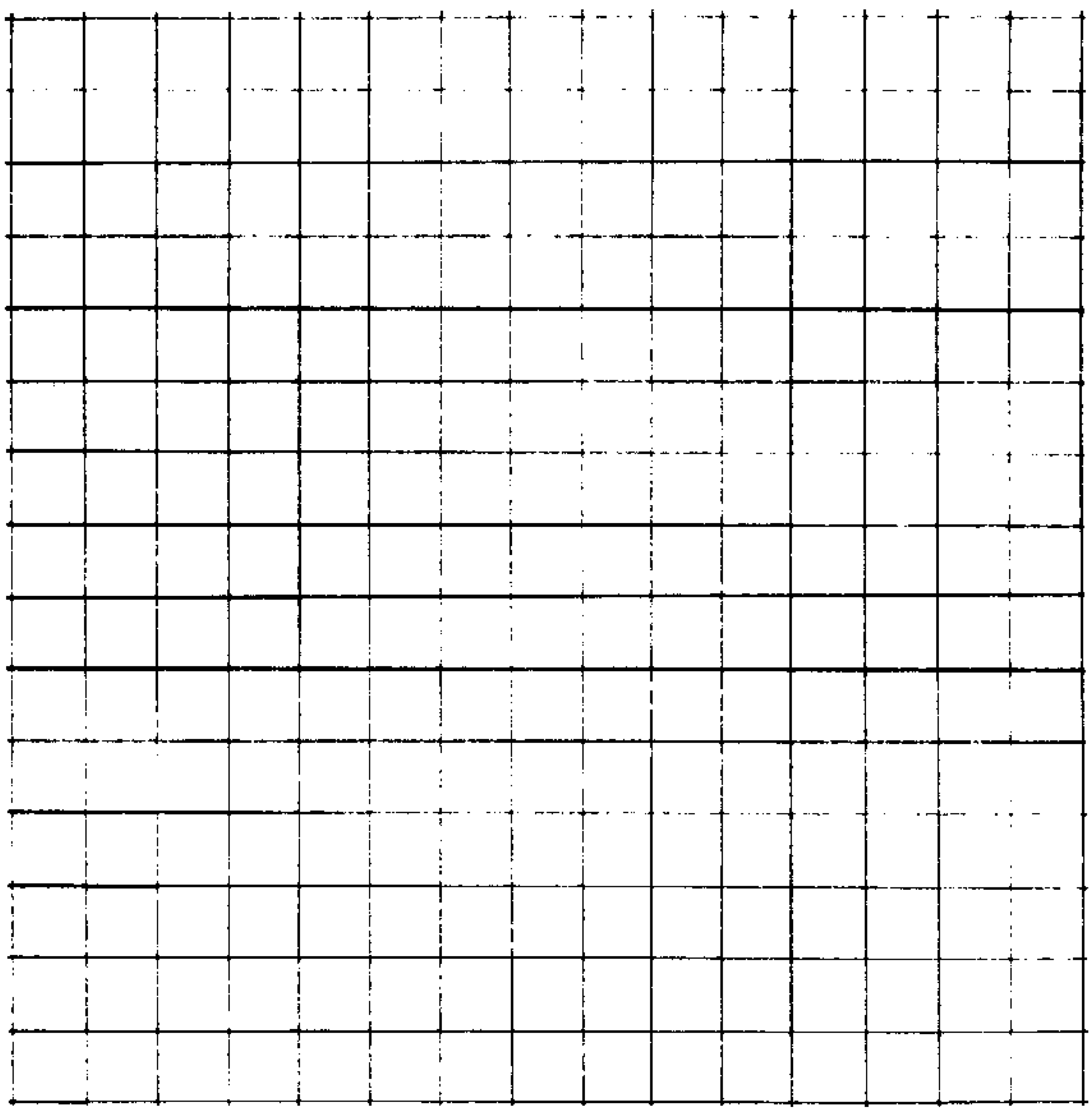
Chart 1



Phytoplankton Identification Chart

Chart 2

Grid master to reproduce on transparency for plankton counting.



LABORATORY 5

Name________________________________

Instructor:________________ Period:____

The Consumer Connection: Food Webs of an Estuary

Purpose:

In this lab you will explore how living things depend on each other for food. This mutual food dependency, called a food web, is a delicate one. If disturbed, a whole ecosystem can change drastically.

Materials: Paper
Pencil
Notes from field trip (optional)

Introduction:

Living things have many problems staying alive in a mud flat. They must be able to keep silt and clay from clogging their breathing structures and suffocating them. They must be able to live in an environment with little or no molecular oxygen present. And because of the lack of oxygen, the toxic gas hydrogen sulfide is present and mud flat animals must learn to cope with that factor. Because of these factors the mud flat often has low diversity. Diversity is a measure of the number of different kinds of organisms that live in an area. Abundance is a measure of how many of one kind of organism exist in an area. Mud flats do not have very many different kinds of animals, but there are a lot of those that do live there. Mud flats have low diversity and high abundance.

High abundance is possible because the estuary is a very productive environment. Detritus in the freshwater streams and rivers, and in the ocean, is carried into the estuary and add a lot of food to the estuary ecosystem.

This detritus is a food source for animals, some of which filter the water while others suck up the mud to get the detritus. Detritus is also broken down by bacteria and fungi into its chemical components: molecules made up of nitrogen, carbon, oxygen, and hydrogen; and elements such as calcium, magnesium, iron, and trace metals. Because of the warm, nutrient-rich water, the phytoplankton form the base of one estuary food chain. Consequently, the mud flat animals which can survive the stresses imposed by physical factors find an abundance of food in the forms of detritus and phytoplankton.

I. Food Web Levels

A. Primary Producers:

There are very few plants that cannot use sunlight, nitrogen, and other nutrients and make sugar by the process of photosynthesis. Oxygen is given off as a waste product. All other types of organisms must consume their food. Plants are their own food factories. Plants are called primary producers. Primary meaning first, because it is through them that energy first enters an ecosystem, and they are called producers because they produce food.

1. List three estuarine primary producers. (Refer to the reading booklet.)

____

____

____

B. Primary Consumers:

Primary consumers are animals that consume plants. They are the first level of consumers but the second level of a food chain. A group of organisms that serve as food for each other form a food chain. All of the food chains in an ecosystem form a food web.

2. What is a consumer? ______________________________

____

3. Name two sources of plant materials for primary consumers.

____

C. Secondary Consumers:

Secondary means second, and these consumers are animals that eat the primary consumers. They are the second consumer level and the third level of a food chain.

4. Name one type of secondary consumer from either the mud flat, open channel, or salt marsh.

____

D. Tertiary Consumers:

These animals eat the secondary consumers (tertiary means third) and there usually are not many of these in any one food chain.

5. Write down an estuarine food chain consisting of one type of primary producer, one type of primary consumer, one type of secondary consumer, and one type of tertiary consumer.

____

____

E. Decomposers:

Bacteria and fungi are decomposers. Decomposers break dead material down into its chemical components which will be recycled by the plants back into food.

6. What is the term given to the chemical components produced by decomposers?
____

II. The Rocky Intertidal Food Web

Outlined in figure 1 is a partial food chain of the rocky intertidal ecosystem on the Oregon coast. The arrows point in the direction of energy flow. Energy enters the food chain from the sun through the plants and then it flows upward through the chain. A food chain is actually very inefficient. Only about 10 percent of the biomass (weight of animal and plant matter) of a lower level is converted to biomass in the next higher level. (See figure 2.) To determine the amount of biomass in each level of a food chain you need to multiply the amount of biomass in the next level up the chain.

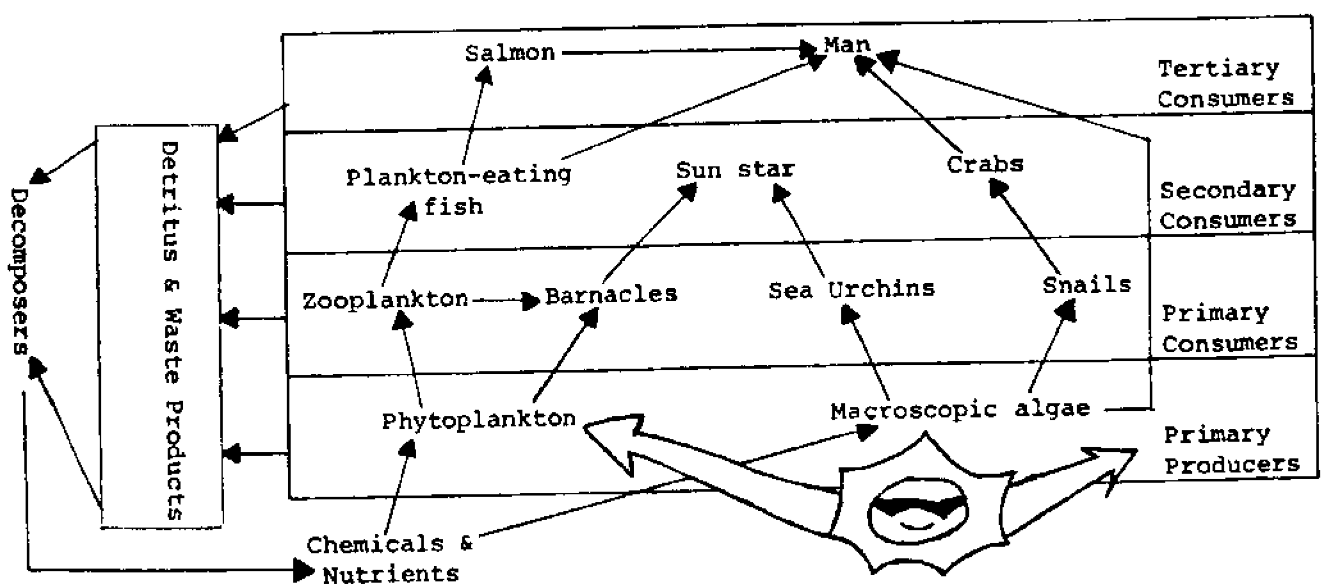


Figure 1. A partial food web found in the rocky intertidal ecosystem along the Oregon coast.

7. Let's start out with 1000 grams of biomass in the primary producer level. Calculate the amount of biomass at each higher level assuming a 10 percent conversion rate.

tertiary consumer level ----- gms

secondary consumer level ---- gms

primary consumer level ------ gms

primary producer level ------ gms

8. Now subtract the amount of biomass you calculated in the tertiary level from the 1000 gms in the primary producer level. Where did the _______ gms of biomass go?

____

____

9. Construct a figure showing the relative volumes of biomass at each level. To do this, start with the primary producer level of 1000 gms. Determine the square root of 1000 to two decimal places, or 31.62. Now draw a square 31.62 mm on a side. This makes a square 1000 sq. mm in area. Now determine the square root of the biomass you calculated for each of the other levels. Draw a square for each level as you did for the primary producer level. This time, though, draw the squares on top of the previous square to form a stack of squares forming a crude triangle. Beside the primary producer square draw a square representing the biomass you calculated for question 8, using the same method as before. This gives you a visual comparison of the amount of biomass required at each level to support a food chain having a 10 percent transfer of energy into each higher level.

III. Your Own Food Chain

Groups of plants and animals from any habitat, such as a desert or forest, can be thought of as composing food chains. Below, write down a food chain you are familiar with. Start with one or more primary producers and finish up with at least one tertiary consumer.

IV. Estuaries: Feeding Habits of Estuarine Animals

A. Filter Feeders:

These animals filter zooplankton, phytoplankton, and detritus from the water. Some may filter out only a certain size of particle, while others filter out a wide variety of sizes.

B. Grazers (Herbivores):

There are basically three kinds of herbivores:

1. Ones that eat phytoplankton (an example is the zooplankton).
2. The "mowers"; animals that eat the diatoms that coat the mud and macroscopic (large) plants such as eelgrass and algae (examples are some species of snails).
3. The "nibblers"; animals that eat the macroscopic plants (examples are some species of birds).

C. Deposit Feeders:

These animals pass mud through their digestive tract to get the detritus, bacteria, and fungi from it. Many of these animals accept only a specific particle size, which effectively eliminates them from living in habitats where other particle sizes are found.

D. Scavengers:

Animals such as crabs, sculpins, and gulls are called scavengers; they eat anything that looks like food. Crabs can be specific to meat or plants, dead or alive. The gulls will consume either plant or animal matter.

E. Predators:

Predators kill and eat live animals. For example, birds that eat worms, shrimp, and fish; starfish that eat clams and barnacles; and fish that eat fish.

Attached to the back of this lab are three pages of lists of invertebrates, plants, birds, and fish associated with estuaries. Twenty-four names have been taken from these lists and reproduced below. In the spaces provided, indicate whether the organisms listed are filter feeders (A), primary producers (B), grazers (C), deposit feeders (D), scavengers (E), decomposers (F), or predators (G). Use the information provided in the lists or other parts of this lab to answer this question.

_____ 1. bacteria
_____ 2. barnacles
_____ 3. bent-nosed clams
_____ 4. black brants
_____ 5. blue mud shrimps
_____ 6. butter clams
_____ 7. Dungeness crabs
_____ 8. eelgrass
_____ 9. fungi
_____ 10. gaper clams
_____ 11. great blue herons
_____ 12. killdeers
_____ 13. lugworms
_____ 14. Oregon mud crabs
_____ 15. oysters
_____ 16. phytoplankton
_____ 17. pickleweed
_____ 18. ribbon worms
_____ 19. salt grass
_____ 20. sea stars
_____ 21. Sitka snails
_____ 22. starry flounders
_____ 23. western gulls
_____ 24. zooplankton

Also using the lists at the back of this lab, construct a food chain for an estuary. If you have previously made a field trip, include the estuarine organisms you saw.

V. Questions

A. Look at the intertidal food web in figure 1. Suppose that one year El Nino (a major warming of the waters of the northern Pacific Ocean) occurs. El Nino greatly reduces the amount of phytoplankton present. What does this do to the food chain?

B. If an organism has several sources of food available to it we say it is very versatile. List in descending order of versatility the organisms in the food chain of figure 1. Ignore the macroscopic algae and the phytoplankton.

1.
2.
3.
4.

C. Theoretically, a food chain with a large number of versatile organisms is more stable than a food chain with few versatile organisms. Why does that theory seem to make good sense?

Organisms: Their habitat requirements and tolerance

(1) sediment mixtures:
- s = sand
- ms = muddy sand
- sm = sandy mud
- m = mud

(2) salinity gradient: 1 — 2 — 3 — 4

1 ↓ fresh water; 4 ↓ sea water

(3) feeding strategies:
- D - deposit feeder
- F - filter feeder
- G - grazer
- S - scavenger
- P - predator

1. Invertebrates

Adults	Sediment mix (1)	Salinity (2)	Feeding Strategies and misc. (3)
lugworm	ms → sm	2 → 3	D
ribbon worm	under sea lettuce	3 → 4	S
Nephtys worm	ms → sm	1 → 4	D
red ghost shrimp	sm → ms	2 → 4	D
blue mud shrimp	m	2 → 4	F
Dungeness crab	in eelgrass beds/ s → m	3 → 4	S
purple shore crab	salt marsh-burrows	2 → 4	S
Oregon mud crab	salt marsh	2 → 4	S
pea crab	inside Gaper clam	2 → 4	S
Pista terebellid worm	sm → m	3 → 4	D
barnacles	rock	3 → 4	F
moss animals	rock and seaweed	2 → 4	F
heart cockle	ms/eelgrass	3 → 4	shallow F/burrower
gem clam	ms	3 → 4	shallow F/burrower
bent-nosed clam	ms → m	2 → 4	can withstand D/low oxygen
zooplankton	open water	1 → 4	G
soft-shelled clam	ms → sm	2	F
white sand clam	s	4	F
littleneck clam	protected ms	2 → 3	F
butter clam	gravel/ms	2 → 4	F
gaper clam	sm	2 → 4	F
bay mussel	rock	3 → 4	F
oyster	rock and cultivated on mud or sticks	2 → 4	F
sea star	rock	3 → 4	P
Sitka snail	salt marsh, pickleweed	2 → 3	G

2. Plants

	Salinity (2)	Habitat
huckleberry	dry land	land
salal	dry land	land
Sitka spruce	dry land	land
skunk cabbage	1	freshwater marsh
rushes	1	freshwater marsh
tufted hair grass	2→4	salt marsh (upper)
gumweed	2→3	salt marsh
salt grass	2→3	salt marsh
pickleweed	2→3	salt marsh
sea lettuce	2→4	tidal flats, rock
Zostera (eelgrass)	2→4	tidal flats, slow water
Endocladia (red algae)	2→4	below high tide, rock
Fucus	2→4	below high tide, rock
phytoplankton	2→4	open water

3. Birds

	Food
murre	fish
loon	fish
black oyster catchers	mussels
great blue heron	animals (ghost shrimp, fish, crabs)
common egret	animals (ghost shrimp, fish, crabs)
black brant	eelgrass
killdeer	soft invertebrates
long-billed curlew	soft invertebrates
western gull	anything

4. Fish*

	Salinity (2)	Food
redside shiner	1	fish eggs, copepods, insects
staghorn sculpin	2 → 4	anything
starry flounder	2 → 4	invertebrates, clam necks
striped bass	2 → 4	fish
shiner perch	2 → 4	invertebrates, zooplankton
juvenile salmon, trout	2 → 4	plankton
speckled sanddab	4	amphipods and copepods

* Remember, most of these fish can be found in the juvenile stage in an estuary as plankton eaters.

LABORATORY 6

Name:________________________________

Instructor:________________Period:____

Inefficiency Experts: Productivity in the Estuary

Purpose:

To compare the productivity of different ecosystems and to examine productivity with respect to the estuary.

Materials: Pencil
Previous lab, "The Consumer Connection," as a reference

Introduction:

Productivity is a measure of how much of something is made in a specified period of time. In an ecosystem the material being made is biomass. "Biomass" is the tissue and storage products, such as fat, composing living organisms. One way we can estimate the productivity of an ecosystem is to estimate the biomass present.

We can measure the biomass of an organism by weighing it alive or in the same condition it would be if it were alive. We call this its "wet weight." This is not a good measure because the water content of an organism changes from hour to hour and day to day. Wet weight is not very accurate. A better way is to measure the biomass of an organism after it is thoroughly dried out. This gives us the "dry weight." One problem with this method is that some substances are lost during drying but they are generally a very small fraction of the total biomass.

When we use biomass to estimate productivity, we're measuring "standing crop." Standing crop is the amount of biomass contained within a volume of water or an area of land at a given time.

Standing crop is a relatively easy but highly approximate measure of productivity. To see why this is so, remember that biomass refers to living organisms. There is also a large amount of detritus, dead and decomposing material, that is found. The detritus would not be included in a measure of standing crop even though it forms a large base of a food web. What we are actually interested in measuring is the amount of available energy. The available energy is the energy content of an organism or ecosystem.

One way to estimate the energy content is to estimate the biomass and other food sources, such as detritus, present and convert this to a measure of energy called a "calorie." A calorie is defined as the amount of heat required to raise the temperature of one gram of water one degree centigrade. We can estimate the energy content of the primary consumers in an area over a given amount of time and estimate the energy content of the primary producers eaten by these consumers over the same length of time, and get an idea of the efficiency of the ecosystem. A common finding is that the efficiency of energy transfer between the links of a food web is 10 percent, as we saw in laboratory 5.

I. Standing Crop

1. Write down a definition of the term "biomass."

   ____

   ____

2. Write down a definition of the term "standing crop."

   ____

   ____

3. Estimate in pounds the standing crop in your classroom.

   ____

4. Are you using dry weight or wet weight?

   ____

5. Briefly describe how you would get the best possible estimate of the standing crop in a wheat field.

   ____

   ____

   ____

II. Calories

Today many people are diet conscious. People are concerned with the number of calories in a meal. A restaurant meal consists of the following:

2 cups of coffee
1 green salad (8 small lettuce leaves; 1 diced, medium sized tomato; 2 diced, small radishes; 3 cucumber slices; 1 tablespoon of blue cheese)
1 cup of clam chowder
1 15-oz baked salmon steak
1 medium sized baked potato
1 piece of pumpkin pie

6. Use the calorie tally chart attached to this laboratory and figure out the number of calories in this meal.

   ____

   ____

7. Look at the different portions that made up this meal. Which portion provides calories most efficiently and why?

____

____

____

8. Which portion provides calories least efficiently and why?

____

____

Let's compare biomass and calories as two ways of looking at energy content. First, look at the calorie tally sheet under "pork" and fill in the following blanks.

	Ounces	Calories	Calories/Ounces
pork chop	______	______	________
pork roast	______	______	________
pork sausage	______	______	________

Notice that the same type of meat, namely pork, can have a different energy content. If we were to use only biomass to determine energy content, we would miss the different energy content of these three kinds of pork.

Now use the calorie tally sheet to fill in the blanks below.

Fish	Ounces	Calories in 3 ounces
halibut	______	__________
mackerel	______	__________

Assume that the weight of halibut and mackerel given above is biomass. Also assume that there is a predator that eats both halibut and mackerel. This predator needs to consume at least 6200 calories a day to live.

9. What is the minimum number of ounces of halibut the predator would have to eat each day to live?

____

10. How many ounces of mackerel?

____

11. If the predator has both halibut and mackerel available to it, which fish should it hunt to be most efficient and why?

____

____

From the exercise above you can see that using calories to measure energy content is a very good way to compare the food value of different species and of different parts of the same organism.

III. Ecosystems

Plants produce biomass using the sun's energy. Any organisms that cannot do this must eat other organisms to produce biomass. As you saw in the lab about food webs, after the initial primary productivity, biomass is inefficiently used and only 10 percent of it can be converted to new biomass every time it passes from one organism to another.

A cow which initially weighs 100 lbs. eats a total of 10 lbs. of hay per lb. of body weight each year. At the end of four years the animal is slaughtered and 50 percent of the weight is used for food. About how many pounds of human biomass will result?

____

If this meat averages 986 calories per lb., (calculated from the value of veal on the calorie tally), how many calories will be incorporated into human biomass?

____

If this same four-year-old cow were a milk cow and produced an average of two gallons per day for three years, how many gallons of milk and calories of milk would be produced? Use the whole milk calorie tally figure and remember that there are 16 cups in a gallon!

____

If humans are estimated to incorporate 10 percent of the calories from milk into biomass, this will result in 560,640 calories of human biomass. Which part of the hay-cow-human ecosystem is more efficient?

____

We can see from this exercise that different parts of the same ecosystem have different efficiencies of energy transfer. When we say that about 10 percent of the energy is transferred between links in a food chain we are using a rule-of-thumb sometimes called the "10 percent rule." Of course, plants are the only primary producers and not all plants have the same efficiency of utilizing sunlight. Look at the chart below:

Ecosystem*	% of earth's surface	Total area in km^2**	Calories/year
open ocean	65.0%	326.0×10^6	32.6×10^{14}
estuaries & reefs	.4%	2.0×10^6	4.0×10^{14}
deserts & tundras	8.0%	40.0×10^6	$.8 \times 10^{14}$
coniferous forests	2.0%	10.0×10^6	3.0×10^{14}
tropical forests	8.0%	14.7×10^6	29.0×10^{14}
grasslands	8.4%	42.0×10^6	10.5×10^{14}
	TOTAL	434.7×10^6	79.9×10^{14}

* Not all ecosystems are included
** Area of earth's surface

Which ecosystem produces the most calories per year on a world-wide basis?

____

Which ecosystem produces the most calories per year on a square kilometer basis? (To calculate this, ignore the "$\times 10^{14}$" and "$\times 10^6$" exponents, and use the formula calories/year divided by total area equals calories/km^2/year $\times 10^8$).

	Calories/km^2/year
open ocean	________ $\times 10^8$
estuaries & reefs	________ $\times 10^8$
deserts & tundras	________ $\times 10^8$
coniferous forests	________ $\times 10^8$
tropical forests	________ $\times 10^8$
grasslands	________ $\times 10^8$

Conclusion

The thing to remember about estuaries is that much of the energy available is in the form of detritus. Even the filter feeders of the estuary are consuming large amounts of detritus suspended in the water. Sources of detritus include the animals and plants that live in the watershed and along the shores of the estuary. These organisms die and the organic material from them often gets washed into the estuary to become part of the food web.

To give you an example of how many organisms this detritus can support:

a. There can be as many as 400 cockles per square meter.

b. Up to 20,000 snails per square meter can be found in estuaries.

c. Up to 6,000 smaller clams, like the bent-nosed clam, can be packed together in every square meter of some estuaries.

Large numbers of secondary consumers, like fish, can therefore use the estuary and have high growth rates. This indicates that the energy content of estuarine organisms is high.

calorie tally

	Calories
Cheese	
American, process, 1 ounce	105
Blue, 1 ounce	105
Camembert, 1 ounce	84
Cheddar, 1-inch cube	70
Cottage, from skim milk, cream-style, 1 cup*	240
Cream cheese, 1 ounce	105
Parmesan, grated, 3 tablespoons	55
Swiss, 1 ounce	105
Cherries, canned (water-packed) tart, red, ½ cup	43
Fresh, sweet, ½ cup	40
Chicken	
Broiled, skinned and boned, 3 ounces	115
Fried, breast, ½	155
Fried, drumstick, 1	90
Chicken potpie, 1 individual (4¼-inch diameter)	535
Chili con carne with beans, canned, ½ cup	167
Chili sauce, 1 tablespoon	20
Chocolate syrup, thin-type, 1 tablespoon	50
Clams, canned, ½ cup in liquor	52
Cocoa (all milk), 1 cup	235
Coconut, shredded, dried, sweetened, 2 tablespoons	43
Coffee or tea	0
Cola, carbonated beverage, 1 cup	95
Coleslaw, on lettuce, ⅔ cup	68
Collards, cooked, 1 cup	55
Cookie, plain (3-inch diameter)	120
Corn, canned, whole kernel, 1 cup	170
Sweet, cooked, 1 ear (5x1¾-inch)	70
Corn syrup, 1 tablespoon	60
Crab meat, canned, flaked, ½ cup	85
Crackers	
Graham, 4 small or 2 medium squares	55
Oyster, 10	45
Rye wafers, crisp, 2 (1⅞x3½ inches)	45
Saltines, 2 (2-inch square)	35
Soda, 2 (2½-inch square)	50
Cranberry juice cocktail, canned, ½ cup	80
Cranberry sauce, sweetened, canned, 1 cup	405
Cream	
Half-and-half, 1 tablespoon	20
Heavy or whipping, 1 tablespoon	55
Light, 1 tablespoon	30
Whipped, unsweetened, 1 tablespoon	28
Cucumber, 6 slices (2x⅛ inch)	5
Custard, baked, 1 cup	285

D-F

	Calories
Dates, fresh and dried, pitted, 1 cup	490
Doughnut, cake type, 1	125
Eggs	
Fried, 1 medium	108
Omelet, plain, 2-egg	214
Poached, hard or soft cooked, 1	80
Scrambled with milk and butter, 1	110
Figs, canned, with syrup, 3 medium	84
Dried, 1 large	60
Fish	
Halibut, broiled, 3 ounces	155
Mackerel, broiled, 3 ounces	200
Ocean perch, breaded, fried, 3 ounces	195
Fish stick, breaded, cooked, 1	40
Frankfurter, cooked, 1	155
Fruit cocktail, canned, with syrup, 1 cup	195
Fruitcake, dark, 1 piece (2x2x½ inch)	115

G

	Calories
Gelatin dessert	
Fruit added, ready-to-serve, 1 cup	160
Plain, ready-to-serve, 1 cup	140
Gelatin, dry, unflavored, 1 tablespoon	35
Ginger ale, 1 cup	70
Grapefruit	
Canned, sections, white, with syrup, 1 cup	175
Fresh, pink, ½ medium	60
Fresh, white, ½ medium	55
Juice, canned, unsweetened, ½ cup	50
Juice, frozen, unsweetened, water added, ½ cup	50
Grapes	
Concord, fresh, 1 cup	65
Juice, canned, 1 cup	165
Seedless green or Tokay, fresh, 1 cup	95
Griddle cake, 1 (4-inch diameter)	60
Buckwheat, 1 (4-inch diameter)	55

H-J

	Calories
Ham, fully cooked, 3 ounces	245
Hard sauce, 2 tablespoons	97
Honey, strained, 1 tablespoon	65
Honeydew melon, ⅛ small (5-inch diameter)	33
Ice cream, vanilla, 1 slice (⅛ quart)	145
Ice milk, 1 cup	285
Jams, marmalade, preserves, 1 tablespoon	55
Jelly, 1 tablespoon	55

K-M

	Calories
Kale, cooked, 1 cup	30
Lamb, chops, broiled, 3 ounces	100
Leg roast, 3 ounces	235
Lemon, 1 medium	20
Juice, 1 tablespoon	5
Lemonade, frozen, sweetened, water added, 1 cup	110
Lettuce	
Boston, ¼ medium head	8
Iceberg, ¼ medium compact head	15
Leaves, 2 large or 4 small	10
Liverwurst, 1 slice (3-inch diameter, ¼-inch thick)	79
Lobster, canned, ½ cup	75
Luncheon meat	
Bologna, 1 thin slice (4-inch diameter)	86
Ham, boiled, 1 ounce	68
Salami, 1 slice (3½-inch diameter, ¼-inch thick)	130
Macaroni, cooked, ½ cup	78
Macaroni and cheese, baked, ½ cup	235
Malted milk, 1 cup	280
Maple syrup, 1 tablespoon	50
Marshmallows, 1 ounce	90
Meat loaf, beef and pork, 1 slice (4x3x⅜ inch)	264
Melba toast, 1 thin slice	15
Milk	
Buttermilk, 1 cup	90
Chocolate, drink, 1 cup	190
Condensed, sweetened, undiluted, ½ cup	490
Evaporated, undiluted, ½ cup	173
Skim, 1 cup	90
Whole, 1 cup	160
Molasses, light, 1 tablespoon	50
Muffin, corn, 1 (2¾-inch diameter)	150
Plain, 1 (2¾-inch diameter)	140
Mushrooms, canned, ½ cup	20

N-O

	Calories
Noodles, cooked, ½ cup	100
Nuts	
Almonds, dried, salted, unblanched, 12 to 15	95

	Calories
Nuts cont	
Brazil nuts, 4	97
Cashews, roasted, 6 to 8	88
Peanuts, roasted, shelled, chopped, 1 tablespoon	55
Pecans, chopped, 1 tablespoon	50
Walnuts, chopped, 1 tablespoon	50
Okra, cooked, 8 pods (3x⅝ inch)	25
Olives, green, 4 medium	15
Ripe, 3 small	15
Onions, cooked, ½ cup	40
Green, 6 small without tops	20
Orange, Navel, 1 medium (2⅘-inch diameter)	60
Orange juice, canned, unsweetened, 1 cup	120
Fresh, California, 1 cup	115
Frozen, water added, 1 cup	110
Oyster stew, 1 cup (3 to 4 oysters)	200
Oysters, raw, ½ cup (6 to 10 medium)	80

P

	Calories
Parsnips, cooked, ½ cup	50
Peaches	
Canned, 2 medium halves and 2 tablespoons syrup	90
Fresh, 1 medium	35
Frozen, 12-ounce package	300
Peanut butter, 1 tablespoon	95
Pears, canned, 2 medium halves and 2 tablespoons syrup	90
Fresh, 1 medium (3x2½-inch diameter)	100
Peas, green, cooked, 1 cup	115
Pepper, green, raw, 1 medium	15
Pickles, dill, 1 large (4x1¾ inch)	15
Sweet, 1 medium (2¾x¾ inch)	30
Pie, ⅙ of 9-inch pie	
Apple	345
Cherry	355
Custard	280
Lemon meringue	305
Mince	365
Pumpkin	275
Pimiento, canned, 1 medium	10
Pineapple, canned, 2 small or 1 large slice and 2 tablespoons juice	90
Fresh, diced, 1 cup	75
Juice, canned, 1 cup	135
Pizza, cheese, ⅛ of 14-inch pie	185
Plums, canned, 3 whole and 2 tablespoons juice	100
Fresh, 1 (2-inch diameter)	25
Popcorn, 1 cup	65
Pork	
Chop, cooked, 3½ ounces	250
Pork cont	
Roast, 3½ ounces	285
Sausage, cooked, links or patty, 3½ ounces	421
Spareribs, roasted, meat from 3 medium ribs	123
Potato chips, 10 medium	115
Potato salad, ½ cup	90
Potatoes	
Baked, 1 medium	90
Boiled, 1 medium	80
French fried, 10 medium	155
French fried, frozen, over-heated, 10 medium	125
Hash browned, ½ cup	229
Mashed with milk, 1 cup	125
Sweet, baked, 1 medium	155
Candied, 1 medium	295
Canned, 1 cup	235
Pretzels, 5 small sticks	20
Prunes, dried, cooked, unsweetened, 1 cup	295
Juice, canned, ½ cup	100
Pudding, vanilla, 1 cup	275
Pumpkin, canned, 1 cup	75

R

	Calories
Radishes, raw, 4 small	5
Raisins, dried, 1 cup	460
Raspberries, red, fresh, ½ cup	35
Frozen, 10-ounce package	275
Rhubarb, cooked, sweetened, 1 cup	385
Rice, cooked, ½ cup	93
Rolls	
Hamburger, 1 medium	89
Hard, 1 medium	160
Plain, 1 medium	115
Sweet, 1 medium	135
Rutabagas, cooked, diced, ½ cup	35

S

	Calories
Salad dressings	
Blue cheese, 1 tablespoon	80
Commercial, plain (mayonnaise type), 1 tablespoon	65
French, 1 tablespoon	60
Home-cooked, 1 tablespoon	30
Mayonnaise, 1 tablespoon	110
Thousand Island, 1 tablespoon	75
Salad oil, 1 tablespoon	125
Salmon, broiled or baked, 4 ounces	154
Canned, pink, 3 ounces	120
Sardines, canned in oil, 3 ounces	175
Sauerkraut, canned, 1 cup	45
Sherbet, orange, ½ cup	130
Shrimp, canned, 3 ounces	100
French fried, 3 ounces	191
Soup, canned, condensed, diluted with water unless specified otherwise	
Bean with pork, 1 cup	170
Beef bouillon, broth, consommé, 1 cup	30
Beef noodle, 1 cup	70
Chicken noodle, 1 cup	65
Clam chowder, Manhattan-style, 1 cup	85
Cream of asparagus, diluted with milk, 1 cup	140
Cream of celery, diluted with milk, 1 cup	166
Cream of mushroom, diluted with milk, 1 cup	211
Split-pea, 1 cup	145
Tomato, 1 cup	90
Vegetable with beef broth, 1 cup	80
Spaghetti, cooked, ½ cup	78
Spaghetti with meatballs in tomato sauce, homemade, 1 cup	335
Spanish rice, 1 cup	130
Spinach, cooked, 1 cup	40
Squash, summer, cooked, diced, 1 cup	30
Winter, baked, mashed, 1 cup	130
Strawberries, fresh, 1 cup	55
Frozen, 10-ounce package	310
Sugar	
Brown, firm-packed, 1 tablespoon	50
Confectioners', 1 tablespoon	30
Granulated, 1 tablespoon	45

T-Y

	Calories
Tangerine, 1 medium (2½-inch diameter)	40
Tartar sauce, 1 tablespoon	95
Tomatoes	
Canned, ½ cup	25
Fresh, 1 medium (2x2½ inch)	35
Juice, canned, 1 cup	45
Tuna, canned in oil, drained, 3 ounces	170
Turkey, roasted, 3 slices (3x2½x¼ inch)	200
Turnip greens, cooked, 1 cup	40
Turnips, cooked, diced, 1 cup	35
Veal, cutlet, broiled, 3 ounces	185
Roast, medium done, 3 ounces	230
Vinegar, 1 tablespoon	2
Waffle, 1 (5½x4½x½ inch)	210
Watermelon, 1 wedge (4x8 inch)	115
White sauce, medium, ½ cup	215
Yogurt, 1 cup	120

LABORATORY 7

Name: ______________________________

Instructor: ______________ Period: ______

Who, Where, and Why in an Estuary:

Predicting the Distribution of Plants and Animals

Purpose:

In this lab you will use much of what you have previously learned about estuaries. This lab will allow you to predict what plants and animals would be found in various areas of a fictional estuary.

Materials: Pencil
Reading book

Introduction:

By this time you should know that the estuary is very dynamic and a difficult place to study. It changes in salinity, sediment mixture, temperature, and other physical conditions from one location to another. By this time you should have a good idea how salinity and sediment mixture change with respect to distance from the open ocean.

In this lab you will use the attached charts labelled "Organisms: Their Habitat Requirements and Tolerances," to determine the habitat requirements of the organisms listed. Using the maps also attached to this lab, you will then fill in the blanks provided for each site and area listed with the appropriate information for estimated salinity, sediment mixture, and organisms you would expect to find there.

As you will notice, there is a series of drawings attached to this lab. The first drawing is of a fictional estuary in which four study sites have been identified. The next eight pages include scale drawings of the study sites A, B, C, and D. The drawings show the water level at a tidal elevation of -2'. Base your predictions on the water being at that level. Also base your predictions on the following conditions:

It is a sunny day.
The time is 2:00 p.m.
The air temperature is 78°.
There is no wind.
It is April 16th and there has not been any rain for 23 days.

Procedure:

1. Use the main map to locate each of the four study sites.

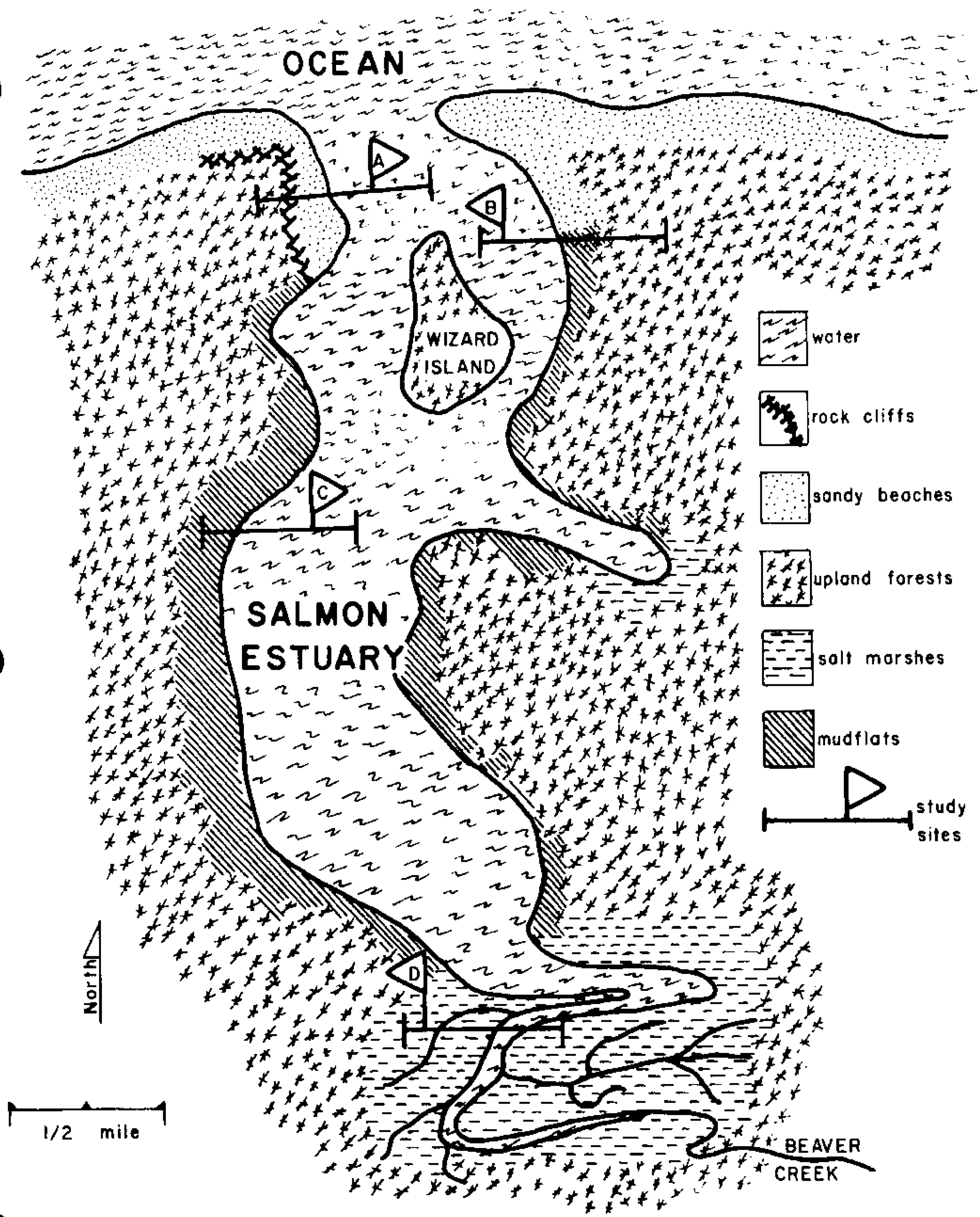
2. Each study site has been drawn in cross section and to scale. Each cross section is then divided into one or more areas.

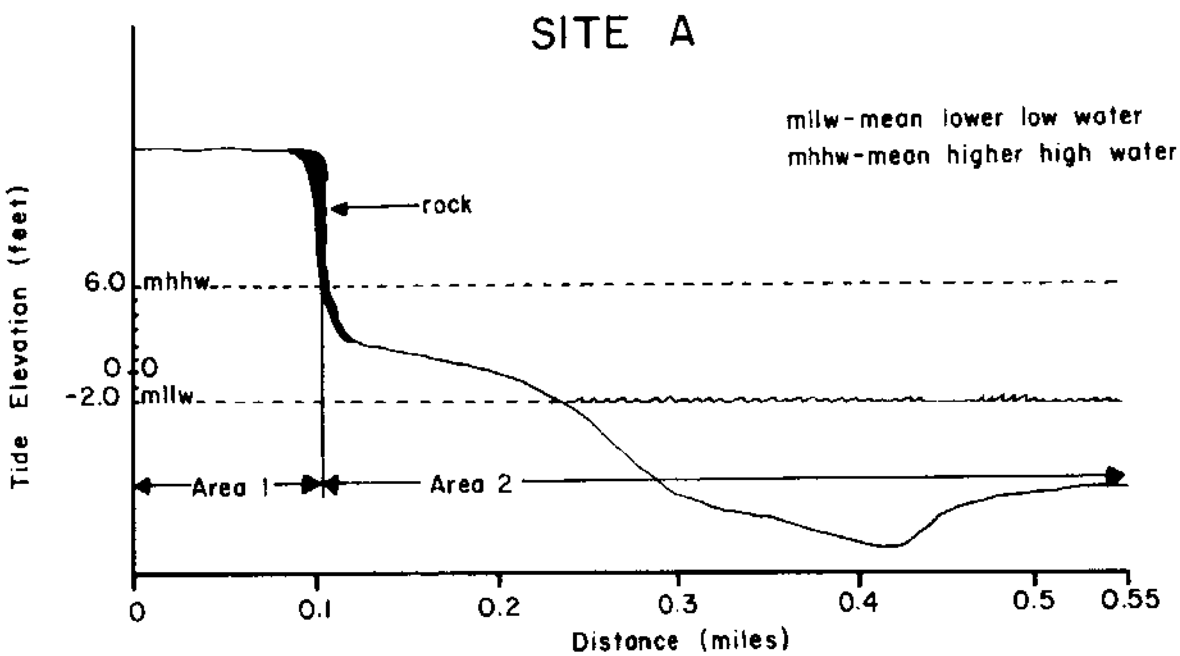
3. Working with the conditions listed above and the tide condition as shown in the drawings, fill in the blanks provided.

4. Good luck!

Conclusion:

Of course it is impossible to predict more than the general patterns we expect to find in any given estuary. There are many factors that, together, determine what organisms are going to be found in any given real ecosystem. But if you become a field biologist or ecologist, or even just a skilled observer of nature, you will become aware of general trends and patterns that will tell you which organisms are expected to be found in different types of habitats. Determining the actual kind and numbers of organisms present and the specific reasons for the distribution patterns in a habitat or ecosystem is the field of study we call ecology.


OCEAN
A
B
C
D
WIZARD ISLAND
SALMON ESTUARY
water
rock cliffs
sandy beaches
upland forests
salt marshes
mudflats
study sites
North
1/2 mile
BEAVER CREEK



Estimated salinity ________

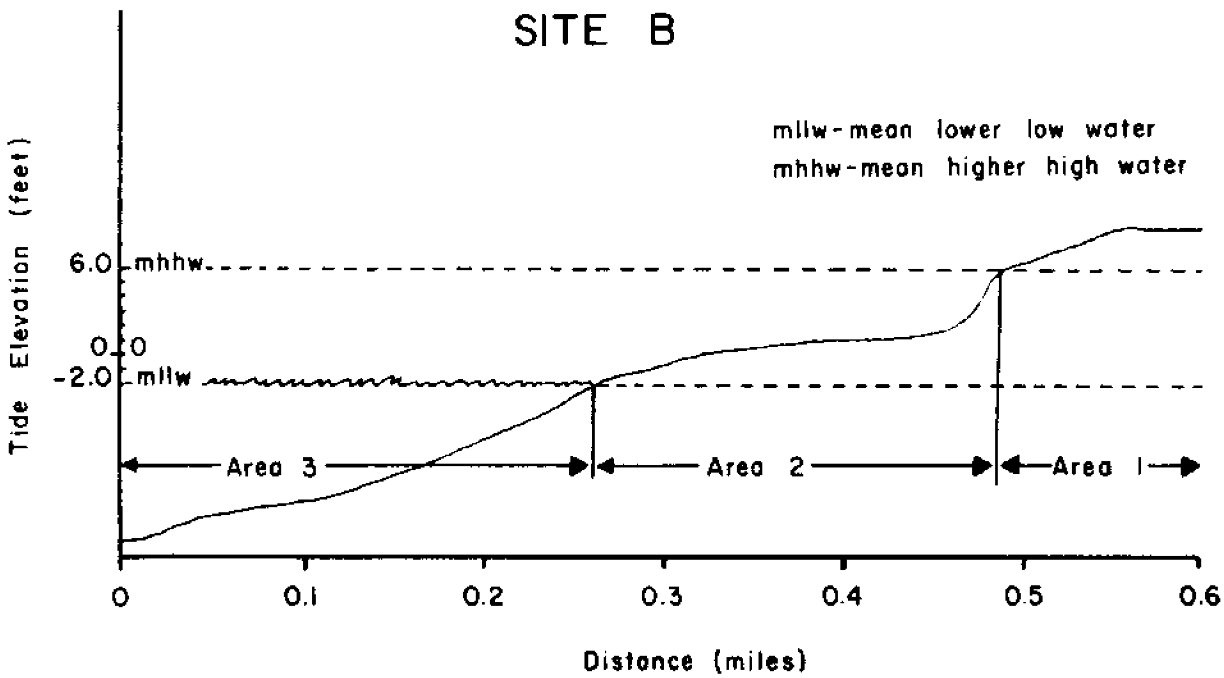
Sediment mixture and habitats--Area 1 ________
--Area 2 ________

Organisms expected to be found (refer to attached lists):

Area 1		
Organisms	Sediment type or habitat where found	Estimated tide height

Site A
Area 2

Organisms	Sediment type or habitat where found	Estimated tide height



Estimated salinity ________

Sediment mixtures and habitats--Area 1 ________
--Area 2 ________
--Area 3 ________

Organisms expected to be found (refer to attached lists):

Area 1		
Organisms	Sediment type or habitat where found	Estimated tide height
________	________	________
________	________	________
________	________	________

Site B
Area 2

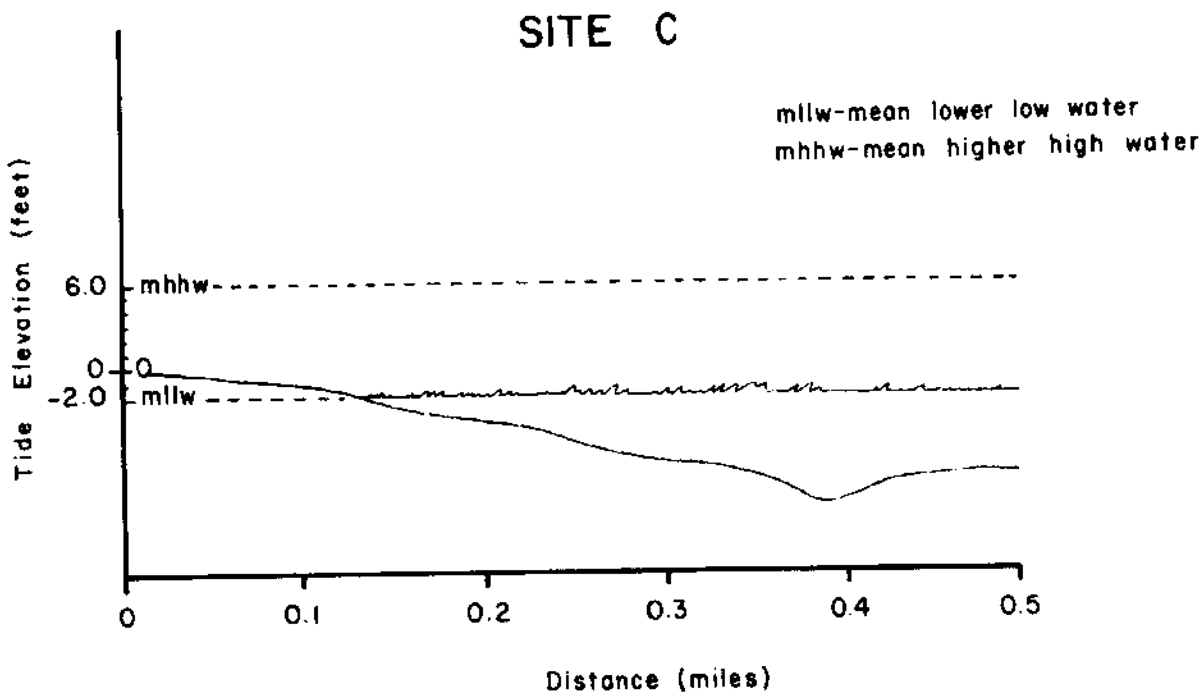
Organisms	Sediment type or habitat where found	Estimated tide height

Area 3

cont'd.

Site B
Area 3 (cont'd.)

Organisms	Sediment type or habitat where found	Estimated tide height



Estimated salinity ________

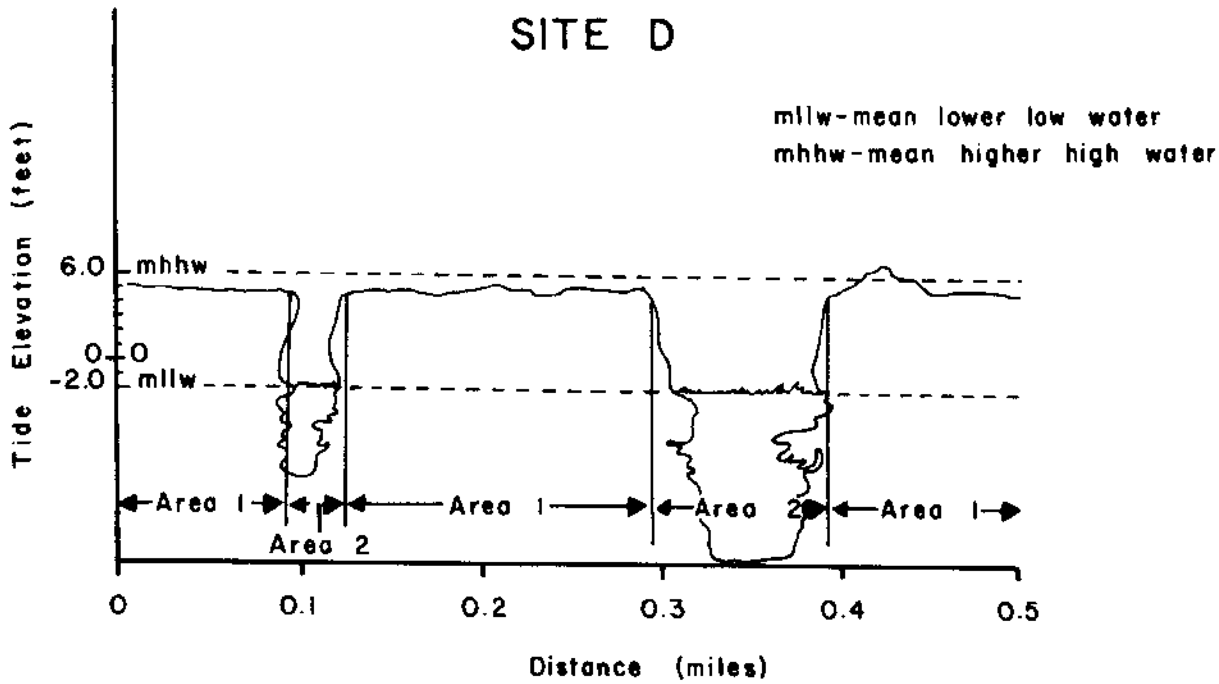
Sediment mixture and habitats ________

Organisms expected to be found (refer to attached lists):

Organisms	Sediment type or habitat where found	Estimated tide height
________	________	________
________	________	________
________	________	________
________	________	________
		cont'd.

Site C (cont'd.)

Organisms	Sediment type or habitat where found	Estimated tide height



Estimated salinity ________

Sediment mixture and habitats--Area 1 ________
--Area 2 ________

Organisms expected to be found (refer to attached lists):

Area 1		
Organisms	Sediment type or habitat where found	Estimated tide height
________	________	________
________	________	________
________	________	________
________	________	________
		cont'd.

Site D (cont'd.)
Area 2

Organisms	Sediment type or habitat where found	Estimated tide height

Organisms: Their habitat requirements and tolerances

(1) sediment mixtures and habitats: s = sand

ms = muddy sand

sm = sandy mud

m = mud

r = rock and gravel

dl = dry land

(2) salinity gradient: 1 —— 2 —— 3 —— 4 (1 ↓ fresh water; 4 ↓ sea water)

(3) feeding strategies: D - deposit feeder

F - filter feeder

G - grazer

S - scavenger

P - predator

1. Invertebrates

Adults	Sediment mix (1)	Salinity (2)	Feeding Strategies and misc. (3)
lugworm	ms → sm	2 → 3	D
ribbon worm	under sea lettuce	3 → 4	S
Nephtys worm	ms → sm	1 → 4	D
red ghost shrimp	sm → ms	2 → 4	D
blue mud shrimp	m	2 → 4	F
Dungeness crab	in eelgrass beds/ s → m	3 → 4	S
purple shore crab	salt marsh-burrows	2 → 4	S
Oregon mud crab	salt marsh	2 → 4	S
pea crab	inside Gaper clam	2 → 4	S
Pista terebellid worm	sm → m	3 → 4	D

1. Invertebrates, cont'd.

Adults	Sediment mix (1)	Salinity (2)	Feeding Strategies and misc. (3)
barnacles	rock	3→4	F
moss animals	rock and seaweed	2→4	F
heart cockle	ms/eelgrass	3→4	shallow F/burrower
gem clam	ms	3→4	shallow F/burrower
bent-nosed clam	ms→m	2→4	can withstand D/low oxygen
zooplankton	open water	1→4	G
soft-shelled clam	ms→sm	2	F
white sand clam	s	4	F
littleneck clam	protected ms	2→3	F
butter clam	gravel/ms	2→4	F
gaper clam	sm	2→4	F
bay mussel	rock	3→4	F
oyster	cultivate on rock & mud or stick	2→4	F
sea star	rock	3→4	P
Sitka snail	salt marsh, pickle-weed	2→3	G

2. Plants

	Salinity (2)	Habitat
huckleberry	dry land	upland
salal	dry land	upland
Sitka spruce	dry land	upland
skunk cabbage	1	freshwater marsh
rushes	1	freshwater marsh
tufted hair grass	2→4	salt marsh (upper)
gumweed	2→3	salt marsh

2. Plants, cont'd.

	Salinity (2)	Habitat
salt grass	2→3	salt marsh
pickleweed	2→3	salt marsh
sea lettuce	2→4	tidal flats, rock
Zostera (eelgrass)	2→4	tidal flats, slow water
Endocladia (red algae)	2→4	below high tide, rock
Fucus	2→4	below high tide, rock
phytoplankton	2→4	open water

3. Fish*

	Salinity (2)	Food
redside shiner	1	copepods, insects, fish eggs
staghorn sculpin	2→4	anything
starry flounder	2→4	invertebrates, clam necks
striped bass	2→4	fish
shiner perch	2→4	invertebrates, zooplankton
juvenile salmon, trout	2→4	plankton
speckled sanddab	4	amphipods and copepods

* Remember, most of these fish can be found in the juvenile stage in an estuary as plankton eaters.

Answer Key to

EER Student's Laboratory Exercises

LABORATORY 1 - The Wet Blanket: Understanding the Tides

2. a. Answers variable

   b. Answers variable

   c. Answers variable

3.

Location	Height Correction	Time Correction
Coos Bay docks	+ 1.0 ft	+ 1 hr 30 min
Coos Bay entrance	+ 0.7 ft	+ 5 min
Port Orford	+ 0.9 ft	- 25 min

   a. The difference in correction times between the Coos Bay docks and Coos Bay entrance is due to the time it takes the tidal bulges and troughs to get from the entrance up to where the docks are located.

   b. The ship's captain must be able to safely navigate ships under all conditions, and knowing how to use correction tables is essential for the safety of his ship in shallow waters.

4. Answers variable

5. Answers variable

6. The highest and lowest tides will occur at the full and new moons; the intermediate level tides will occur at the quarter moons.

LABORATORY 2 - Mud Mixer: Exploring the Bottom Sediments of an Estuary

Introduction:

Current Speed	Maximum Sediment Size
Fast	Large
Moderate	Medium
Slow	Small

Procedure A, Question 6a:

Answer: Green and yellow (When a cadmium sulphide photocell is purchased, the photoelectric response characteristics are given with it. This information can be used to explain the operation of the cell in some detail.)

Procedure C:

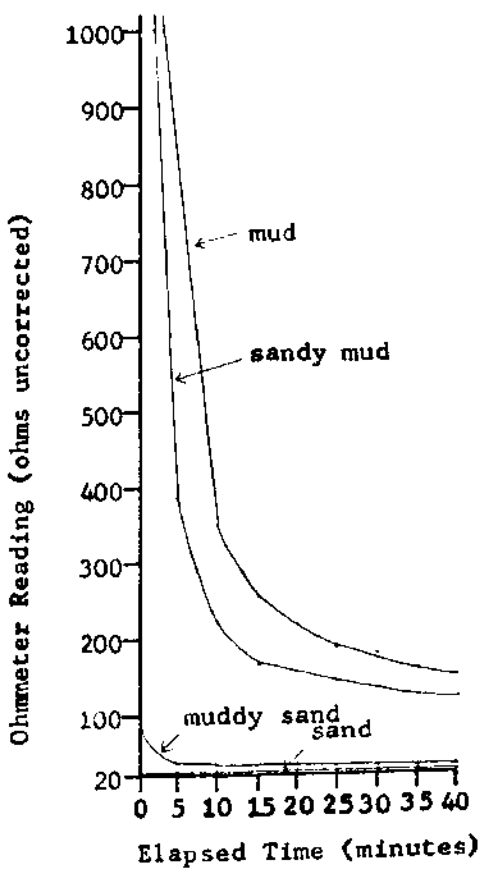
(The answers listed below are those data typically gathered when the exercise was piloted. Since resistance is being measured, these values are in ohms. The exercise does not require that the students use the corrected ohm values but rather only the indicated readings to simplify the procedure and let the students concentrate on the principles involved.)

Time Intervals (minutes)

Sample Labelled	0	0+5	0+10	0+15	0+20	0+25	0+30
sand	25	23	22	22	22	22	21
muddy sand	400	80	60	51	45	41	42
sandy mud	1500	172	121	97	84	76	75
mud	1900	320	218	170	145	130	128
S. Slough 1	80	37	34	33	32	31	30
S. Slough 2	1900	385	220	165	158	142	133

Procedure D:

(Reproduced below is an example of the curves that were typically produced when this exercise was piloted.)



3. a. BASELINE is a word often used to denote the starting condition or status of some body of information often used in ecological studies and chemical analysis. A standard curve serves the same purpose on a graph. Therefore, the terms can be thought of as being synonyms, ie., a curve produced by a standard solution or serves as a baseline for interpreting the data from the experimental or unknown condition.

b.

sand	South Slough 1	
muddy sand		
sandy mud	South Slough 2	either of these may be correct
mud	South Slough 2	

c.

SITE 1	SITE 2	SITE 3	SITE 4
South Slough 1		* South Slough 2	* South Slough 2
sand	muddy sand	sandy mud	mud

* either may be correct

d. The sedimentation curves initially have high values because most of the particles are in suspension and very little light penetrates. As time goes by, larger and larger particles fall to the bottom and the water clears.

LABORATORY 3 - Wasting Away: The Effects of Pollutants on Dissolved Oxygen

1. a. fish guts

   b. wood

2. differences in amount of bacteria initially present

3. wood--store logs out of the water

   guts--grind up fish wastes for fertilizer

   manure--fence off stream banks and estuary shoreland

LABORATORY 4 - The Phyto and Zoo of Plankton

Procedure: (Second lab period)

1. Answers variable

2. Answers variable

5. a. $SA = 3.14(4.5\text{ cm})^2 = 63.6\text{ cm}^2$

   b. Each sq. centimeter of the grid is therefore 1/63.6 or 0.016 of the total area.

13. Refer to the Exercise Follow-up discussion for this lab.

LABORATORY 5 - The Consumer Connection: Food Webs of an Estuary

A. 1. Primary Producers - phytoplankton, marsh grasses, eelgrass

B. 2. Any organism that cannot make its own food through photosynthesis.

3. Living plants and detritus

C. 4. Salmon

D. 5. Phytoplankton, zooplankton, zooplankton-eating fish, osprey

E. 6. Nutrients

II. The Rocky Intertidal Food Web

7. Tertiary consumer level ---- 1 gm

Secondary consumer level -- 10 gms

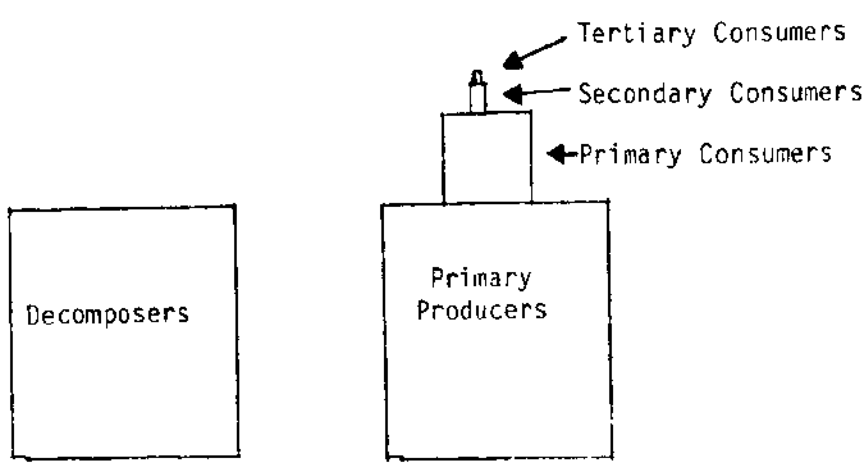
Primary consumer level --- 100 gms

Primary producer level -- 1000 gms

8. 999

through the decomposers and into the chemicals and nutrients part of the ecosystem.

9.



IV. Estuaries

F	1.	bacteria	D	13.	lugworms
A	2.	barnacles	E	14.	Oregon mud crabs
D	3.	bent-nosed clams	A	15.	oysters
C	4.	black brants	B	16.	phytoplankton
A	5.	blue mud shrimps	B	17.	pickleweed
A	6.	butter clams	E	18.	ribbon worms
E	7.	Dungeness crabs	B	19.	salt grass
B	8.	eelgrass	G	20.	sea stars
F	9.	fungi	C	21.	Sitka snails
A	10.	gaper clams	G	22.	starry flounders
G	11.	great blue herons	E	23.	western gulls
G	12.	killdeers	C	24.	zooplankton

V. Questions

A. Reduces a large portion of the base of the food chain, reduces the amount of detritus available, and ultimately affects us economically because it reduces the salmon availability.

B. 1. Decomposers

2. Man

3. Sun star
Barnacles

4. Salmon
Plankton-eating fish
Crabs
Zooplankton
Sea urchins, snails

C. Because when one of the parts of the food chain becomes scarce, another food source can be used.

LABORATORY 6 - Inefficiency Experts: Productivity in the Estuary

I. Standing Crop

1. The tissue and storage products, such as fat, composing living organisms.

2. The amount of biomass contained within a volume of water or area of land.

3. Answers variable

4. Answers variable

5. a. Take a sample
b. Dry it
c. Weigh the sample
d. Multiply by the size of the field

II. Calories

6. 1360 calories

7. The salad because it is made up of primary producers and, incidentally, has not been cooked, so the energy used in its preparation is minimal.

8. The salmon because it is a tertiary consumer and has been cooked using energy in its preparation

	Ounces	Calories	Calories/Ounces
pork chop	3 1/2	250	71.4
pork roast	3 1/2	283	80.8
pork sausage	3 1/2	421	120.3

Fish	Ounces	Calories in 3 ounces
halibut	3	155
mackerel	3	200

9. 120 ozs

10. 93 ozs

11. The mackerel because it gets more energy per ounce from it than from the halibut.

III. Ecosystems

- 80 pounds
- 78,880 calories
- 2,190 gallons or 5,606,400 calories of milk
- The hay to cow to milk to human is more efficient by a factor of 9.5
- Open ocean

	Calories/km/year
Open ocean	0.1×10^8
Estuaries and reefs	2×10^8
Deserts and tundras	$.02 \times 10^8$
Coniferous forests	$.3 \times 10^8$
Tropical forests	1.97×10^8
Grasslands	$.25 \times 10^8$

Estuaries and reefs = 2.00×10^8 ; and tropical forests = 1.97×10^8

LABORATORY 7 - Who, Where, and Why in an Estuary: Predicting the Distribution of Plants and Animals

Site A:

Estimated salinity 4

Sediment mixture and habitats--Area 1 dl & r
--Area 2 r & s

Organisms	Sediment type or habitat where found	Estimated tide height
Area 1		
huckleberry	dry land	above the tides
salal	dry land	above the tides
Sitka spruce	dry land	above the tides
Area 2		
ribbon worm	r; under sea lettuce	+6 to +2
barnacles	r	+6 to +2
moss animals	r	+6 to +2
bay mussel	r	+6 to +2
oyster	r	+6 to +2

Site A Area 2 (cont'd.) Organisms	Sediment type or habitat where found	Estimated tide height
sea star	r	+6 to +2
sea lettuce	r	+6 to +2
Endocladia	r	+6 to +2
Fucus	r	+6 to +2
white sand clam	s	+2 and below
zooplankton	open water	Below -2'
phytoplankton	open water	Below -2'
staghorn sculpin	open water	Below -2'
starry flounder	open water	Below -2'
striped bass	open water	Below -2'
shiner perch	open water	Below -2'
juvenile salmon & trout	open water	Below -2'
speckled sand dab	open water	Below -2'

Site B:

Estimated salinity 3→4

Sediment mixture and habitats--Area 1 s & dl
--Area 2 sm
--Area 3 sm

Area 1 Organisms	Sediment type or habitat where found	Estimated tide height
huckleberry	dry land	above the tides
salal	dry land	above the tides
Sitka spruce	dry land	above the tides

Site B
Area 2 (cont'd.)

Organisms	Sediment type or habitat where found	Estimated tide height
lugworm	sm → ms	+2 to -2
Nephtys worm	sm → ms	+2 to -2
red ghost shrimp	sm → ms	+2 to -2
Dungeness crab	s → m; in eelgrass beds	+2 to -2
pea crab	sm → ms; inside gaper clam shell	+2 to -2
Pista terebellid worm	sm → m	+2 to -2
ribbon worm	tidal flats; under sea lettuce	+2 to -2
gaper clam	sm	+2 to -2
sea lettuce	tidal flats; rock	+2 to -2
Zostera (eelgrass)	tidal flats; slow water	+2 to -2

Area 3

lugworm	sm → ms	below -2
ribbon worm	tidal flats; under sea lettuce	below -2
Nephtys worm	sm → ms	below -2
red ghost shrimp	sm → ms	below -2
Dungeness crab	s → m; in eelgrass beds	below -2
pea crab	sm → ms; inside gaper clam shell	below -2
Pista terebellid worm	sm → m	below -2
zooplankton	open water	below -2
soft shelled clam	sm → ms	below -2
gaper	sm → ms	below -2

Site B
Area 3 (cont'd.)

Organisms	Sediment type or habitat where found	Estimated tide height
sea lettuce	tidal flats	below -2
Zostera (eelgrass)	tidal flats; slow water	below -2
phytoplankton	open water	below -2
staghorn sculpin	open water	below -2
starry flounder	open water	below -2
striped bass	open water	below -2
shiner perch	open water	below -2
juvenile salmon & trout	open water	below -2

Site C:

Estimated salinity 2→3

Sediment mixture and habitats ms→m

Organisms	Sediment type or habitat where found	Estimated tide height
lugworm	sm→ms	0 to below -2'
ribbon worm	tidal flats; under sea lettuce	0 to below -2'
Nephtys worm	sm→ms	0 to below -2'
red ghost shrimp	sm→ms	0 to below -2'
blue mud shrimp	ms→m	0 to below -2'
Dungeness crab	s→m; in eelgrass beds	0 to below -2'
pea crab	sm→ms; in gaper clam shell	0 to below -2'
Pista terebellid worm	sm→m	0 to below -2'
heart cockle	ms/eelgrass	0 to below -2'

Site C (cont'd.)		
Organisms	Sediment type or habitat where found	Estimated tide height
gem clam	ms	0 to below -2'
bent-nosed clam	ms → m	0 to below -2'
zooplankton	open water	below -2'
soft shelled clam	sm → ms	0 to below -2'
littleneck clam	protected ms	0 and below
butter clam	gravel/ms	0 and below
oysters	cultivated on mud; sticks	0 and below
sea lettuce	tidal flats	0 and below
Zostera (eelgrass)	tidal flats; slow water	0 and below
phytoplankton	open water	-2' and below
staghorn sculpin	open water	-2' and below
starry flounder	open water	-2' and below
striped bass	open water	-2' and below
shiner perch	open water	-2' and below
juvenile salmon/trout	open water	-2' and below

Site D:

Estimated salinity 1 → 2

Sediment mixture and habitats--Area 1 salt marsh
--Area 2 m

Area 1		
Organisms	Sediment type or habitat where found	Estimated tide height
purple shore crab	salt marsh; burrows	+5' and below
Oregon mud crab	salt marsh	+5' and below

Site D
Area 1 (cont'd.)

Organisms	Sediment type or habitat where found	Estimated tide height
Sitka snail	salt marsh	+5' and below
tufted hair grass	salt marsh, upper	+5'
gumweed	salt marsh	+5'
salt grass	salt marsh	+5'
pickleweed	salt marsh	+5'

Area 2

blue mud shrimp	m	-2' and below
purple shore crab	salt marsh; burrows	-2' and below
Oregon mud crab	salt marsh	+5' and below
bent-nosed clam	m	-2' and below
zooplankton	open water	-2' and below
oyster	cultivated on mud; sticks	-2' and below
phytoplankton	open water	-2' and below
staghorn sculpin	open water	-2' and below
starry flounder	open water	-2' and below
striped bass	open water	-2' and below
shiner perch	open water	-2' and below
juvenile salmon/trout	open water	-2' and below

Field Trips

Field Trips: Introduction

Field trips to the South Slough Sanctuary are greatly encouraged. The state of Oregon offers, free of charge, access to the facilities of a 1 1/2 mile Estuary Study Trail, the use of all necessary field equipment, and the coordination services of the sanctuary education specialist.

If you cannot visit the sanctuary, we encourage you to use a modified field program at an estuary nearer to your school. If a field trip to any estuary is impossible, but you would still like to use the other elements of the program, then simply phone or write the sanctuary to arrange for any necessary samples that you need. We will send them to you for the cost of postage.

Before the Field Trip

Group organization

The ideal class size for a visit to the South Slough is 25 to 30 students. The class should be divided into four groups. Each group should contain students who are able to work well together.

Equipment

Each student should be equipped with

* Boots or sneakers they don't mind getting wet. Dry shoes and socks should be waiting for them on the bus.
* Rain gear.
* Lunch and something to drink.
* A backpack to carry their equipment in.
* Pencil.
* A copy of the EER field guide.

Study equipment

All necessary equipment for the field program will be provided by the sanctuary except

* 1 one-liter plastic water collecting bottle.
* 2 small collecting jars, of about one cup capacity, per group.
* ice chest and ice--leave on bus at trailhead.

Sample Field Trip Schedule

8:30 a.m.	Arrive at the viewpoint.
8:30 - 8:45	Orientation given at the viewpoint.
8:45 - 9:30	Hike to the lookout. Begin the "Observe and Interpret" activity.
9:30 - 9:45	Rest stop. Orientation given at the lookout.
9:45 - 10:45	Session 1
10:45 - 11:45	Session 2
11:45 - noon	Lunch
12:00 - 1:00 p.m.	Session 3
1:00 - 2:00	Session 4
2:00 - 2:15	Wrap-up
2:15 - 2:45	Hike to the trailhead.

Classroom Follow-up

After the field trip, you may wish to review the class's findings.

Field Study 1: Observe and Interpret

Discuss the activity giving each student group an opportunity to share their observations and interpretations.

Field Study 2: Plankton Tow

The analysis of the plankton samples will be done as part of Laboratory 4. As a class, review the formula and data needed to calculate the number of gallons of estuary water that was filtered through the net.

Field Study 3: Vegetation Transects in the Salt Marsh

Review the student's answers to the analysis and conclusion section of the exercise. Have the students graph the information they gathered in the field.

Field Study 4: Physical Factors of the Estuarine Environment

As a group, review the student's data for weather, nutrients, dissolved oxygen, tides, salinity, and temperature.

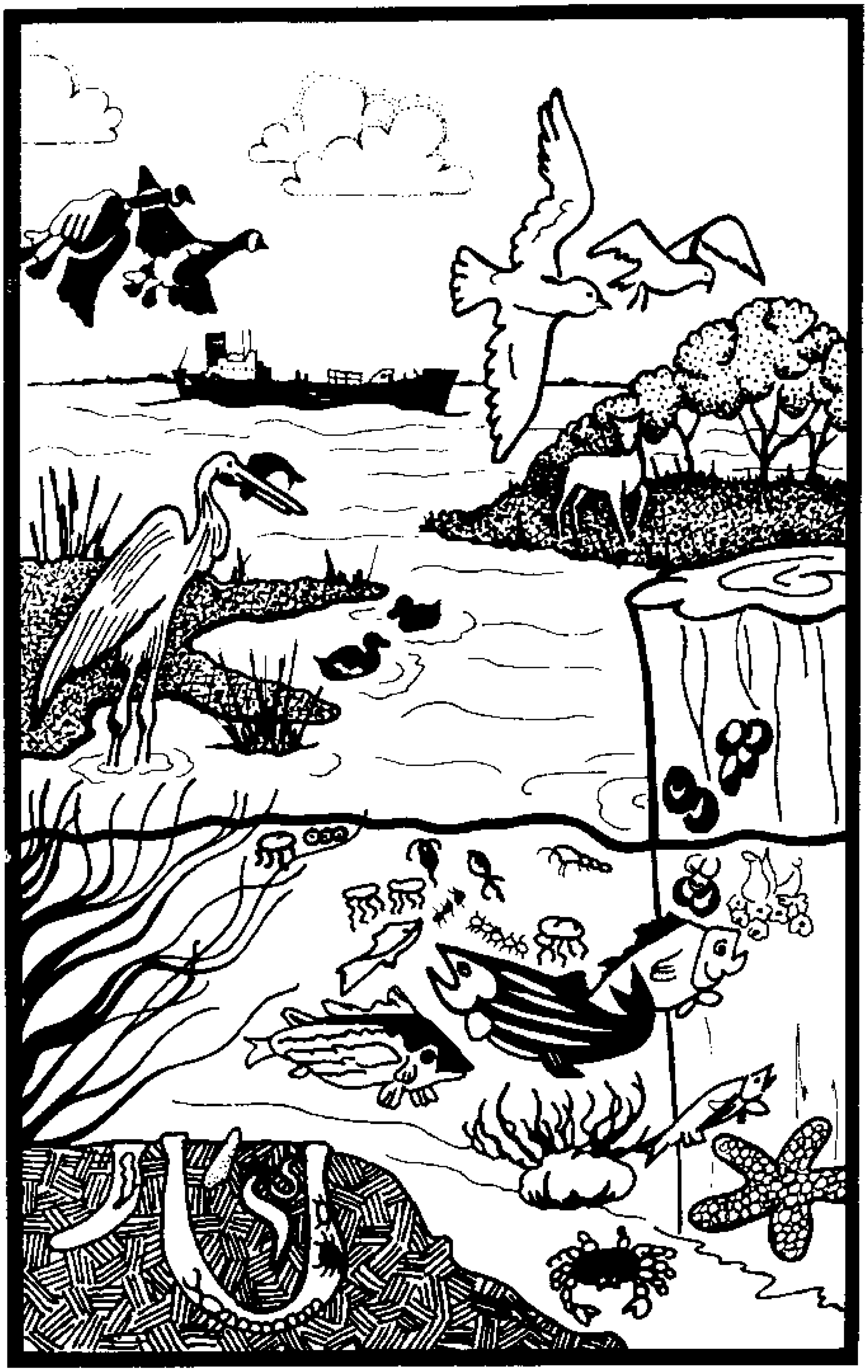
Field Study 5: Creatures of the Mud

Review the observations made by the students which indicate life in the mud. Compare the color and other characteristics of the sediment at various levels of the mud flat sediment core and the different species of plants and animals that were identified.

Reproduction masters of student handout materials are found in this section of the manual.

Note

The following Student's Field Guide (odd-numbered pages 217-275) is a master copy. One copy per student will be required.



E. E. R.

STUDENT'S FIELD GUIDE

NAME ________________ DATE ____

ACKNOWLEDGEMENTS

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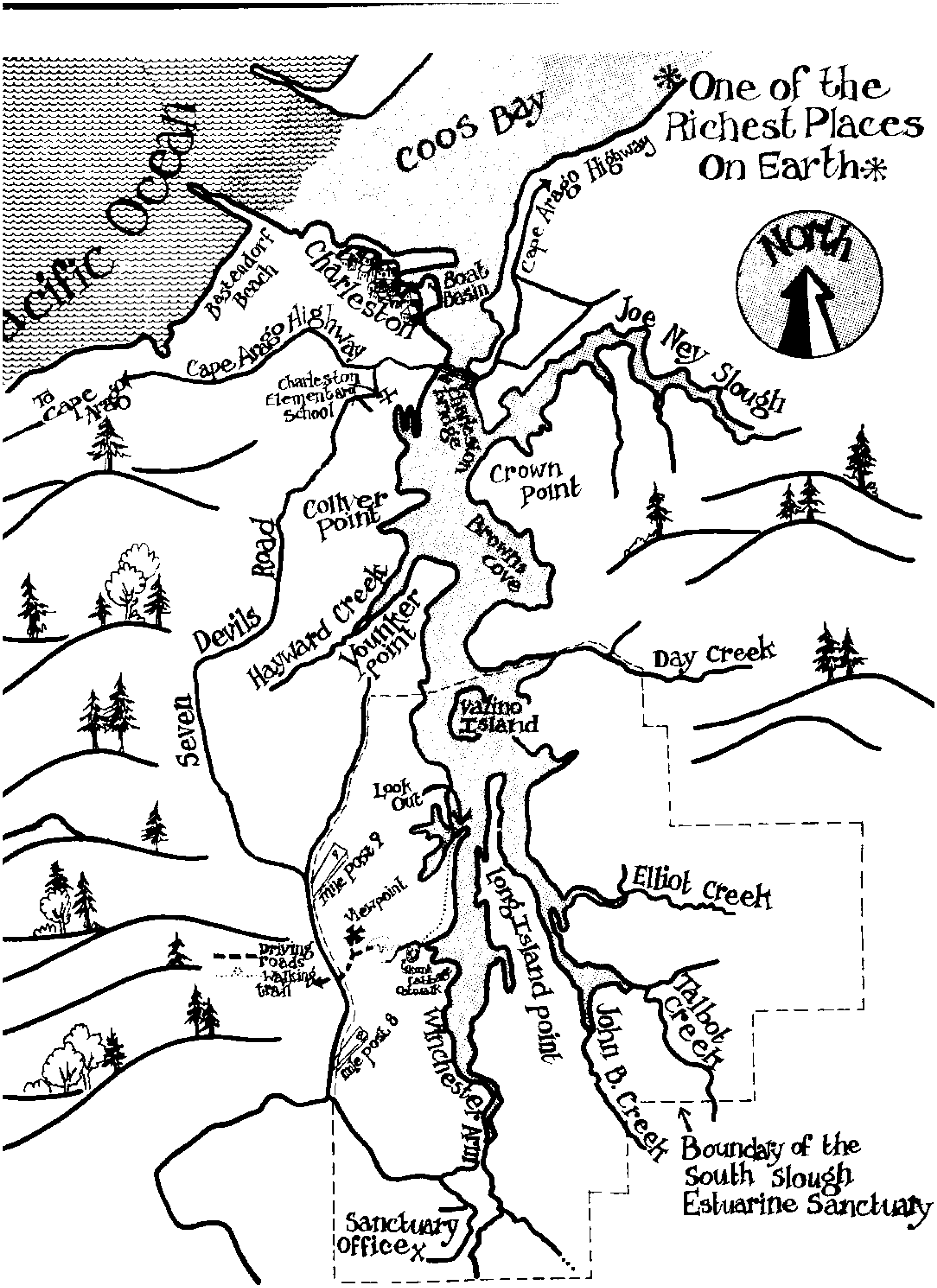
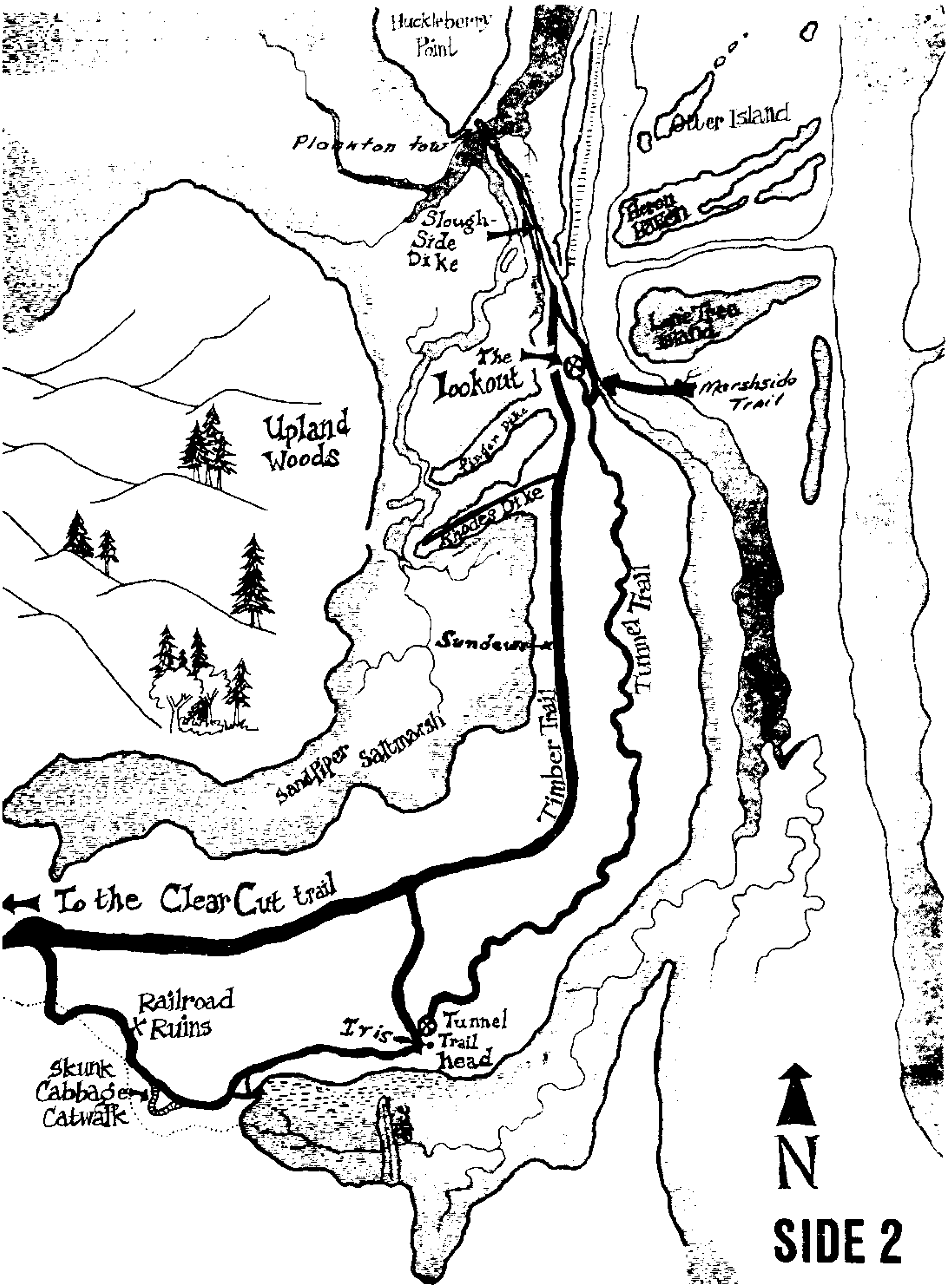
Signs of Animals Seen During Your Visit to the South Slough

NOTES



One of the Richest Places On Earth*
North
Pacific Ocean
Coos Bay
Cape Arago Highway
Bastendorf Beach
Charleston
Boat Basin
Cape Arago Highway
To Cape Arago
Charleston Elementary School
Joe Ney Slough
Crown Point
Collver Point
Browns Cove
Seven Devils Road
Hayward Creek
Younker Point
Day Creek
Valino Island
Look Out
Elliot Creek
Long Island point
mile post 9
Viewpoint
Driving roads
Walking trail
John B. Creek
Talbot Creek
mile post 8
Winchester Arm
Boundary of the South Slough Estuarine Sanctuary
Sanctuary Office



Huckleberry Point
Plankton tow
Otter Island
Slough-Side Dike
The Lookout
Marshside Trail
Upland Woods
Finger Dike
Rhodes Dike
Sundew
Tunnel Trail
Timber Trail
Sandpiper Saltmarsh
To the Clear Cut trail
Railroad Ruins
Iris
Tunnel Trail head
Skunk Cabbage Catwalk
N

SIDE 2

Field Study 1

Observe and Interpret

Purpose:

To learn how to really see what you are looking at.

To learn how much more interesting a hike in the woods can be when you learn how to pay more attention to your environment.

Materials: Pencil
Map in field manual

Introduction:

Work alone or with one other person on your team to solve these questions. You will find most of the solutions while hiking into or out of the estuary.

Procedure:

Study the whole list before starting on the trail. Some questions will ask you to mark something on the map included in this field manual. Others will request a sketch or explanation. Remember, keep the solutions you find to yourself or your two-person team.

1. The first portion of the trail has been logged many times. On a large white cedar stump that lies along this section of the trail, you will notice two springboard notches. Loggers once stood on springboards to avoid having to cut the thicker "bell" or bottom of the tree. Your task here is to describe or identify the shrub that is growing on top of this cedar stump.

2. As you hike along the trail, stop at the RAILROAD RUINS marked on the map. The old logs you see against the bank were part of the massive railroad trestle that once stood here. Look closely and you will see even better evidence that an old bridge was situated here. Describe the evidence that shows how these trestle were fastened together.

3. When a large Douglas fir, Sitka spruce, or cedar tree has grown up in a clearing with plenty of sunlight, it develops low branches that are long and robust. Find at least two old coniferous trees (trees with needles or green scales) with long low branches. Mark them on your map with the word "clearing."

   Note: These clearings were probably made by people.

4. Use the plant identification chart in Field Study 2 to find the names of the two most aromatic plants you come across on the Estuary Study Trail. Tear a small part of the leaf to get the full impact.

   Smelly Plant 1 ______________________

   Smelly Plant 2 ______________________

5. When you come to the place marked IRIS on your map, try to solve the following questions. You will see a large ring of iris with a clump of sword fern in the middle. These iris with their long, thin green leaves are not native to this part of the country; they were planted by someone. Form two possible explanations for why they might have been planted here a few generations back.

6. Find a place where an old railroad track once stood on pilings. A channel was dredged for boats to come alongside. Long ago the dredge dumped its sediments or spoils (the materials it dredged up) in three big piles. Observe the area carefully. On the map, mark the locations of the site with the letter "SI" (spoil island).

7. On your way to the plankton tow pulley, you will be walking on top of the SLOUGH SIDE DIKE. Until the end of this dike was naturally breached, it held the salt water out so the land to the left (west) could be farmed. If you needed to figure out the age of the dike (so you could say, "It is at least __xx__ years old"), what would be a quick and inexpensive way to do it without talking to old timers or reading old documents?

8. From the Slough Side Dike, look into the mud flats to the west and describe one of the metallic objects that pioneers abandoned there. (This takes a keen eye.)

9. As you reach the end of the Slough Side Dike, look to the left (west) at right angles to the dike. In two drainage channels of the mud flat, about 50 feet from you, notice lines of short sticks going across the channels. They are about one inch in diameter. Years ago, before the area was diked, Indians used fish traps or weirs on this mud flat. The weirs would allow fish to pass through them at high tide but would trap them behind the weir at low tide. These short stubs are probably all that's left. (The fish weirs are only visible at low tide.)

Draw how you think the weir once looked.

Somewhere in a part of the estuary that you will pass today is a phony "Indian weir." A group of students set it up a couple of years ago. When you find it, mark the spot on your map with "Fake Weir."

10. Search for the two old cars that were abandoned at a point near the base of the lookout. Now give the name of these two cars.

11. Watch for great blue herons, four-foot-tall shore birds with wing-spans of about 50 inches. How does this bird hold its neck when it flies? How does it fold its feet?

12. The Estuary Study Trail is mainly built on two old roadbeds. The older one to the north was used by pioneers in the late 1800s. Roads that skirt the slope of a hill are cut into the uphill slope as you see in this cross section:

Put the letters "c.b." on the map where you find the two most obvious cutbanks on the old roads.

13. On your hike back to the trailhead you will notice the sundew observation platform. Look carefully for these small plants that eat insects. Describe how you think the sundews capture their meal. Please stay on the platform to avoid stepping on the sundews.

Analysis and Conclusions:

14. Which of the numbered questions above caused you to see something you would not have noticed otherwise?

____

____

15. What activities do you do in which it would help you to be better able to observe and interpret? What about activities you might do in the future?

____

____

____

16. Think of three careers in which being able to really see and understand what you see would be important skills.

____

____

____

Field Study 2

Plankton Tow

Purpose:

To collect zooplankton and phytoplankton for experiments in the classroom.

Materials:

- Ice chest and ice (leave on bus)
- Collecting jars (2 per group)
- 2 - 30x field microscopes
- 1 plankton net
- Labels (important)
- Watch with a second hand
- Tide tables (2 per team)
- Eye dropper
- Piece of wood from study site
- 2 depression slides
- 1 liter capacity bottle
- Graduate
- Rubbing alcohol
- Ruler
- Squeeze bottle

Introduction:

Plankton, tiny floating plants and animals, are a very important food source for many larger animals. In this activity you will collect some of these strange-looking little plants and animals to study in the classroom.

Procedure:

1. Using the clothesline pulley, carefully move the plankton net to the middle of the channel. At the same time, another student should hold the safety rope so the net is held above the water and tree roots. When the net is in the middle of the channel, use the safety rope to lower the net into the water. Be careful not to trap air in the end of the net; you won't catch any plankton that way. Be sure that the tube clip is snapped shut at the end of the net. Tie off the safety rope.

   A. Record when your plankton tow began ____________________

2. Label two jars.

   Sample 1--preserved, time of tow __________, sample volume ______

   Sample 1--live, time of tow __________, sample volume ___________

   Subsequent team--do samples 2 and 3 and so on.

3. To figure out the volume of water that you filtered, you will need to get some data.

   A. Is the tide going in or out? (Look at the direction of the current as it moves against the tide staff.) ____________________

   B. Use the rule to measure in centimeters the diameter of the opening of the plankton net. ________________

C. Now compute the area of the opening.

$A = \pi r^2$

$\pi = 3.14$

$\text{Radius } (r) = \frac{\text{diameter}}{2}$

4. Now measure the speed of the current. The two poles that are located in the channel are exactly one meter apart. Find a piece of wood that floats and throw it into the channel above the pole. Time the number of seconds it takes to cover the distance from one pole to another.

$\frac{\text{one meter}}{\_\_\_\_\_\_\_ \text{ seconds}}$

Turn to "Physical Factors, Field Study 4." Do the section on tides.

5. Now pull the plankton net from the water to the shore. Make sure the net does not snag on a root. Record the stop time: ____________.

6. Now use the squeeze bottle to wash any plankton that is clinging to the sides of the net into the bottom of the net. Open the clip at the bottom of the net and allow the sample to flow into the graduate.

7. Pour 1/2 of the plankton sample into the "live" collection jar and 1/2 into the jar marked "preserved."

8. Now add 2 parts of alcohol to every 1 part of plankton and water that is found in the "preserved" jar.

9. Use the eye dropper to place some of the plankton from the "live" jar on a depression slide. Use the field microscope to help describe and sketch the color, movement, and shapes of the plankton you have collected.

____

____

____

10. Place the jars in a cool place until you can get to the bus and put them in the ice chest. About every 30 minutes you will want to loosen the lid on the "live" sample and swirl the contents to mix air with the water.

11. Now, if you have additional time, begin the calculations on the volume of estuary water that was filtered through the net.

Here is the formula to use:

1. Area of net opening x speed of current x time of tow = volume filtered

2. The raw data you have is

   Area--cm^2

   Speed of current--$\frac{\text{meters}}{\text{seconds}}$

   Time of tow--minutes + seconds

3. You will first need to convert everything to the same units:

   A) Convert cm^2 by dividing by 100.

   B) Convert all time measurements to seconds.

4. Now, here is the equation:

   (area of opening) (speed of current) (time of tow) (volume filtered)

$$m^2 \quad \times \quad \frac{m}{s} \quad \times \quad sec \quad = \quad m^3$$

5. Now, let's convert cubic meters to gallons:

   A) Convert cubic meters to cubic feet by dividing by 0.03.

   B) Convert cubic feet to gallons by dividing by .1337.

   ____________ gallons filtered

Field Study 3

Vegetation Transects in the Salt Marsh

Purpose:

To measure the changes in vegetation as you move from the water's edge to the forest and to guess which changing physical factors in the environment might be the reason for the change in vegetation.

Materials: 2 - 30 x 30 cm quadrat frames
6 Ziploc bags
Measuring tape

Introduction:

The salt marsh plant community is very important to the ecosystem of the estuary. Tons of plant tissue are produced here, providing aquatic (living in the water) animals with life-giving energy: FOOD. It is important for people who will vote and decide on the use of estuaries to understand how physical factors can affect living things, in this case plants. By studying how the dominant plants change from the shore to the forest, and by thinking creatively, you may be able to discover some things about the physical environment.

When vegetation changes over a distance, because of changes in the physical environment, you can see zones of similar vegetation in bands at right angles to the direction of change. This is called zonation.

Procedure:

1. Start in the intertidal zone with the vascular plants nearest the channel.

   NOTE: In this transect, do not include algae.

2. Stretch the measuring tape from the edge of the marsh to the forest. When you have pulled it taut, carefully set the full length down on the ground.

3. At the "0" mark, place the quadrat (a square or rectangular frame) on the ground with the lower left corner at the "0" mark.

4. Look on the vascular plant chart at the end of this lab to find the names of the plants within the quadrat. For plants you cannot identify, collect a piece in a ziploc bag and label it "Unknown A," and the next, "Unknown B," etc.

5. List the three most abundant species on the record sheet. If you see more than three species in the quadrat, don't take time to identify them. Record "plus one other" or "plus three others," etc. Judge abundance by the amount of area in the quadrat covered by the leaves and stems of the species as you look down on it. Remember, the number

of individual plants isn't important in this study, just the area covered.

NOTE: Work quickly. Be as accurate as possible. Do your best and be consistent.

6. Record the same information at 1-meter (39 inches) intervals along the tape. Continue into the forest, doing 3 or 4 quadrats there.

7. Once in the forest, besides recording the quadrat data, also record the name of the tree nearest the lower left-hand corner of the quadrat. Use different individual trees for each quadrat station (every 1 meter). Record the second nearest tree if a tree has already been recorded.

Analysis and Conclusions:

You will graph the data you just collected when you return to the classroom. Now is the time to make some good observations about the possible physical causes of the plant zonation along the shore of the estuary. Remember, physical factors include weather, soil, tides (over a long period of time), sunlight, salinity, and any other nonliving thing that affects the plants.

(1) Below, list several physical factors that might explain the change in the composition of plant species as you move toward the upland forests.

NOTE: The composition of plant species is the kind of plants that make up the community.

____

____

____

____

Diversity refers to the number of species in a given area. Looking back at the "plus x others" entries on your data sheet, determine which part of your plant transect has the greatest diversity. Answer below:

(2) ____________________________________

(3) What is a possible explanation? HINT: Think about adaptations and physical factors.

____

____

____

MARSH TRANSECT RECORD SHEET

DISTANCE	3 MOST ABUNDANT PLANT SPECIES I	II	III	PLUS OTHERS	TREE SPECIES	NOTES

Vascular Plants of the Upland Zone

YELLOW SKUNK CABBAGE

Lysichiton americanum

Notes:

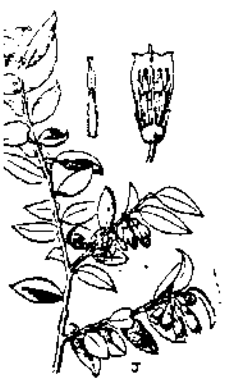
Grows in moist soil
Yellow, hoodlike structure encloses a thick "cob" of flowers
Large, green leaves
Leaf edge wavy

HEDGE NETTLE

Stachys sp.

Notes:

Square stem
Opposite leaves
Purple flowers
Aromatic smell to leaves
30-60 cm high



EVERGREEN HUCKLEBERRY

Vaccinium ovatum

Notes:

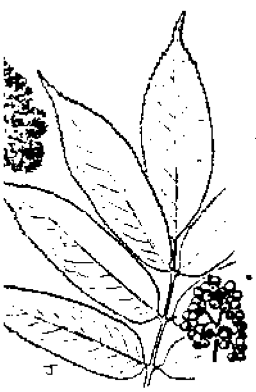
Woody shrub
Black to blue berries
0.5-2 meters high
Leaves are evergreen and shiny--less than 2 cm long
Bell shaped flowers

SALAL

Gaultheria Shallon

Notes:

Woody shrub
Evergreen leaves 5-10 cm long
White or pink urn-shaped flowers
Dark purple pulpy berries

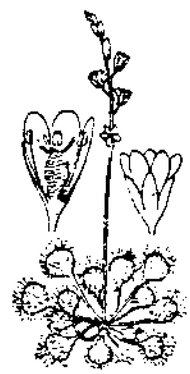


ELDERBERRY

Sambucus callicarpa

Notes:

Woody shrub
Cream-colored flower
2-5 meters high
Red clusters of berries



ROUND LEAVED SUNDEW

Droser rotundifolia

Notes:

Found in freshwater bogs
Reddish leaves 1 cm long
Leaves covered with hairs
Sticky red drops of fluid on hair tips
Insectivore

SALMONBERRY

Rubus spectabilis

Notes:

Woody shrub
Reddish-purple flower
Salmon-red berry
2-5 meters high

PACIFIC BLACKBERRY

Rubus ursinus

Notes:

Trailing or draping vines
White flower
Sweet, black berry

Vascular Plants of the Upland Zone

DOUGLAS FIR

Pseudotsuga Menziesii

Notes:

Woody
Young trees have pitch pockets in the bark
Needles are attached singly on all sides of twigs
Needles are bright green above, paler below

SITKA SPRUCE

Picea sitchensis

Notes:

Sharp needles!
Woody
Mature bark is thin, reddish-brown, and breaks off in large scales
Tree height to 35 meters

SWORD FERN

Polystichum munitum

Notes:

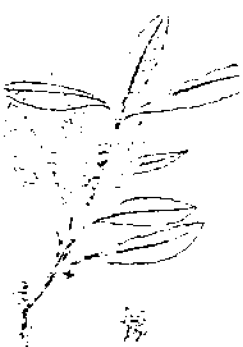
Sword-shaped frond 30-140 cm long
Many fronds found in a clump
Spores may be found in sacs lining margins of leaflets

PORT ORFORD CEDAR

Chamaecyparis Lawsoniana

Notes:

Underside of scale-leaves show pattern of white x's
Round cones
Woody
25-50 meters high



CALIFORNIA WAX MYRTLE

Myrica californica

Notes:

Leaves dark green
Large shrub 18 meters high
Brownish fruit in bunches along stem

RED ALDER

Alnus rubra

Notes:

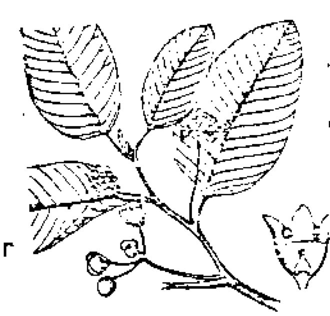
Deciduous tree
15-25 meters high
Leaves have teeth along edges and coarse veins
Small, woody cones
Outer bark is greenish-white

MADRONE

Arbutus Menziesii

Notes:

Woody tree
Rusty-maroon bark peels to expose bright green inner bark
Waxy green leaves



CASCARA

Rhamnus Purshiana

Notes:

Shrub or tree
Leaves with prominent veins
Similar to alder, but leaf edges without teeth

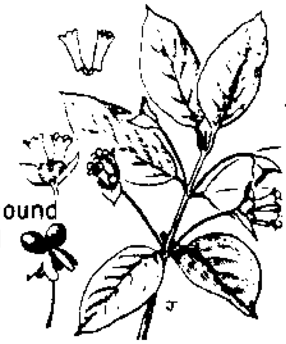
Vascular Plants of the Salt Marsh and Fringe Zone

DODDER

Cuscuta salina

Notes:

Small, waxy, and coiled around other plants--pickleweed in particular
Flesh colored
Small, white flowers



BLACK TWINBERRY

Lonicera involucrata

Notes:

Woody shrub
1-3 meters high
Often found along marsh fringe
Twin black berries

JAUMEA

Jaumea carnosa

Notes:

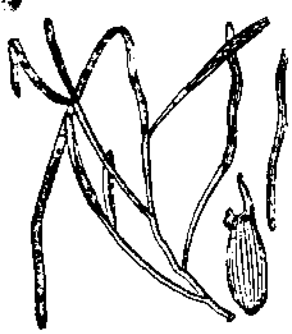
Fleshy
Yellow ray flowers
Narrow, succulent leaves
1-2.5 dm long

GUMWEED

Grindelia nana

Notes:

Long, narrow leaves
Small bracts beneath flowers are hooked backwards
Yellow flowers with sticky base
2-8 dm high

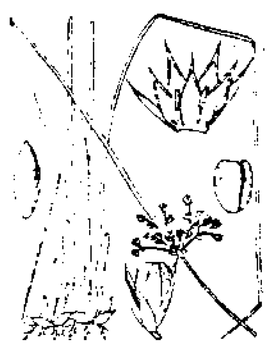


EELGRASS

Zostera marina

Notes:

Grows along channel edges
Completely aquatic
Long, limp leaves
1-3 meters long
Flowers crowded

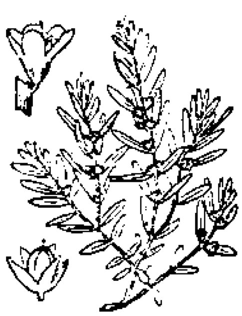


COMMON RUSH

Juncus sp.

Notes:

Stems round, dark green
Nonwoody
5-15 dm high
Grows in clumps



SEA MILKWORT

Glaux maritima

Notes:

Fleshy, opposite leaves
Flowers white or pinkish
Nonwoody

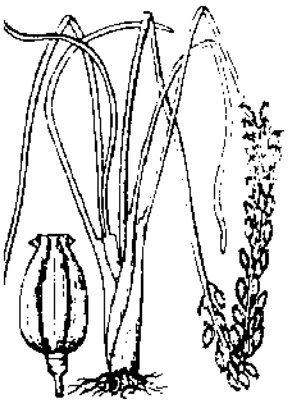
GIANT VETCH

Vicia gigantea

Notes:

16-30 leaflets
Usually climbing
Flowers tan to yellowish, often tinged with purple
Pods about 2 cm long or less

Vascular Plants of the Salt Marsh and Fringe Zone



SEASIDE ARROW GRASS

Triglochin maritima

Notes:

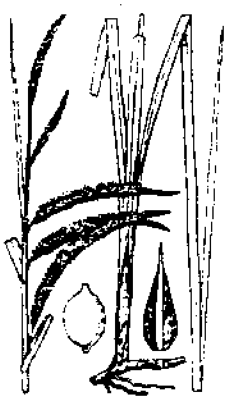
Fleshy-appearing grass
Stands erect
1-7 dm high

SALT GRASS

Distichlis spicata

Notes:

Long rhizomes (root-like structures running along the ground)
10-60 cm tall
Salt crystals often visible on leaves

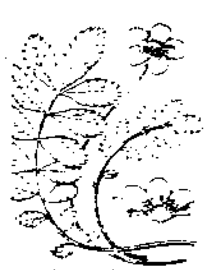


SEDGE

Carex sp.

Notes:

Stems often triangular at base
Slender plant
5-15 dm high



PACIFIC SILVERWEED

Potentilla pacifica

Notes:

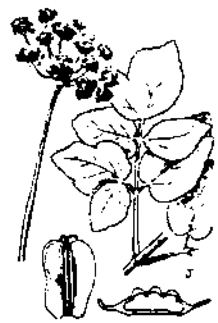
Silvery-white color of undersides of leaflets
Yellow flower
Leaves 2-4 dm long

TUFTED HAIR GRASS

Deschampsia caespitosa

Notes:

Grows in clumps
Blades have coarse veins
Seed-bearing stems are taller than leaf blades
60-120 cm tall

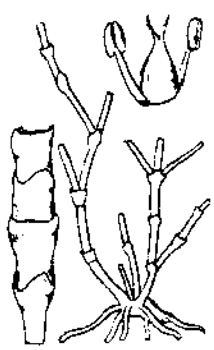


ANGELICA

Angelica sp.

Notes:

Large, flowering umbel (flower cluster)
Compound leaves
White flowers



PICKLEWEED

Salicornia pacifica

Notes:

Appears as if it has no leaves
Succulent stems
Branches 16-20 mm long

SULPHUR PEA

Lathyrus sulphureus

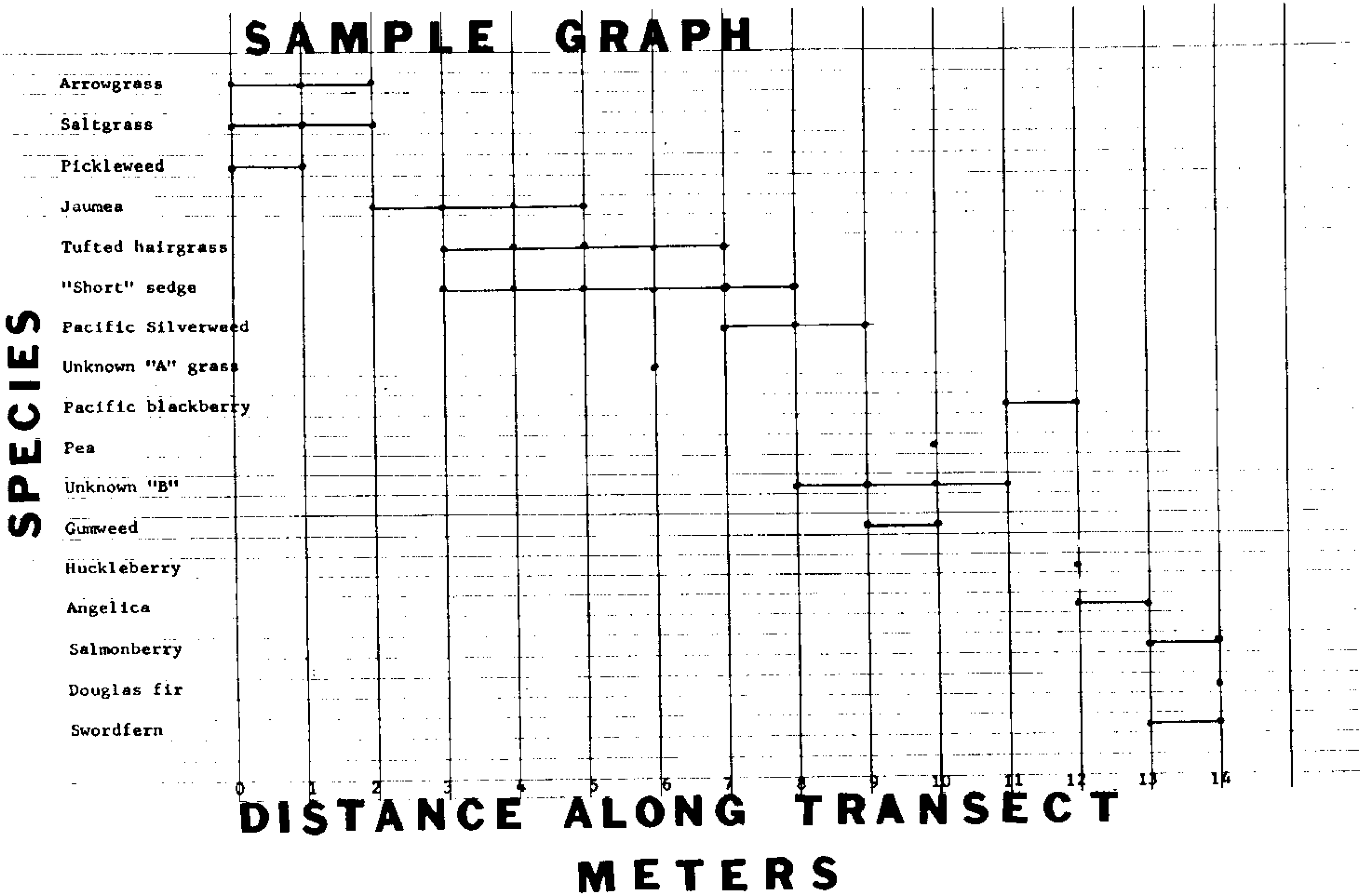
Notes:

Tendrils on ends of leaves anchor the plant to other vegetation
Thin leaves 5-10 dm long
Flowers tan to yellowish or orange

Instructions for Graphing

1. Label your graph paper: South Slough Vegetation Transect.
2. Label horizontal axis: Distance along transect (in meters).
3. Label vertical axis: Species.
4. Along the horizontal axis, for each quadrat, write the distance from the beginning of the transect in meters.
5. In the top left corner, make three large dots in a vertical column above the zero distance for the three most abundant plant species found in the first quadrat. (See examples in Field Manual.)
6. On the line above the next quadrat distance, make dots for the three most abundant species found there. If there are new species, drop down a line to make your dot.
7. Continue until you have plotted all of your data.
8. Connect the dot of species which were found in adjacent quadrats.

SAMPLE GRAPH



Field Study 4

Physical Factors of the Estuarine Environment

Purpose:

To become aware of some of the physical factors in the estuary and how they might affect the plants and animals there.

Materials:
1 salinometer and probe
Thermometers (1 per team)
Large flasks for collecting creek water (1 per team)
2 hack kits: dissolved oxygen, phosphates
Current tide tables (3 per team)
Tideflat samples (for use at high tides)
1 sample bottle per team
Bucket and rope
Trowel
Ocean water sample

Introduction:

Because of its changing conditions, the estuary is a difficult place for organisms to live and thrive. Animals and plants have adapted to live in this changing environment.

I. Weather

Introduction:

Weather, when taken into account over a long period of time, makes up the climate of an area. Climate is one of many limiting factors that determine which animals and plants can live here.

Procedure:

1. Record the time.____________
2. What percent of the sky is covered by clouds (a quarter of the sky would be 25 percent)?________________
3. Is it raining? _________
4. Measure the air temperature in centigrade.__________
5. Measure the mud temperature in centigrade.__________

II. Nutrients and Dissolved Oxygen

Introduction:

Primary productivity is the amount of carbon stored in plant tissue in a given area and length of time by photosynthesis. Some estuaries have incredibly high productivity, higher than anything we can achieve with our most advanced farming techniques. One thing that allows for high productivity is the availability of nutrients which are vital for plant growth. Nutrients are supplied from the land, the sea, and the estuary itself. Two of the major nutrients that are essential for plant growth are phosphates and nitrates. During our tests today we will be testing for phosphates.

Having enough dissolved oxygen in the water is vital for animals to survive. Bacteria, which are so important for recycling nutrients from dead plants and animals, also use up a lot of oxygen.

Procedure:

The team should break into two groups. The group responsibilities are to conduct the following tests:

Group A	Group B
+Dissolved oxygen in creek water	+Dissolved oxygen in estuary water
+Phosphates in estuary water	+Phosphates at 2 cm level of mud flats

CAUTION:

The chemicals used in the Hach kits are caustic and may cause burns. BE VERY CAREFUL not to allow contact with skin, eyes, or clothing. In case of contact, flush with water for 15 minutes. See the individual chemical containers for further instructions. An eye wash kit is included in the day pack.

Dissolved Oxygen:

1. Follow the instructions in the Hach kit for the HIGH RANGE test.

2. Take special note under step 3 regarding the statement "Note the floc will not settle in samples with high concentrations of chloride, such as sea water. No interference with the test results will occur as long as the sample is allowed to stand for four or five minutes."

3. While you are waiting four or five minutes, do the section on tides and weather.

4. If it is low tide, you may have to go to the end of the Slough Side Dike to get estuary water. Use the bucket and rope to help get a sample.

5. Record your data here: DISSOLVED OXYGEN MG/L

ESTUARY ______________

CREEK ________________

Phosphates:

1. Follow the instructions in the Hach kit for the LOW RANGE test.

2. When using the color comparator, hold a piece of white paper up behind the viewing ports. Try squinting with one eye when viewing the color comparator. Some of the shades of blue will be very light. Try to be as precise as possible when determining your results. A good idea would be to do three color matches of each sample and then average to get your result.

3. When you finally arrive at an average number, be sure to DIVIDE BY TEN to place your figure in the low range scale.

4. Here are some special instructions for sampling the phosphates in the mud flats. IF IT IS A HIGH TIDE, USE THE SAMPLES THAT ARE PREPARED FOR YOU. During low tides collect and prepare your sample as follows:

   2 cm depth sample: SKIM the surface of the mud flat to get about ONE teaspoon of mud. Now fill the jar half full with distilled water. Cap the jar and shake to mix thoroughly. Now use the funnel and filter paper to filter your mud sample into the two test tubes found in the Hach kit.

5. Record your data here: PHOSPHATES MG/L

ESTUARY ______________

2 cm LEVEL OF MUD FLATS ________________

Conclusions:

Now assemble into your large team and answer the following questions:

1. It has been determined that salmon need at least 5 mg/l of dissolved oxygen to survive as they pass from the ocean to their freshwater streams to spawn. From your dissolved oxygen tests, can the estuary support salmon passage through its waters? (yes or no) __________. (Note: Fish can often tolerate lower D.O. levels for periods of time.)

2. It has also been found that salmon need at least 5 mg/l of dissolved oxygen in the freshwater streams to successfully spawn and support the development of young fish. Does the stream that you sampled have enough dissolved oxygen in it to support spawning salmon? (yes or no) __________.

3. Where did you find the most phosphates? ____________________

____

4. What role do dissolved oxygen and bacteria play in the process of nutrient recycling? ____________________

____

5. What are some possible sources of phosphates that are later deposited on the surface of the mud flats? ____________________

____

6. List at least two factors that affect the amount of dissolved oxygen that is found in water. ____________________

____

III. Tides

Introduction:

Here at the bottom of the Estuary Study Trail, the landscape looks very different, depending on the height of the tide. Tides have a large impact on the lives of the plants and animals here. The twice daily tidal cycles may be the limiting factor preventing many organisms (animals and plants) from living in the tideflats or salt marsh. The tidal cycles may limit plants and animals to certain zones.

Procedure:

1. In the water at the end of the Slough Side Dike, you will find a staff marked in feet. It shows the distance from the bottom of the channel. You will use it to determine the proper correction factor for high (or low) tide using the Humboldt Tide Table. Where would high tide happen first? The jetty at the mouth of the Coos Bay Estuary, or here, 3 1/2 miles upstream at the base of the Estuary Study Trail? ______________________

2. In the chart below, record the level of the water on the graduated staff, the time, and whether the tide is coming in, going out, or slack. (Slack tide is when the tide is not coming in or going out.) Record this information at several different times when you come back to the dike. Remember, you'll be using the marks on the staff to measure only a change in the level of the tide. It is totally different from the tide height given in the tide table.

Staff level	Time	Tide direction	Change (+ or 1)
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________

3. Look under today's date in the tide table. When is high tide? ______________ When is low tide? ______________

4. What is the proper correction factor for the time of high tide ______________ or low tide ______________ here at the Slough Side Dike?

IV. Salinity and Temperature

Introduction:

The amount of salt in the water, or the salinity, is a very important part of the physical environment for all the plants and animals that live here.

A drastic change in salinity, such as times when all the fresh water from a heavy rain storm hits the estuary, can cause clams and oysters to close their shells tightly and stop feeding until the salinity returns to a tolerable range. The salinity of water is measured in parts per/thousand (/oo). This means that there are x parts of salt in 1000 parts of water. In this activity you will compare the salinity of estuary, creek, and ocean water.

Procedure:

Use the salinometer with care.

1. Plug probe (on spool) into jack on side of salinometer.
2. Switch the MODE knob to RED LINE. Use RED LINE control (the other knob) to adjust meter needle to the red line (between 300 and 400 on the upper scale).
3. Now place the probe in the creek water sample bottle.
4. To measure the temperature, switch the MODE knob to TEMPERATURE. Record the meter reading when the needle is steady.
5. To measure salinity, set the upper C control knob to the temperature you just measured. Switch MODE to SALINITY. Read the red S /oo scale. Record the salinity of the creek water in parts per thousand.
6. Next, you will measure the temperature and salinity in the water of South Slough Estuary. If the tide is really low you may have to go to the end of the Slough Side Dike to test the estuary water.
7. Try to not stir up the mud when taking the salinity measurement of the estuary. Follow instructions 4 and 5 above.
8. Now measure the temperature and salinity of the ocean water sample. Note: since this sample has been previously collected, the temperature will not accurately reflect that of the ocean.

Estuary water	Creek water	Ocean water
________ C	________ C	
________ Salinity in o/oo	________ Salinity in o/oo	________ Salinity in o/oo

9. Is the salinity of the estuary closer to that of seawater or creek water?

____

10. When do you think the salinity in the estuary would be highest (saltiest), high or low tide?

____

During stormy winters or in dry summers? _______________________

NOTES: Two types of salt are primarily responsible for the saltiness of seawater: Sodium chloride and magnesium chloride.

For those who are curious, the MHOS (upper) scale of the salinometer is for conductivity. The OHMS scale measures resistance. Resistance is the opposite of conductivity.

11. The animals and plants that live in an estuary have become adapted to life in a changing environment. List four environmental changes that you observed.

____

____

____

Field Study 5

Creatures of the Mud

Purpose:

To find out what kind of animals live in a mud flat.

Materials:
- Clam gun
- 2 trays
- Bucket with rope
- Petri dishes
- 8 - hand lenses
- 8 - pairs of tweezers
- Sieve set

Introduction:

Each group will take only one sample of the mud flat for analysis. In order to minimize impact on the mud flat, use a previous group's sample for analysis rather than taking a new one.

Procedure:

1. Venture out onto the mud flat walkway. BE CAREFUL--IT MAY BE SLIPPERY! Look closely at the surface of the mud flat. Describe any evidence that animals live there.

   ____

   ____

   ____

2. Using the clam gun, collect a sample from the mud flat to a depth of around 4 inches. Use your hand to hold the bottom of the sample in the gun until you transfer it to a white collecting tray.

3. Compare the color of the top section of the mud core sample with the color of the bottom. Describe your findings.

   ____

   ____

   ____

4. Sort through your sample and place any obviously large creatures in separate petri dishes.

5. Now place part of the sample on the sieve (screen) set. Using the bucket and rope, get some water from the estuary and begin screening your sample. Separate and break down large chunks to thoroughly screen. Repeat with more water as necessary.

6. Sieve the rest of your sample using this method.

7. Separate the stack of sieves and begin serching for signs of life. Sort all similar looking creatures into petri dishes. This sieving process not only separates creatures by size but also separates sediment particles by size.

8. Identify the species by using the picture keys found in this lab.

Species	# of specimens found
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________

Answer Key to

EER Student's Field Guide

<u>Field Study 1--Observe and Interpret</u>

1. (Huckleberry) Leaves shiny green; bell-shaped flowers, purple to black berries.

2. Metal spikes.

3. Clearings are located in the vicinity of the "Skunk Cabbage Catwalk" and the "Lookout."

4. Possible choices are skunk cabbage, hedge nettle, and Port Orford cedar.

5. Various answers are possible here.

6. Lone Tree Island, Heron Haven, and Otter Island should be marked.

7. One way would be to determine the age of the trees on the dike using an increment borer to obtain a sample of the trunk. The age rings in the sample are then counted.

8. A hay rake has been abandoned there.

9. The weirs were made in a "V" shape with an opening at the apex. The apex of the "V" points in the direction of the flooding tide. One branch of the "V" blocks off a channel area. The fish are able to swim through the opening and around the weir during flooding tides but are trapped between the weir and the mud flat as the tide ebbs. See the diagram to the right.

   The "fake weir" is located in the channel immediately below "The Lookout."

   A diagram showing the placement of a fish weir.

10. Both cars are Hudsons.

11. A great blue heron flies with its neck folded back in an "S" curve and with its legs swept back against its body.

12. One cut-bank is at the base of "The Lookout," along the "Marshside Trail." The second cut-bank is along the "Timber Trail" where the sundews are located.

13. The leaves of the sundews are covered with red-stalked, sticky hairs capped by a bulbous tip. Small animals, such as ants, are trapped on the hairs and then digested for their nitrogen content.

14. Answers variable.

15. Answers variable.

16. Answers variable.

Field Study 2--Plankton Tow

The answers for this section are dependent on specific conditions at the time of sampling. The only fixed answers are

3. B. 20 cm

3. C. 314.2 cm^2

Field Study 3--Vegetation Transects in the Salt Marsh

1. Possible physical factors are
   a. changes in available sunlight
   b. changes in the soil
      i. particle size
      ii. organic content
      iii. salinity
      iv. water-holding capacity
   c. changes in soil moisture
      i. frequency and duration of flooding
      ii. salinity of flooding waters

2. The answer to this question depends to some degree upon the specific location of the transect. In general, you would expect to find a greater diversity in the transition zone between the uplands and the salt marsh.

3. In general, the edge of the salt marsh at the tideflats is the lowest portion of the marsh. The constantly wet and exposed nature of this area makes it difficult for plants to adapt to the physical conditions found there and fewer plants have been able to do so.

Field Study 4--Physical Factors of the Estuarine Environment

I. Weather

Answers variable.

II. Nutrients and dissolved oxygen--conclusions

1. Answer variable. Please be aware that the South Slough does have annual migrations of salmon through it.

2. Answer variable.

3. Most phosphates are located within the first 2 cm of the mud flats.

4. The bacteria near the surface of the sediment use oxygen in their metabolic processes. In these processes organic material serves as an energy source. The waste products given off are nutrients, such as phosphate and nitrate, which plants then utilize for growth. Therefore, the bacteria serve a key role in nutrient recycling by converting organic compounds into nutrients for plant growth.

5. In general there are two sources of phosphates available on the surface of the mud flats. One is detritus and the other is algae living on the surface of the mud. Sources of organic detritus include marsh plants, eelgrass, dead fish, tree leaves, dead plankton, and animal waste products.

6. Factors which affect the amount of dissolved oxygen found in water include water temperature, the concentration of aerobic bacteria present, the rate of turbulent mixing that occurs, the time of day, and the density of animals living in the area.

III. Tides

1. At the jetty.

2. Answers variable.

3. Answers variable.

4. Data to answer this question is being gathered from the classes using this curriculum. You can expect that at least one of the student groups during the day will be measuring the tide level at or very close to the ebb high or low tide. The time difference between the time of that observation and the ebb time in the tide table is the correction factor being sought.

IV. Salinity and temperature

7. Answers variable.

8. The answer to this question will depend on the time of year. During the summer low runoff period, the salinity of the water will be nearly that of sea water. During the winter high runoff period, the salinity will be nearly that of fresh water.

9. First part - <u>high</u> Second part - <u>dry summers</u>

10. This question is actually a question designed to synthesize the information from several sources. Possible answers to this question are

    a. salinity

    b. tides

    c. time of exposure to air

    d. temperature

    e. dissolved oxygen

    f. nutrient levels

<u>Field Study 5--Creatures of the Mud</u>

1. Evidence includes coiled fecal castings on the mud, burrows, shells, and the tracks of birds and animals of various kinds.

3. There will be a thin surface layer of brown to orange-brown sediments. This color is due to the presence of oxidized iron. The remainder of the sediments will be black. This is due to the presence of iron sulfide, FeS, indicating oxygen dificient conditions. If the core includes a burrow, for example of a mud shrimp, there will be a thin, brownish layer surrounding the burrow for the reason given above.

8. Answer variable.

Miscellaneous

Note

The following odd-numbered pages are master copies: 285-297. One copy per student will be required.

Curriculum Test

Instructions: Place the letter of the answer you choose on the line provided.

_____ 1. The average salinity of the ocean is

A. 35°/oo
B. 3.5°/oo
C. 0.5°/oo
D. 15%

_____ 2. The salinity of an estuary is

A. 0.5%
B. 35°/oo
C. 35%
D. variable

_____ 3. Which of the following produces its own food by the process of photosynthesis?

A. copepod
B. Corophium
C. nekton
D. detritus
E. phytoplankton

_____ 4. The estuarine habitat which has the greatest exposure to air is

A. the mud flat
B. the channel
C. the salt marshes
D. the swamps

_____ 5. Halophytes are

A. benthic animals
B. diatoms which coat the mud flats and the leaves of eelgrass
C. flowering plants that live in saline soils
D. wet areas supporting grasses and grass-like plants and which are covered by an occasional very high tide

_____ 6. Which of the following could not become detritus?

A. a salt marsh plant
B. a plastic bag
C. a rotting pier piling
D. a dead duck

_____ 7. The main role that salt marshes play in the estuarine ecosystem is to provide

A. detritus
B. shoreline protection
C. secondary production
D. upland habitat

_____ 8. Adaptation is

A. any genetic modification in a group of organisms that makes them better suited to live and reproduce in their environment
B. a regular change in a variable in a specific direction
C. the wide range of genetic characteristics seen within a species
D. a part of a cell that passes genetic characteristics along from generation to generation

_____ 9. In the Coos Bay estuary, the largest amount of which estuarine habitat has been lost through the activities of man?

A. channels
B. open water
C. mud flats
D. salt marshes

_____ 10. Primary productivity is

A. not a particularly noteworthy characteristic of estuaries
B. a measure of the amount of animal biomass upon which other animals feed
C. a measure of the amount of detritus in an ecosystem
D. a measure of the number of grams of plant material produced per square meter per day

_____ 11. Plankton is the term for

A. microscopic particles of dead organic material floating in the water
B. the bacteria found floating in the estuary waters
C. aquatic plants or animals, usually microscopic, that are dependent upon water currents for movement
D. the organisms in a given area that interact with each other and their environment

_____ 12. The ocean tides are caused mainly by

A. the pull of the moon on the ocean
B. the centrifugal force due to the earth spinning on its axis
C. the pull of the sun on the ocean
D. the shape of the coastline and the bottom of the ocean along the coast

_____ 13. Upland vegetation is important to the estuary because

A. the upland vegetation contributes organic materials to the estuary
B. the upland vegetation helps prevent excessive erosion of the estuary shoreline
C. the upland vegetation protects the tributary streams emptying into the estuary
D. the upland vegetation contributes organic materials, helps prevent excessive erosion of the shoreline, and protects the tributary streams.

_____ 14. Logging activities in the watershed of an estuary

A. cannot occur without having negative effects on the estuary
B. can occur any place except on the banks of the estuary without worrying about effects on the estuary
C. can occur anywhere without having negative effects on the estuary as long as all logging roads are well constructed and maintained
D. should not occur until all aspects of the operation are reviewed to see what their effects might be on the estuary and the tributaries emptying into it

_____ 15. Of the many economic uses of estuaries, two of the most recently developed are

A. oyster culturing and salmon ranching
B. recreational fishing and clamming
C. shipping and boat moorage
D. log storage and transportation

_____ 16. People's earliest use of estuaries was for

A. locating dock facilities to store goods and materials for transportation into the interior of the country
B. harvesting their abundant food resources
C. diking the marshes for cattle grazing and farming
D. transporting logs to lumber mills

_____ 17. The key to the wise use of our estuaries is

A. letting the courts decide what are the wisest uses of them
B. developing more rules and regulations for those people using them
C. cooperation among all of its users
D. stopping any further use of them

_____ 18. In general, an estuary has a sediment gradient from the mouth to the head of the estuary consisting of

A. mud, sand, sandy mud, and muddy sand
B. sand, sandy mud, muddy sand, and mud
C. mud, muddy sand, sandy mud, and sand
D. sand, muddy sand, sandy mud, and mud

_____ 19. The life cycle of the coho salmon consists of

A. fertilization of the eggs, hatching of the eggs into alevin, growth of the alevin into fingerlings, migration of the fingerlings into the estuary to become smolts, migration of the smolts into the ocean, and return of the adults to the streams to spawn
B. fertilization of the eggs, hatching of the eggs, migration of the juvenile salmon into the estuary, and the return of the adults to the ocean to spawn
C. fertilization of the eggs, hatching of the eggs, settling of the larvae, metamorphosis of the larvae into adults, and migration of the adults into the streams to spawn
D. fertilization of the eggs, hatching of the eggs, migration of the larvae into the estuary, metamorphosis of the larvae into adults, migration of the adults into the ocean, and the return of the adults to the streams to spawn

_____ 20. One of the fish that uses the estuary as a nursery is the

A. Pacific herring
B. Corophium
C. sanderling
D. Zostera

Instructions: To answer the questions below, fill in the blanks with a word from the following list. Only one word goes in each of the 20 blanks.

anadromous	filling
agriculture	habitat
aquaculture	manage
bacteria	neap
condensation	oxygen
decomposers	photosynthesis
detritus	phytoplankton
dredging	respiration
ecosystem	salinity
enhancement	salmon
estuary	spring
evaporation	trout
inorganics	

1. One major food web in the estuary is based on the large amount of ______________ present and the other major food web is based on the large numbers of ______________ found there.
2. An ______________ is a place where fresh water from the land mixes with the salt water of the ocean.
3. ______________ is a measure of the amount of salt in the water.
4. Approximately every 26 days there is a series of higher than average tides called ______________ tides and a series of lower than average tides called ______________ tides.
5. ______________ and ______________ of mud flats and salt marshes are two activities that are often necessary for the economic development of an estuary.

6. Fish, like salmon, that hatch in fresh water, become adults in the ocean, and then return to fresh water to spawn are called __________.

7. STEP stands for the ______________ and __________ ____________ Program.

8. ______________ is the raising and harvesting of aquatic organisms for human use.

9. ______________ is the process whereby plants use the sun's energy to produce sugars from carbon dioxide and water, with oxygen given off as a waste product.

10. When organic waste is dumped into an estuary, bacteria use the _____________ dissolved in the water to sometimes create anaerobic conditions.

11. Organisms, like bacteria and fungi, that break down organic materials into nutrients are called the ________________.

12. A group of living organisms that interact with each other and their environment is called an ___________________.

13. The place where an organism naturally lives and grows is a ________.

14. The South Slough Estuarine Sanctuary was established in order to help gather information so we can better _____________ our estuaries.

15. The water cycle involves the continual ______________ of fresh water from the oceans and the return of that water to the oceans by the rivers of the world.

Essay questions:

1. You are the director of the Department of State Resources Protection and Development. One part of your job is to protect the natural resources of your state. Your department is also responsible for reviewing written plans for all development projects in estuary waters and wetlands. If a project does not cause the irreversible loss of significant estuarine resources, you issue all required dredge and fill permits.

   Two years ago you issued a permit to fill 20 acres of mud flats in an estuary covering 20,000 acres. Work was started by building a dike partly around the fill area. Now the developer wishes to complete the fill. The permit has expired so your department has received a request for renewal of the original permit. You have 30 days to make a decision. Yesterday the staff biologist reported that a 22 acre eelgrass bed has formed in the fill area. Fish are spawning in the eelgrass, making the area one of only three places in the estuary where they do spawn. What is your decision? Use the facts outlined above to justify your decision.

2. How does the movement of the tides affect the estuary?

Answer Key to Curriculum Test

Multiple Choice

A 1.
D 2.
E 3.
C 4.
C 5.
B 6.
A 7.
A 8.
D 9.
D 10.
C 11.
A 12.
D 13.
D 14.
A 15.
B 16.
C 17.
B 18.
A 19.
A 20.

Fill in the Blanks

1. detritus, phytoplankton
2. estuary
3. salinity
4. spring, neap
5. dredging, filling
6. anadromous
7. salmon, trout enhancement
8. aquaculture
9. photosynthesis
10. oxygen
11. decomposers
12. ecosystem
13. habitat
14. manage
15. evaporation

Sanctuary Facilities

In addition to the services of an on-site coordinator, the Sanctuary also has available an overnight facility capable of housing up to 35 students at a charge of $2.50/person/night. This two-story ranch-style house was a former private residence and offers a standard equipped kitchen, two full bathrooms, and both upstairs and downstairs sleeping space on the floor. For more information about this opportunity, contact the Sanctuary directly.

Other Points of Interest in the Bay Area

Bastendorff Beach County Park	Near Charleston
Cape Arago State Park	Near Charleston
Charter fishing	Charleston
Coos Art Museum	5th & Market, Coos Bay
Crabbing, clamming	Coos Bay
Marshfield Sun Building	Front & Bayshore, Coos Bay
Mingus Park	10th & Commercial, Coos Bay
Shore Acres State Park (Botanical Garden)	Near Charleston
Sunset Bay State Park	Near Charleston
Simpson Reef--Sea Lion Observation Point	Near Charleston
North Bend indoor swimming pool	North Bend

Tours

Weyerhauser Co. 3050 Tremont North Bend	756-5121	Friday's at 1:30 pm Length--1 1/2 hours FREE
House of Myrtlewood 1125 S. 1st Coos Bay	267-7804	Anytime during business hours Hours: 8:30 am-5:30 pm 7 days a week FREE
Coast Guard Air Station 2000 Connecticut North Bend	756-4142 Mr. LaMontagne	Schedule ahead FREE
USCGC Citrus Port Dock Coos Bay	269-5859	Schedule ahead to see if the cutter is in FREE
Coast Guard Lifeboat Station Charleston	888-3266	Schedule ahead FREE
Coos-Curry Historical Museum Simpson Park North Bend	756-6320	Hours: T-Sa 10:00 am-4:00 pm FREE
The World Newspaper 350 Commercial Coos Bay	269-1222	Call for hours FREE
Tap Fisheries Charleston	888-3251	Schedule ahead FREE
Qualman Oyster Farms Crown Point Road Charleston	888-3145	Schedule ahead FREE

Annotated Bibliography

Clean Water, Streams and Fish: A Holistic View of Watersheds.

Wendy Borton, Lavonne Bucher, Claire Dyckman, Art Johnson, and Bill Way. Washington State Office of Environmental Education. 1983. 292 pages.

An in-depth look at salmonids for upper elementary grades and middle schools. Topics include habitats, threats, solutions, and contemporary issues.

The Estuary Book.

Mollie Bryne and Kip Anastasiou. University of British Columbia and Province of British Columbia, Ministry of the Environment. 1981. 39 pages.

Contains six pages of background reading. Twenty-two pages of field and lab activities and detailed line drawings. Mainly written for a high school audience. Contains units on harbor study and on physical and biological aspects of estuaries.

The Estuary: Exploring the Fertile Complex Realm Where the River Meets the Sea.

William H. Amos. Defenders of Wildlife, Inc. Educational Supplement No. 55-4-a. 1224 Nineteenth St., N.W., Washington, D.C. 20036. 1980. 15 pages.

Fantastic color photography complemented with a National Geographic writing style. Discusses mismanagement of estuaries, evolutionary significance, bio-economics, productivity, and habitats.

Estuary, What a Crazy Place: Wildlife of Coastal Waters.

Lee D. Salber. National Wildlife Federation. 1979. 19 pages.

A very readable overview of what an estuary is, species diversification, habitat changes and discussion of problems and solutions surrounding management.

Guide to Marine Ecology Research: A Curriculum for High School Students.

Project MER. Office of the Superintendent of Schools, 685 A St., Hayward, CA 97451. No date. 121 pages. $5.50.

Project MER was designed to involve students in a monitoring program to provide critical information for the management of the San Francisco Bay-Delta estuary complex.

A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae.

Deboyd L. Smith. Kendall/Hunt Publishing Co., 2460 Kerper Boulevard, Dubuque, IA 52001. 1977. 161 pages.

This paperback contains excellent line drawings of phyto and 300 plankton. The key and glossary add to its value as a reference book for the plankton lab.

Intertidal Salt Marshes of Oregon.

Theodore R. Boss. Sea Grant College Program, Oregon State University, Corvallis, OR 97331. SG 63. 1981. 7 pages. 50¢.

A presentation of some of the underlying ecological concepts of salt marshes including adaptation. Also discusses the need for the protection of estuaries.

Descriptions and Information Sources for Oregon Estuaries.

David Bella, Peter Klingeman, Katherine Percy, and Chet Sutterlin. Sea Grant College Program, Oregon State University, Corvallis, OR 97331. ORESU-H-74-001. 1974. 294 pages. $2.50.

Includes general and hydraulic descriptions and biological, physical alteration, and use information for 21 Oregon estuaries.

Oregon's Fragile Few...Estuaries.

Gerald R. MacLeod. American Fisheries Society, Estuary Conservation and Development Committee, Oregon Chapter. No date. 15 pages.

A guide describing the estuary and why it is so fragile. Includes facts and figures about the natural wealth of estuaries.

SG 9 Phytoplankton: Grass of the Sea. 25¢

This publication discusses the different types of phytoplankton, productivity, and the forces which affect productivity in the sea.

SG 63 Intertidal Salt Marshes of Oregon. 50¢

How salt marshes are formed, the types of plants growing in marshes, and the importance of salt marshes to estuaries are discussed in this publication.

SG 30 Catching, Cooking and Cleaning Bay Crabs. 25¢

This bulletin shows the methods of catching and cooking bay crabs. It includes instructions for building a crab ring.

SG 35 Oregon's Everchanging Coastline. 50¢

This bulletin covers the physical forces which shape Oregon's coastline and her beaches.

SG 45 Today's Youth in Tomorrow's Sea. 50¢

A pamphlet about the marine career opportunities for young people.

SG 25 Understanding Tides. 25¢

Discusses the forces which cause the tides. Includes diagrams and illustrations showing the influence of the sun and moon on the earth which causes tides.

SG 13 Oyster Farming. 25¢

This bulletin discusses culturing, harvesting and processing oysters in Oregon.

FILM Estuary: Columbia's Link With the Sea. ($20 rental fee)

These materials may be ordered through: Oregon State University
Sea Grant College Program
AdS 418
Corvallis, OR 97331

-- Tides and Marshes. Chris Pouler. University of Maryland Sea Grant Program. Publication No. UMSG-ES-79-01. 37 pages.

Detailed explanation of tides and how they affect the marsh. Activities for the junior high student include learning how the sun and moon affect the tides, how often the tides change, and more.