DOCUMENT RESUME

ED 289 684 SE 048 769

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TITLE Tides. Ocean Related Curriculum Activities.
INSTITUTION Pacific Science Center, Seattle, Wash.; Washington Univ., Seattle. Washington Sea Grant Program.
SPONS AGENCY National Oceanic and Atmospheric Administration (DOC), Rockville, Md. National Sea Grant Program.; Washington Office of the State Superintendent of Public Instruction, Olympia.
PUB DATE 80
NOTE 67p.; Drawings may not reproduce well.
AVAILABLE FROM Pacific Science Center Giftshop, 200 2nd Ave. North, Seattle, WA 98109 ($6.00).
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Astronomy; Earth Science; Environmental Education; Interdisciplinary Approach; Marine Biology; *Marine Education; *Oceanography; *Science Activities; Science and Society; Science Curriculum; Science Education; *Science Instruction; Secondary Education; *Secondary School Science; Water Resources
IDENTIFIERS *Project ORCA; Tides; Washington

ABSTRACT

The ocean affects all of our lives. Therefore, awareness of and information about the interconnections between humans and oceans are prerequisites to making sound decisions for the future. Project ORCA (Ocean Related Curriculum Activities) has developed interdisciplinary curriculum materials designed to meet the needs of students and teachers living in Washington State. Each activity packet provides the teacher with a set of lessons dealing with a particular topic related to the oceans. Included are student worksheets, lesson plans, a vocabulary list, and a bibliography. This activity packet, designed for the junior high level, is an introduction for students to the nature of tides. It includes activities designed to aid the student in understanding the relationship between the tides and the position of the sun, moon and earth. Other activities aid students in reading tide charts and in making predictions about tides. The skills students learn are used in a final activity that examines tidal activity in Puget Sound. (TW)

TIDES

ORCA

OCEAN RELATED CURRICULUM ACTIVITIES

PACIFIC SCIENCE CENTER / SEA GRANT
MARINE EDUCATION PROJECT

ANDREA MARRETT, AUTHOR
ANDREA MARRETT, MANAGER

ORCA PUBLICATIONS

ELEMENTARY

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

JUNIOR HIGH

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

SENIOR HIGH

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

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

PROJECT ORCA

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

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

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

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

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

ACKNOWLEDGEMENTS

The Ocean Related Curriculum Activities (ORCA) are a product of a cooperative effort. These materials were developed at the Pacific Science Center. Assistance was provided by the National Oceanic and Atmospheric Administration (NOAA) Sea Grant held by the University of Washington. The Office of the Washington State Superintendent of Public Instruction provided technical support and assistance.

TRIAL TEACHERS

Trial teachers test us and answer the most important question of all: "Does it work?" The teachers who gave their time, effort and advice were:

Lynda Hughes and Allen Husker, Edmonds School District
Lee Boulet; Highline School District
Barbara Deihl and Susan Swenson; Kent School District
Andrea Marrett; Lake Washington School District
Claire Jones and Jenifer Katahira; Pacific Science Center School for Science
Greg Aveleson, Joe Budde and Mary Ketcham; Renton School District
Margaret Bonham, Ivan Ellis, Willim Lippit, Barb Norsen and Jay Sasnett; Seattle School District

CONSULTANTS

Several marine consultants provided valuable assistance and expertise. Our grateful thanks to:

Wolf Bauer, Hydraulic Engineer, Seattle
Dave Borden, Director of the Marine Science Center, Poulsbo
Dennis Campbell, Teacher, Edmonds School District
Alyn Duxbury, Ph.D., Assistant Director for New Programs, Division of Marine Resources, University of Washington
Charles J. Flora, Ph.D., Director of Aquatic Studies, Western Washington University
Charles Hardy, Coordinator, Math and Science, Highline School District
Richard Sternberg, Ph.D., Department of Geology, University of Washington

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

Ann Foley, Reading Specialist; Edmonds School District
Angela Hoffman, Teacher, Pacific Science Center
David Kennedy, Supervisor of Science and Environmental Education, Office of the Superintendent of Public Instruction
Nan Munsell, Supervisor for the Archeology Project, Pacific Science Center
Pam Phillips, Program Assistant, Pacific Science Center
Ann Sankey, Manager of Elementary Programs, Pacific Science Center
Elizabeth Sears, Biology Teacher, Edmonds School District
Jan Turnbull, Environmental Education and Energy, Shoreline School District
Beverly Williams, Education Intern, Pacific Science Center

Other consultants who offered their time and special expertise were:

Sally Snyder, Ph.D., Anthropologist
Hilary Stewart, Author
Jerry Strain and Joel Rogers, Photographers
Terry Taffoya, United Indians of All Tribes

ADVISORY COMMITTEES

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

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

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Levon Balzer, Ph.D., Dean of Instruction, Seattle Pacific University
Charles Hardy, Coordinator, Math and Science, Highline School District
David Kennedy, Supervisor of Science and Environmental Education; Office of Superintendent of Public Instruction
Roger Olstad, Ph.D., Associate Dean of Graduate Studies, University of Washington, Committee Chairperson
Alice Romero, Teacher, West Seattle High School
Sally Stapp, Teacher, Frank Wagner Elementary
William Stevenson, Superintendent, Shoreline School District

STAFF

Finally, our heartfelt appreciation to the staff members who were instrumental in creating, developing and supporting this project. Thank you to the curriculum writers Jenifer Katahira, Claire Jones, Andrea Marrett, Florence Sands and Sally Snyder. We appreciate the efforts of the people responsible for graphics and paste up; Susan Lundstedt, graphics; Luann Bice, artwork; Valene Starrett, covers; and Andrea Marrett and Carolyn Hanson, paste up. We sincerely thank our project investigator, Bonnie DeTurck, Director of Education and Debbie Fowler, the Marine Education Intern at the Pacific Science Center. We wish also to express our gratitude to Patty Kelley, Jan McLachlin, Leslie Wozniak and Peggy Peterson, for their patience in typing, retyping and alas, typing it all over one more time.

A special thanks to my husband, John Pauls, for all the moral support he provided during the development of these materials and his idea-generating questions.

Shirley Pauls
Project Manager
September 1977 to February 1979

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TIDES (6 days)

ABSTRACT: The Tides activity packet is an introduction for students to the nature of tides. It includes activities designed to aid the student in understanding the relationship between the tides and the position of the sun, moon and earth. Other activities aid students in reading tide charts and in making predictions about tides. The skills students learn are used in a final activity that examines tidal activity in Puget Sound.

SUBJECT AREAS: Science; Oceanography

GRADE LEVELS: Junior High

WRITTEN BY: Andrea Marrett

TIDES

OBJECTIVES:

After completing this Activity Packet, students will be able to: .

1. define what tides are
2. list the factors affecting tides
3. explain the differences between neap and spring tides
4. explain the causes of the neap and spring tides
5. explain the differences between diurnal, semi-diurnal, and mixed tides
6. state which classification of tide is found in Puget Sound
7. read a tide chart
8. predict when neap and spring tides will occur?

TABLE OF CONTENTS AND OVERVIEW:

ACTIVITY 1:

INS AND OUTS OF TIDES

(2 days)

ACTIVITY 1: INS AND OUTS OF TIDES (2 days)

CONCEPTS:

The tides are governed by the relative position of the sun and moon to the earth.

OBJECTIVES:

Following the activity, the learner will demonstrate his/her ability to:

1. define what tides are.
2. determine the phases of the moon.
3. list the factors affecting tides.
4. state the relationship between phases of the moon and the height of the tides. (neap and spring tides)

TEACHER PREPARATION:

1. Before the class, the teacher should read Teacher Information Sheet, Tides.
2. For a more extensive understanding of the tides of Puget Sound, the teacher should read Teacher Information Sheet, Pacific Search reprint, "Washington Tides".
3. Before assigning the two student readings, "Tales of the Tides" and "Variations in a Tide" by Dennis Schatz, the teacher should familiarize him/herself with the content.
4. The teacher should be familiar with reading a tide-calendar chart. See Teacher Information Sheet - Tide Calendar.
5. The teacher should practice preparing a Moon-Tide Wheel and doing the student activity.

MATERIALS:

1. 30 copies each of student readings - "Tales of the Tides" and "Variations in a Tide".
2. 30 copies of Moon-Tide Wheel Activity and Worksheet
3. 1 Moon-Tide Wheel activity made into an overhead transparency - see Teacher Information Sheet - Moon-Tide Wheel for instructions
4. 30 pairs of scissors; 30 brads
5. 1 Tide Calendar transparency

PROCEDURES:

1. Have students discuss what tides are and what causes tides to occur. Probably several will say tides are caused by the moon pulling on the water. (Gravity) Lead the discussion to the definition:

   Tides are the daily rise and fall of the water in the Sound.

2. Following the discussion, distribute copies of the student readings, "Tale of the Tides" and "Variations in a Tide". Have the students complete the readings.

3. Show the film, "Tides of the Ocean" (optional, yet an excellent film. See bibliography for the available sources.)

4. Provide classroom instruction and/or discussion for students. Students must know phases of the moon; gravitational effect of the sun and moon on the tides. If you show the film, this is done in a complete and comprehensive manner.

5. Distribute the materials for the Moon-Tide Activity. Explain to students the procedure for assembling the Moon-Tides-Sun Chart. This activity is designed to help students understand the relationships between the phases of the moon, the hour of the day, and the size of the tide. Hand out worksheets #1 and #2 to the students. Have them prepare the Moon-Tides-Sun Chart.

6. Use the transparency of the Moon-Tides-Sun Chart to explain how to make and use the chart.

7. Use the transparency of the Tide Calendar. Explain to students how to read the Tide Calendar for information about the tides, the times and the phases of the moon.

ASSIGNMENT:

8. After the Moon-Tides-Sun Chart is prepared, hand out Moon-Tide Wheel Assignment to students. Have them complete it and turn it in for evaluation.

EXTENDED ACTIVITIES:

1. Do the E.S.S. Activity, "Where is the Moon?"

2. Visit a planetarium. This helps students visualize the relationships in size and distance between the earth, sun and moon.

3. One may attempt to show the effects of gravitational pull. Obtain a large steel wrecking ball and suspend it from the ceiling. Next to it hang a small pith ball. The relative proximity of the steel ball to the pith ball, as opposed to the earth, allows for "gravity" to work between the steel and pith balls. The steel "attracts" the pith ball. The difficulty here is obtaining and suspending such a large item as a steel wrecking ball.

BIBLIOGRAPHY:

A. Resources Used:

Books

Pless, Dr. Herbert; Ignatuk, Nicholas; and Spennato, Nicholas. Ventures in Science, Specialized Education Systems, Inc., for William H. Sadlier, Inc., New York, N. Y.

Films

Tides of the Ocean, University of Washington, Seattle, Washington ($8.00 rental fee). Also available -- Seattle Public Schools -- or write: Academy Films, 748 N. Seward St., Hollywood, CA 90038.

Student Reading adapted from:

WASHINGTON STATE UNIVERSITY COOPERATIVE EXTENSION SERVICE, Osis, Vicki; and Giles, Don. Washington State University, Pullman, Washington.

4-H Marine Science, February, 1975.

Magazines

Williams, Robert E. and Alyn C. Duxbury, Pacific Search reprint,"Washington Tides", 1975; Washington Sea Grant Communications Program/Division of Marine Resources. University of Washington, Seattle, WA 98195.

B. Suggested Resources:

Films

Tides & Currents, National Oceanic and Atmospheric Administration, Washington Science Center, Rockville, Maryland 20852. (Describes tides, reviews tide-producing forces and their influence.)

Tides

One thing an "inlander" sees on a visit to the Puget Sound is the rhythmic variation in the depth of the water at different times of the day. Coastal people would recognize this variation as the TIDE.

Tides are very important to people who live on Puget Sound. Those who make a living from the sea are influenced in their fishing and shipping by the depth of water resulting from the tides. Other coastal dwellers must keep a wary eye on storms. Storm winds can raise the level of the tide to greater heights. Many marine animals and plants (including commercially important species) are influenced by the tides.

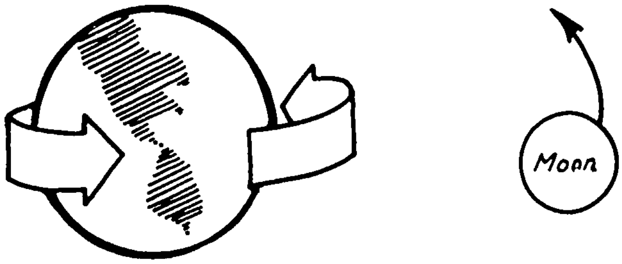
Man has been observing the results of the tide since he took to the sea. Yet, it is only recently that he has been able to explain the tides. Ancienct mariners thought the tide was caused by the breathing of an earth monster. Later in history, when man began recording the events around him, he found the tides to be related to the movements of the moon and its phases.

Although the sun is much larger than the moon, the moon's pull is greater. This is because the moon is so much closer to the earth than the sun. Other celestial bodies also exert a gravitational pull on the waters of the earth, but not very much.

How do the oceans on earth react to the pull of the moon and the sun? The gravitational pull of the moon causes a bulge of water toward itself and on the opposite side of the earth. It is as if the water directly under the moon was being pulled away from the center of the earth, while the earth's center was being pulled away from the water on the opposite side. Actually it is more complicated and involves mathematical calculations of the moon's gravity and centrifugal forces on earth.

The moon's gravity causes two bulges of water on the earth's surface. One toward the moon and one on the opposite side of the earth.

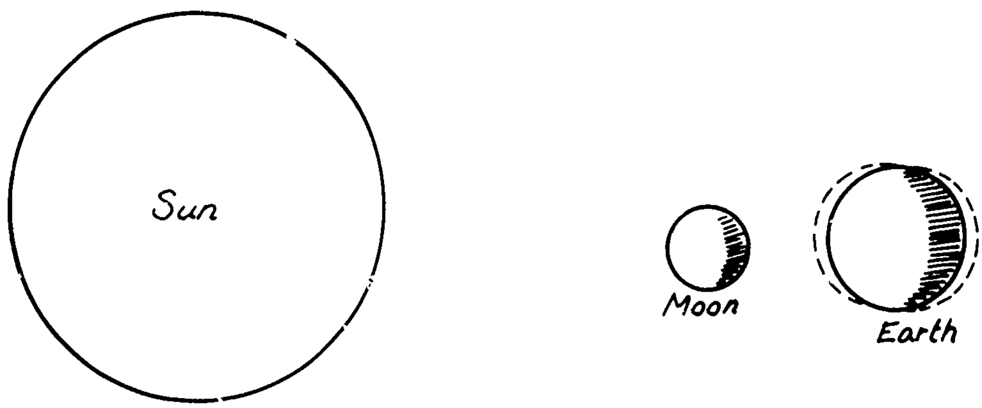
Since the moon travels around the earth once every month, we should have two low and two high tides each month. However, the earth rotates once every twenty-four hours. This results in the daily high and low tides as the earth rotates inside the bulging water envelope. But, if the earth rotates every twenty-four hours, why does the tide average twenty-four hours and fifty minutes? This is because the moon is revolving around the earth in the same direction that the earth is rotating. It takes an average of fifty more minutes for a spot on the earth to complete a rotation relative to the moon because the moon progresses along its orbit in the direction of the earth's turning.



If the moon remained in the same position to the earth at all times, Puget Sound would pass under the moon every 24 hours; but, the moon revolves around the earth in the same direction that the earth rotates. While Puget Sound makes a complete circle in 24 hours, the moon has traveled about 54,636 miles along its orbit. In order for Puget Sound to pass directly under the moon again, it must travel for about another 50 minutes. Thus, the tides are about 50 minutes later each day.

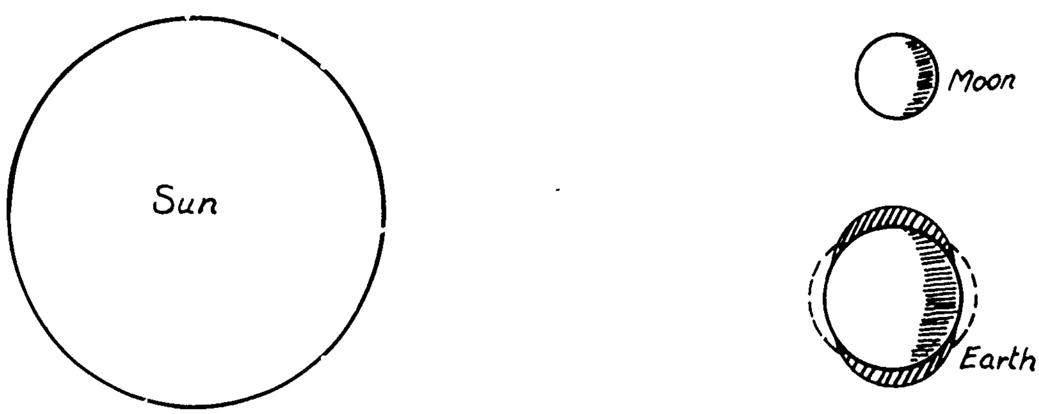
Tea her Information Sheet

The sun exerts some influence on the waters of the earth. The smaller sun bulges can be out of phase or in phase with the moon bulges. Two times a month the pull of the sun and moon are in phase and this produces SPRING TIDES. Spring tides occur at the time of the"new moon" (sun and moon lined up on the same side of the earth) and the "full moon" (sun and moon on opposite sides of the earth).



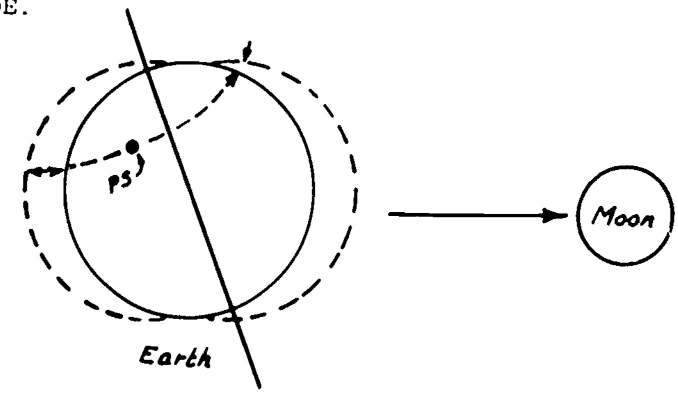
When the earth, moon, and sun line up at full and new moon, the tides are highest and lowest. The tides at that time are called SPRING TIDES.

Another and almost opposite effect is achieved when the moon is at first and last quarter. This produces the least high and low tides, which are called the NEAP TIDES. In this phase the moon, earth and sun form a 90° angle and the bulges are out of phase. The change from spring tide to neap tide is gradual, following the progressive movement of the moon around the earth.



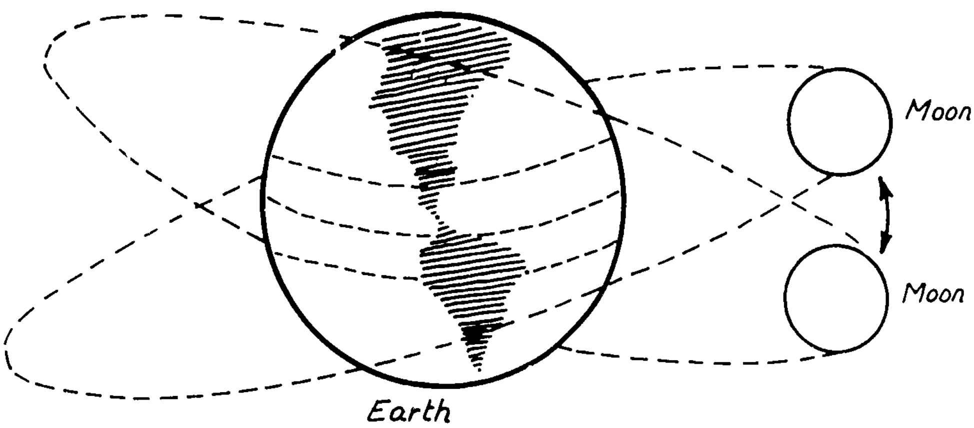
Neap tides occur when the earth, moon, and sun form a 90° angle with each other. The tides do not change as much from low to high at this time.

Besides spring and neap tides, there are other reasons why the tides are not equally high or low. The earth's axis is tilted in its plane of rotation about the sun. As the earth spins in its daily rotation, Puget Sound enters the tidal bulges (caused by the moon) twice a day. However, because of its geographical location, Puget Sound enters different depths of the bulge each time. The result is two daily high and two daily low tides of different depths. This type of tide is called a MIXED TIDE.



There are two other types of tides. A DIURNAL TIDE results in one daily high tide a[illegible] one daily low tide. A purely SEMIDIURNAL TIDE has two daily high tides of equal height and two daily low tides of equal height.

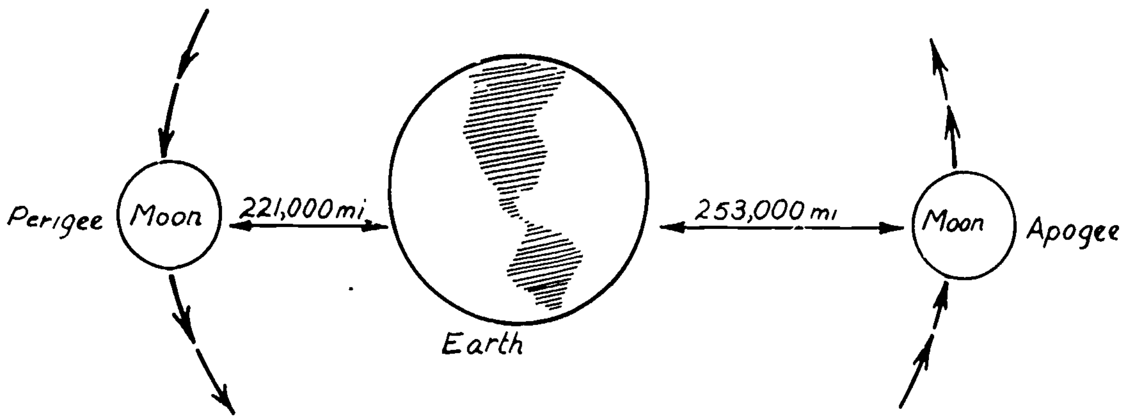
The moon and sun are not always directly over the equator, but vary north or south. The moon varies as much as 28° north or south each month. However, two times in the 30 day period the moon will be directly over the equator.



The moon changes position in relation to the earth each month. Since the tidal bulges follow the gravity of the moon, they will also change with the moon.

Likewise, the sun is over the Tropic of Cancer ($23\frac{1}{2}^{\circ}$ north) and the Tropic of Capricorn ($23\frac{1}{2}^{\circ}$ south) once each year and over the equator twice a year. As the sun and moon vary from northern to southern hemispheres and back again, the tidal bulges follow their movement.

The orbit of the moon around the earth is not round; rather, it is elliptical with a distant point (apogee) and a near point (perigee). The same is true for the orbit of the earth around the sun. Since gravity exerts the strongest influence on objects when they are nearest, perigee tides will be greater. This occurs once a month.

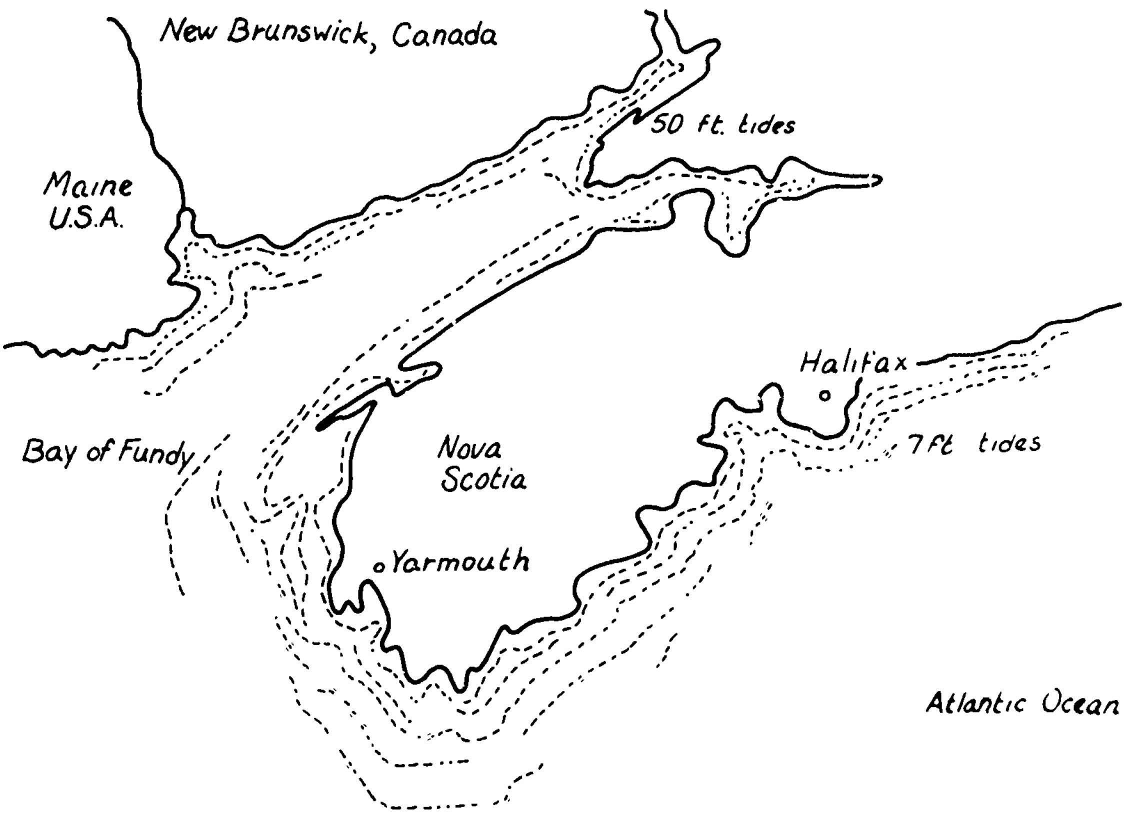


Winds also produce variation in the water level. If a strong wind is blowing water on shore with a flooding tide, the resulting high tide may be several feet higher than predicted. Likewise, if a wind is blowing in the opposite direction to the ebbing tide, the low tide level may remain higher than at normal ebb tide. This is caused by fr ction of the air against the water. Witness the extreme tides of hurricanes, when water is actually blown in or out according to the direction of the wind. The wind induced changes in water level are called storm tides. These are more important in coastal areas having extensive shallow regions than in an area such as Washington and Oregon.

The topography of the features of the earth beneath a body of water exerts tremendous influence on the depth variation between high and low tides. The Bay of Fundy, with fifty foot tides at its head, is an excellent example. Although Fundy is deep and wide at its mouth, it narrows gradually, and the floor slopes upward toward the head. At low tide, the upper reaches of the Bay are dry, but as the tide changes, large volumes of water entering the mouth quickly fill the limited space and greatly raise the water level. At high tide the water level rises as much as fifty feet at the head of the Bay and the tidal currents may reach a speed of eight knots. Also associated with bottom topography and the flooding tides are Tidal Bores. A tidal bore is a wave of water created as the incoming tide moves up a coastal river. These and other conditions make it very dangerous for fishermen caught in the basin during changing tides.

Teacher Information Sheet

In contrast to the Bay of Fundy are the tides at Halifax, Nova Scotia. Halifax is located on the Atlantic and the water is rather deep near shore. Here, tides vary at the most only seven feet.



Map of New Brunswick and Nova Scotia showing the Bay of Fundy.

NAME ______________________
DATE ______________________
PERIOD ____________________

TALE OF THE TIDES
by Dennis Schatz
For February issue of Pacific Search

Everyone enjoys strolling along the beach and examining the varied shells, seaweed, and trinkets brought in by a high tide. To decide when to take your walk or go tide-pooling, you might consult a tide book with its endless, and sometimes imposing, columns of numbers that seem to have no rhyme or reason. However, if you examine a tide table, such as the one in this section, you will notice some regularities that can help you understand what produces the tides.

Look at this month's tide table, and see if you can determine:

a) how many low and high tides there are per day.
b) how often in the month the high tide peaks and is higher than a few days before or after it. Is there a similar trend for low tide?
c) the phase of the moon when there are exceptionally high or low tides.

Now that you have found some of the regularities, we can examine what produces the tides.

Most of the tidal effects seen on the earth are produced by the moon. Actually, any object which has a gravitational pull on the earth will produce tides. The more massive the object pulling on the earth, and the closer it is, the greater the gravitational pull and the greater the tides it will produce.

To understand how the moon produces tides on the earth, think of the earth as completely covered with water. The moon pulls on the closest side of the earth harder than on the center of the earth, and on the center harder than on the far side. Thus, the moon pulls a bulge of water out on the near side of the earth, and leaves behind a bulge of water on the far side of the earth.

The water tries to stay bulged toward and away from the moon. Therefore, as the earth rotates on its axis once a day, most people observe two high and two low tides as they pass in and out of the two bulges.

Using our idealized model, we could also predict that since the two bulges of water try to line up toward and away from the moon, during one of the high tides in the day the moon should be at its highest point in the sky.

However, tides are caused by any object which exerts a substantial gravitational pull on earth. In addition to the moon, there is another dominant object in the sky--the sun. The sun has a substantial influence because, although the sun is 400 times farther away than the moon, it is also 27 million times more massive, and the tidal influence of an object depends both on its mass and distance. The sun's effect is approximately one-half that of the moon's.

The sun slightly complicates our analysis. The location of the sun and moon relative to the earth now becomes important. The solar effect produces bulges of water toward and away from the sun. When the moon, sun, and earth are lined up, these bulges join to produce even higher bulges, resulting in higher high tides and lower low tides. These tides are called the spring tides, from the Greek word for "lively", though they do not occur only in the spring. We find the earth, moon, and sun lined up approximately two times during the month when the moon is at full phase, and also when it is at new phase.

When the moon is at right angles to the sun from the earth, the bulges counteract each other, and the difference between low and high tide is small. These are called neap tides, from the Anglo-Saxon word for "scant". The sun and moon are also at right angles relative to the earth twice a month, when its phase is first quarter and third quarter.

Thus, we would expect approximately two times in the month (near full and new moon) when the high tides are extra high and the low tides extra low. Approximately seven days on either side of the spring tides, there should be days (near first and third quarter) when we have relatively high low tides and low high tides - the neap tides.

If you examine the tide table, you find that the predictions are born out in general. However, you will also find that the correlation is not as close as expected. Other questions may also arise. For instance, why are there such large differences between the height of the two low tides or the two high tides on a given day? Why do certain times of year produce extremely low, low tides?

The combined gravitational effect of the moon and sun explains much of what we see, but some additional factors need to be determined. These factors will be the subject of next month's article.

Student Reading

NAME ______________________________

DATE ______________________________

PERIOD ______________________________

Puget Sound

Day		HIGH TIDES Time	Ft	Time	Ft	LOW TIDES Time	Ft	Time	Ft
W	1	12 39	11 6			4 04	5 7	5 28	1 1
Th	2	[illegible] 25	9 2	11 02	11 4	5 14	6 7	6 28	0 2
F	3	1 42	10 0	11 58	11 3	6 46	7 2	7 29	0 6
Sa	4	2 57	10 9	1 00	11 3	7 51	7 2	8 23	-1 3
Su	5	3 43	11 7	2 02	11 3	9 57	6 8	9 13	1 7
M	6	4 31	12 3	3 01	11 4	9 53	5 2	10 01	-1 8
Tu	7	5 10	12 8	4 00	11 4	10 45	5 4	10 46	1 5
W	8	5 43	13 0	4 57	11 2	11 30	4 6	11 32	0 8
Th	9	5 24	13 0	5 52	10 8			12 19	3 8
F	10	6 59	12 8	6 49	10 3	0 14	0 1	1 08	3 2
Sa	11	7 35	12 5	7 50	9 8	0 53	1 3	1 52	2 8
Su	12	8 13	12 0	8 56	9 7	1 42	2 7	2 45	2 5
M	13	8 51	11 5	10 13	8 9	2 28	4 0	3 41	2 3
Tu	14	9 33	10 9	11 43	8 9	3 22	5 3	4 37	2 1
W	15	10 22	10 4			4 25	5 4	5 41	1 9
Th	15	1 09	9 3	11 12	9 9	5 45	7 0	6 42	1 5
F	17	2 18	9 8	12 11	9 7	7 12	7 2	7 35	1 2
Sa	18	3 10	10 4	1 03	9 6	8 20	7 1	8 23	0 8
Su	19	3 49	10 8	1 59	9 7	9 07	6 7	9 02	0 5
M	20	4 21	11 2	2 45	9 8	9 46	6 2	9 37	0 4
Tu	21	4 48	11 4	3 30	10 0	10 18	5 7	10 13	0 4
W	22	5 11	11 6	4 12	10 2	10 53	5 0	10 45	0 5
Th	23	5 33	11 7	4 53	10 3	11 25	4 3	11 20	0 8
F	24	5 55	11 9	5 37	10 4	11 57	3 6	11 55	1 2
Sa	25	6 21	11 9	6 25	10 3			12 35	2 8
Su	26	6 50	11 9	7 18	10 1	0 30	2 1	1 16	2 1
M	27	7 23	11 8	8 15	9 9	1 12	3 0	2 00	1 6
Tu	28	7 59	11 6	9 21	9 7	1 55	4 1	2 51	1 1

Ocean Beaches

Day		HIGH TIDES Time	Ft	Time	Ft	LOW TIDES Time	Ft	Time	Ft
W	1	5 01	8 5	7 09	6 2			1 00	1 0
Th	2	7 05	8 6	8 31	6 3	1 35	2 7	2 10	0 6
F	3	8 13	8 8	9 41	6 7	1 54	3 0	3 19	0 0
Sa	4	9 13	9 1	10 39	7 2	3 10	2 9	4 18	0 6
Su	5	10 15	9 4	11 31	7 8	4 17	2 6	5 12	-1 0
M	6	11 11	9 5			5 16	2 2	6 03	-1 3
Tu	7	0 18	8 2	12 03	9 5	5 13	1 8	6 49	-1 3
W	8	1 03	8 6	12 51	9 4	7 02	1 4	7 30	1 1
Th	9	1 44	8 8	1 40	9 0	7 51	1 1	8 11	-0 6
F	10	2 24	8 8	2 25	8 4	8 33	1 0	8 51	0 0
Sa	11	3 05	8 8	3 14	7 8	9 25	1 0	9 31	0 6
Su	12	3 44	8 6	4 03	7 1	10 14	1 1	10 13	1 3
M	13	4 27	8 4	4 58	6 5	11 05	1 2	10 57	2 0
Tu	14	5 14	8 1	6 03	6 1	12 0	1 3	11 46	2 6
W	15	6 06	7 9	7 15	5 9			1 03	1 3
Th	16	7 06	7 8	8 22	5 9	0 49	3 0	2 06	1 1
F	17	8 07	7 8	9 24	6 2	1 54	3 2	3 05	0 9
Sa	18	9 02	7 9	10 16	6 5	3 20	3 2	3 59	0 6
Su	19	9 54	8 1	11 03	6 9	3 58	3 0	4 47	0 3
M	20	10 40	8 2	11 40	7 2	4 49	2 7	5 29	0 0
Tu	21	11 22	8 3			5 23	2 4	6 05	0 1
W	22	0 16	[illegible]	12 01	8 4	5 13	2 1	6 40	0 0
Th	23	0 46	7 8	12 39	8 3	6 50	1 7	7 12	0 1
F	24	1 19	8 1	1 15	8 2	7 27	1 4	7 41	0 3
Sa	25	1 50	8 3	1 55	8 0	8 04	1 2	8 13	0 6
Su	26	2 22	8 5	2 37	7 6	8 46	0 9	8 45	1 0
M	27	2 57	8 6	3 26	7 2	9 31	0 7	9 23	1 4
Tu	28	3 [illegible]	8 6	4 24	6 7	10 23	0 5	10 09	2 0

Tide tables courtesy the Evergreen Tide Guide, ©1978 by Bernie Straub Publishing Co., Inc., Seattle

NAME____________________
DATE____________________
PERIOD__________________

VARIATIONS IN A TIDE

For the March 1978 issue of Pacific Search
by Dennis Schatz
Pacific Science Center

Last month we found that the earth's tides are caused by the combined gravitational pull of the sun and moon forming one bulge of water on one side of the earth, and one bulge on the other side of the earth. Although this basic theory explains many tidal characteristics, the theory needs some refinement to make it more accurate.

The two bulges do explain why we experience approximately two high and low tides each day, but it is not clear why one tide in the day is usually higher than the other high tide. It was also argued last month that the most extreme tides (the highest high and lowest low tides) should occur each month close to when the moon, sun, and earth are in line, at new and full moons. Examination of the tide tables showed that the extreme tides are close to, but not precisely on, the dates of the new and full moons.

If the moon and sun were always located directly above the earth's equator, we would not find any differences between the two high tides in one day. The two bulges produced would be symmetrically distributed north and south of the equator. Therefore, as we rotate on our axis once each day, we would experience tides of equal height.

However, the moon and sun are often located over points north or south of the equator, thus producing bulges of water that are not symmetrical around the equator. One bulge will have its highest point in the northern hemisphere, the other in the southern hemisphere. Seattle, in the northern hemisphere, and is further from the center 12 hours later when we experience the bulge centered in the southern hemisphere. Consequently, the height of our two high tides in a given day will vary.

Another variable affecting the tides is the changing distance of the earth from the sun. The earth's orbit is not exactly a circle. On January 1 we were 91,400,000 miles from the sun; on July 5 we will be 94,500,000 miles from the sun. The closer the earth is to the sun, the greater the sun's gravitational pull on the earth, and the greater the tidal bulge produced. In July, we would expect less extreme high and low tides as we are farther from the sun.

However, this prediction is complicated by the fact that the orbit of the moon is not exactly a circle. We would expect more extreme tides during the time of the month when the moon is closest to the earth. Of course, we have also found that more extreme tides occur when the earth and the sun are lined up. The most extreme tides occur when all three of these things happen at once; the sun and moon are closest to the earth, and all three are in a line.

NAME______________________________
DATE______________________________
PERIOD____________________________

This year, the highest tides occurred close to the date of the new moon in January when the earth was close to the sun, and the moon was also close to the earth. Another period of extreme tides will occur in July. The earth will be relatively far from the sun, but the earth, moon, and sun will be lined up and the moon will be at its closest point to the earth in its orbit.

There are some tidal effects which do not depend upon the moon and sun. In the Bay of Fundy in Newfoundland, it is typical to have a 50 foot difference between high and low tide. This unusual tidal behavior is due to the shape of the Bay of Fundy, a large funnel with two narrow bays at the end. At its opening, a typical difference between high and low tide is 9.5 feet. But as the rising tide water moves into the bay, it is funneled down into a smaller and smaller area, causing tidal differences of between 49 and 51 feet at the end of the bay. A similar situation occurs in the Red Sea.

Now occuring is an even more dramatic, long-term effect of the tidal interaction of the moon, sun, and earth. The tides are causing the earth's spin to slow down, making our days longer. This is the same interaction that causes the moon to always have one face toward the earth. We'll pursue this topic in next month's column.

Teacher Information Sheet
Moon-Tide Wheel Activity

A. Instruction Sheet for Teacher - Before presenting this to the students, you might want to try it yourself.

1. Run dittos of worksheet #1 and #2. Each student should have a diagram of the Moon-Tide Wheel and the Earth disc.

2. Have students cut out the Moon-Tide Wheel and earth disc. Be certain students cut out the center section between the Moon circle and the tide eclipse. It might be useful to have students color the "water" blue to show more clearly how the water bulges out from the earth.

3. Have students poke a small hole through the center spot of the earth disc with a sharp pencil.

4. Likewise, have students poke a small hole through the center spot of the Moon-Tide Wheel.

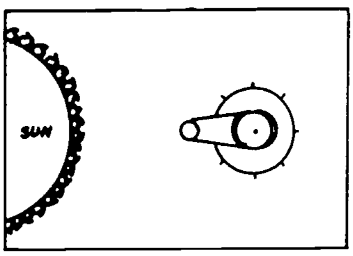
5. Next distribute copies of Worksheet 2 to each student.

6. Have students poke a small hole through the center of the Time Circle.

7. Place the Moon-Tide Wheel directly over the Sun Time Circle. Adjust so the punched holes are in line.

8. Directly on top of the Moon-Tide Wheel place the punched Earth Disc. Line up the punched holes.

9. Secure all the parts together with a brad. You should now have a chart that looks like this.



B. Notes to the teacher:

1. It is important that the teacher identify the abilities of his/her class. Some classes will need minimal instruction for this activity. Some classes will require extensive preparation to understand the relationship of the moon to the tides.

2. It is helpful to prepare this Moon-Tide Wheel Activity on a transparency for use with an overhead. It allows students to visually see how it is put together. Furthermore, it may then be used as an instructional aid.

3. It is useful to apply color to the Moon-Tide Wheel and to the Earth Circle transparencies. This can be done with Color Adhesive Film (a 3-M product). Use one color for the Earth circle and another color for the Moon-Tide Wheel.

4. The * on the Earth circle represents Puget Sound. Students should be aware of this.

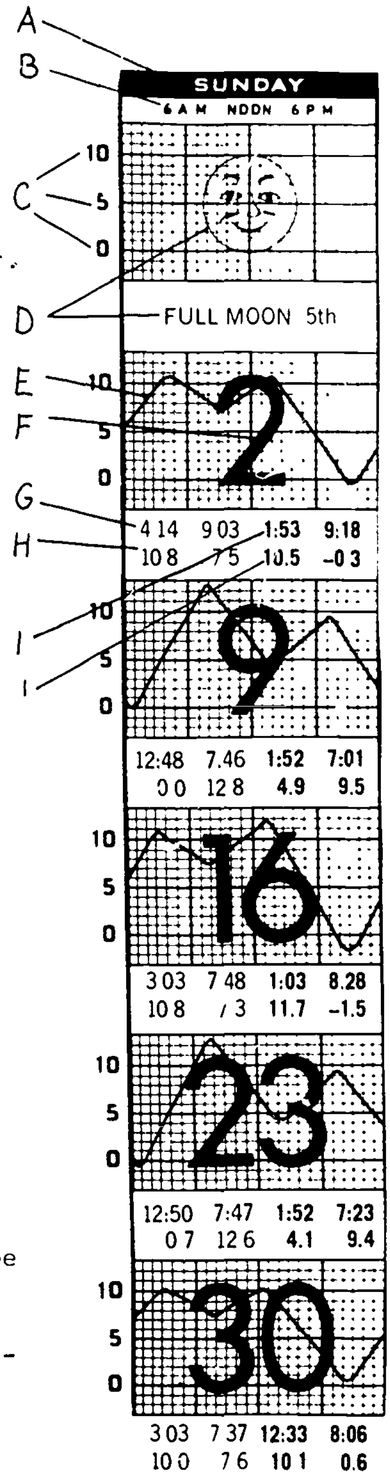
5. The elongated circle on the Moon-Tide Wheel represents the bulge of water (the tides) that follows the gravitational pull of the moon. Students should be made to understand this.

6. Following this activity, the student should be able to identify the phases of the moon by the relative position of the Earth and Sun. The students should understand the gravitational pull of the moon on the waters of the Earth causes tides.

7. Prepare the Tide Calendar for the students. It is best to make a transparency of the Tide Calendar enclosed in the packet. This allows for instruction on how to read the chart and reduces the amount of paper used. Alternative suggestions include obtaining a current Tide Calendar (and adjusting for correct answers to the student worksheet questions.)

Teacher Information
Tide Calendar

Before doing the Moon-Tide Wheel Activity, instruct students on how to read the tide calendar. The students will use a copy of the tide calendar for the month of January 1977. On the right is the column of Sundays taken from the January 1977 tide calendar. The following is a key to help explain the calendar. The letters correlate with parts on the calendar.



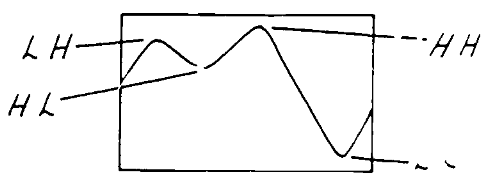
A - This indicates the day of the week.

B - The vertical lines represent the hours of the day. The first dark line is 6:00 a.m. The middle dark line is 12:00 noon. The third dark line is 6:00 p.m. Each line equals the hour. The extreme edges of the day represent midnight - separating two days from each other.

C - The 10, 5 and 0 lines represent the height of water in feet above the tidal datum. Each line between the dark numbered horizontal lines is equal to one foot. Below the 0 represents minus tides, water level below mean lower low water.

D - The figure represents the phase of the moon and is stated below the drawing. The number is the date upon which that lunar phase begins.

E - The tide curve depicts the changing water level during the daily cycle. Note: in Puget Sound there is a higher high tide (H.H.), and lower high (L.H.), a low low tide (L.L.), and a higher low tide (H.L.). On the chart it can be seen like this:



F - the date of the month

G - the morning time of the tides. The light type indicates AM hour.

H - the height of the tides in the morning. The lighter type indicates AM hours.

I - the afternoon time of the tides. The boldface type indicates PM hours.

J - the height of the tides in the afternoon. The boldface type indicates PM hours.

January 1977

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
FULL MOON: 5th	LAST QUARTER. 12th	NEW MOON 19th	FIRST QUARTER 27th			**1** 3 32 8 07 1 16 8 41 10 1 7 3 10 6 0 2
2 4:14 9 03 1:53 9:18 10 8 7.5 10.5 -0.3	**3** 4 51 9 47 2:33 9:50 11 3 7 4 10:5 -0.7	**4** 5 21 10 29 3 11 10.24 11 7 7 3 10.5 -1.0	**5** 5 51 11 04 3:50 10 59 12 1 7 0 10 5 -1.1	**6** 6 18 11 43 4.32 11.32 12 3 6 7 10.4 -1 0	**7** 6 44 12.24 5.17 12 5 6.2 10.2	**8** 12 09 7 15 1:06 6:06 -0 7 12 7 5.6 9.9
9 12:48 7:46 1:52 7:01 0 0 12.8 4.9 9.5	**10** 1 28 8 19 2:41 8:04 0 9 12 8 4.1 9.0	**11** 2 10 8 57 3:37 9.19 2 1 12 6 3.2 8 7	**12** 3 01 9 38 4:36 10 47 3 5 12 5 2.3 8 6	**13** 4 00 10 23 5:38 5 0 12 2 1.2	**14** 12:21 5:10 11.12 6:37 9 0 6 2 12 0 0.2	**15** 1 54 6 29 12:05 7:33 9 8 7 0 11 8 -0 7
16 3 03 7 48 1:03 8:28 10 8 7.3 11 7 -1.5	**17** 3 55 8 54 1:59 9:18 11 7 7 2 11.6 -1.9	**18** 4 44 9 55 2.54 10.04 12 3 6 8 11.4 -2 0	**19** 5 24 10 46 3:49 10.49 12 7 6 3 11.2 -1.8	**20** 6 01 11 33 4:43 11:28 12 9 5 7 10.9 -1.2	**21** 6 36 12 21 5 34 13 0 5 2 10 5	**22** 12 10 7 13 1:07 6:28 -0 4 12 8 4.6 9 9
23 12:50 7:47 1:52 7:23 0.7 12.6 4.1 9.4	**24** 1 30 8 19 2:45 8.24 1 9 12 2 3.7 8.8	**25** 2 13 8 56 3:36 9.38 3 3 11 8 3 3 8.4	**26** 3 01 9 32 4:34 11 05 4 6 11 3 2 8 8 3	**27** 3 54 10 13 5 28 5 8 10 9 2 4	**28** 12 47 5 01 10 55 6:27 8 6 6 8 10 5 1 8	**29** 2 03 6 22 11 43 7 19 9 3 7 4 10 2 1 2
30 3 03 7 37 12:33 8.06 10 0 7 6 10.1 0.6	**31** 3 48 8 41 1.24 8·48 10 6 7 5 10.1 0.1					

Daily tide graph scale: 10, 5, 0; 6 A.M., NOON, 6 P.M.

Whistle Call

• Seattle	"1-3800	• Everett	252 4131
• Tacoma	.2 0362	• Olympia	357 7746
• Port Angeles	457 3688	• Bellingham	734 2240
• Anchorage, AK	(907) 274 1577	• Vancouver, B C	(604) 682 3888

Seattle Tides

Pacific Standard Time

Teacher Information Sheet
Moon-Tide Wheel Activity
Assignment

MOON-TIDE WHEEL ACTIVITY

Questions:

1. Take the prepared Moon-Tides-Sun Chart. Spin the Moon-Tide Wheel until the moon circle covers the letter A above the Time Circle. If a person on Earth looked to the moon in this position, they would see all of the moon lighted. What do we call this kind of moon?

   FULL MOON

   Label this spot on the Sun-Time Chart.

2. Move the moon to the letter D. A person would see half of the moon. The name for this phase of the moon is *THIRD QUARTER* . Label this spot on the Sun-Time Chart.

3. Move the moon to the letter C. What would a person on earth see of the moon in this position? *(NOTHING, THE SUN WOULD ILLUMINATE THE SIDE OPPOSITE THE EARTH)* The name of this phase is *NEW MOON*. Label this spot on the Sun-Time Chart.

4. At the position letter B the moon would be in what phase? *FIRST QUARTER* Label this spot on the Sun-Tide Chart.

Problem Series I - Use the Moon-Tides-Sun Chart to answer these questions.

A. Move the Moon-Tide Wheel so the the moon is at new moon position. Turn the earth disc until the * (which represents Puget Sound) is at 12:00 noon. (The earth disc should always be turned in the counterclockwise direction.)

   a. Is Puget Sound at high or low tide? *HIGH*
   b. At what time will Puget Sound have the next low tide? *6:00 p.m.*
   c. At what time will Puget Sound have the next high tide? *12:00 p.m.*

B. Move the Moon-Tide Wheel so the moon is at the first quarter position. Turn the earth disc to approximately the 3:00 p.m. position.

   a. At 8:00 p.m. is the tide going in or out in Puget Sound? *OUT*
   b. At what time will Puget Sound have its high tides when the moon is in the first quarter positions? *6:00 a.m. & 6:00 p.m.*
   c. At 3:00 p.m. is the tide coming in or going out in Puget Sound? *COMING IN*

Problem Series II - Use the Tide Calendar to answer these questions.

A. Find the date of the New Moon on the calendar.
   a. On what date is the new moon? *JANUARY 19*
   b. At what times are high tides? *5:24 a.m. & 3:49 p.m.*
   c. At what time is the P.M. low tide? *10:49 p.m.*
   d. How low is the low P.M. tide? *-1.8*

Teacher Information Sheet
Moon-Tide Wheel Activity
Assignment

B. Locate January 22nd on the Tide Calendar Answer these question.

a. This date is between what two phases of the moon?

New moon and first quarter phase

b. At what time is the first low tide of the day? *12:10 a.m.*

c. How low is it? *-0.4 fee*

d. High tides are at what times? *7:13 a.m. & 6:28 p.m.*

e. Which is the highest tide? *7:13 a.m., 12.8 feet high*

Student Handout
Construction of MOON-TIDE WHEEL
Worksheet #1

NAME____________________

DATE____________________

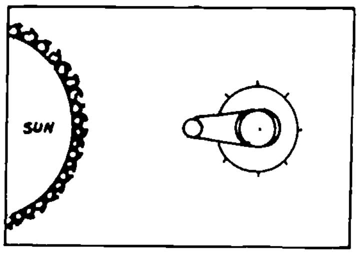
PERIOD____________________

Directions for the Moon-Tide Wheel construction:

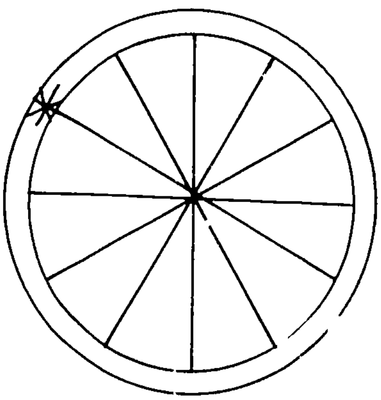
1) Cut out the Moon-Tide Wheel and the Earth disc.
2) Cut out the center section (rectangle) between the "water" and "moon". See the diagram below.

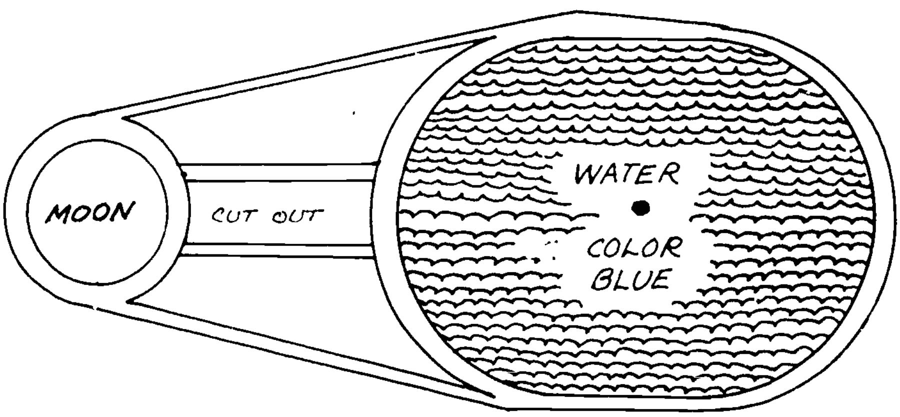
3) Color the "water" blue.
4) Poke a small hole through the center spot of the Earth Disc with a sharp pencil.
5) Also, poke a small hole through the center spot on the Moon-Tide Wheel.
6) Get a copy of Worksheet #2.
7) Poke a small hole through the Center of the Time Circle on Worksheet #2.
8) Place the Moon-Tide Wheel directly over the Sun Time Circle. Line up the punched holes.
9) Place the punched Earth Disc directly on top of the Moon Tide Wheel. Line up the punched holes.
10) Put a brad (paper fastener) through all the lined up punched holes and bend the ends out.

Now you have a chart that looks like this:



Begin the assignment named <u>Moon-Tide Wheel Activity</u>.



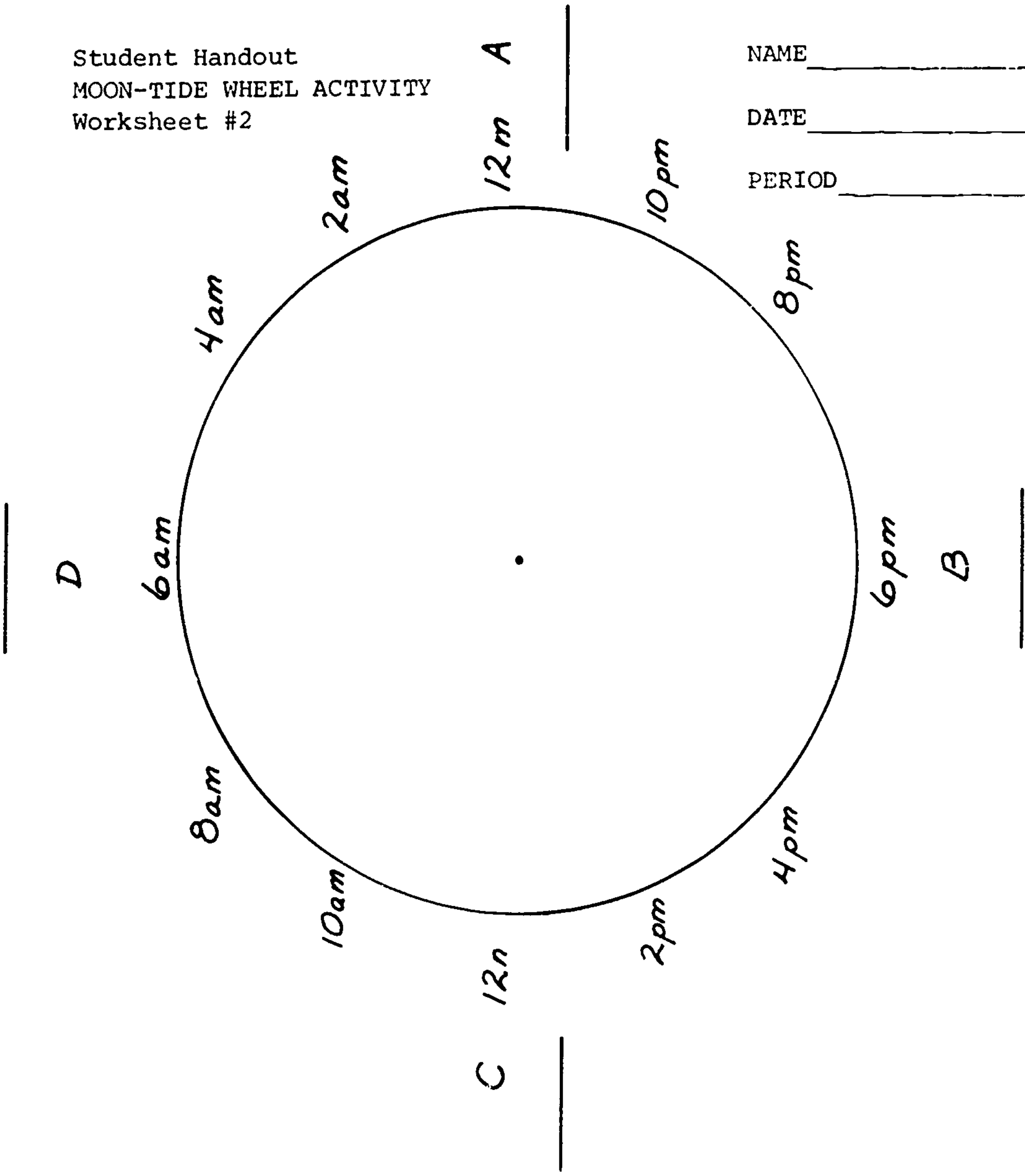


Student Handout
MOON-TIDE WHEEL ACTIVITY
Worksheet #2

NAME ______________________

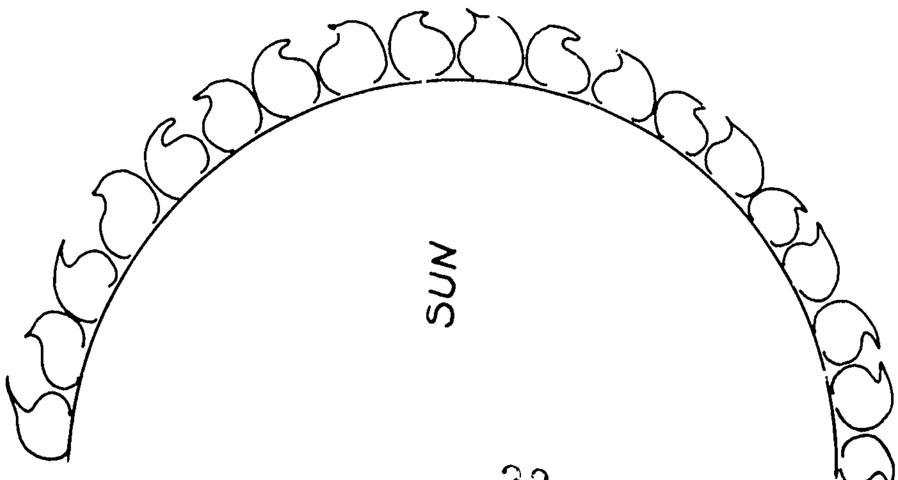
DATE ______________________

PERIOD ____________________



WORKSHEET 2

SUN-TIME CHART



Student Handout
MOON-TIDE WHEEL ACTIVITY
Assignment

NAME ____________________

DATE ____________________

PERIOD ____________________

MOON-TIDE WHEEL ACTIVITY

Questions:

1. Take the prepared Moon-Tides-Sun Chart. Spin the Moon-Tide Wheel until the moon circle covers the letter A above the Time Circle. If a person on earth looked to the moon in this position they would see all of the moon lighted. What do we call this kind of moon?

   Label this spot on the Sun-Time Chart.

2. Move the moon to the letter D. A person would see half of the moon. The name for this phase of the moon is ____________________. Label this spot on the sun time chart.

3. Move the moon to the letter C. What would a person on earth see of the moon in this position?

   The name of this phase is ____________________. Label this spot on the Sun-Time Chart.

4. At the position letter B the moon would be in what phase? ______________ Label this spot on the Sun-Tide Chart.

<u>Problem Series I</u> - use the Moon-Tides-Sun Chart to answer these questions.

A - Move the Moon-Tide Wheel so that the moon is at new moon position. Turn the earth disc until the * (which represents Puget Sound) is at 12:00 noon. (The earth disc should always be turned in the counterclockwise direction.)

   a. Is Puget Sound at high or low tide? ____________
   b. At what time will Puget Sound have the next low tide? ____________
   c. At what time will Puget Sound have the next high tide? ____________

B - Move the Moon Tide Wheel so the moon is at the first quarter position. Turn the earth disc to approximately the 3:00 p.m. position.

   a. At 8:00 p.m. is the tide going in or out in Puget Sound? ____________
   b. At what time will Puget Sound have its high tides when the moon is in the first quarter positions? ____________________
   c. At 3:00 p.m. is the tide coming in or going out in Puget Sound? ____________

Problem Series II - Use the Tide Calendar to answer these questions.

A - Find the date of the New Moon on the calendar.

   a. On what date is the new moon? ____________
   b. At what times are high tides? ____________
   c. At what time is the p.m. low tide? ____________
   d. How low is the low p.m. tide? ____________

Student Handout
MOON-TIDE WHEEL ACTIVITY
Assignment

NAME____________________

DATE____________________

PERIOD____________________

B - Locate January 22nd on the Tide Calendar. Answer these questions:

a. This date is between what two phases of the moon?

b. At what time is the first low tide of the day?

c. How low is it?

d. High tides are at what times?

e. Which is the highest tide?

ACTIVITY 2:

TIDES, CHARTS AND PREDICTIONS

(2 days)

ACTIVITY 2: TIDES, CHARTS AND PREDICTIONS (2 days)

CONCEPTS:

Predicting tides for any given area is difficult because of the many factors that influence the tides. Tide charts have been developed to help improve the prediction of the type of tides, and the time and size of tides.

OBJECTIVES:

Following the activity, the learner will demonstrate his/her ability to:

1. explain the differences between neap and spring tides.
2. explain the causes of the neap and spring tides.
3. explain the differences between diurnal, semi-diurnal, and mixed tides.
4. state which classification of tide is found in Puget Sound.
5. read a Tide Chart and make specific determinations about the size, time, and kind of tide on any given day.
6. predict when neap and spring tides will occur.

TEACHER PREPARATION:

1. Read the student reading Tides, Charts and Predictions.

MATERIALS:

1. Teacher Information Sheet, "Tides, Charts and Predictions"
2. 30 copies: Student Handout "Tides, Charts and Predictions"
   a. Student Reading
   b. Student Worksheet
   c. Graph of tides of Seattle area.

PROCEDURES:

1. Conduct an informational review of the causes of tides. Have students state what they know about tides: the causes, the kinds, and the classifications.

2. Explain to the students that tides are even more complex. Have the students think about and suggest other things that would influence the tides in Puget Sound. Guide students.

3. Continue the review/instruction by having the students complete the student reading, "Tides, Charts and Predictions". This student reading is regarding kinds and classifications of tides. Be certain students understand the differences in tides.

4. Help students remember:

   There are two kinds of tides a month:
   a. when the sun and moon are in line with the earth the combined gravitational pull causes very high tides --called Spring Tides.

   b. when the sun and moon are at right angles to the earth, the tides are significantly lower. These are called Neap Tides.

5. Introduce the classification system for tides.

   Tides are classified three ways:
   a. Diurnal tides - one high and one low tide a day.
   b Semi-diurnal tides - two high and two low tides a day. The two high tides are of nearly equal height. The two low tides are also nearly equal.
   c. Mixed Tides - two high and two low tides a day. The two high tides are of unequal height and the two lows also reach unequal heights.

   Puget Sound experiences a Mixed Tide.

6. Tides are difficult to predict precisely because so many factors influence the time and size of the tides. Some of the factors affecting tides are:

   1) gravitational pull of the moon
   2) gravitational pull of the sun
   3) the topolography of Puget Sound
   4) the geological features of Puget Sound
   5) the geographical location of Puget Sound
   6) the weather - including atmospheric pressure and prevailing winds.

   To eliminate the guesswork of predicting tides, tide charts have been devised. These are made after long periods of observation of tidal changes in a given locale.

ASSIGNMENT:

7. Distribute to the students the Tides, Charts and Predictions worksheet. This is a worksheet designed to help students in understanding: Neap and Spring Tides and the Mixed Tides of Puget Sound.

EXTENDED ACTIVITIES:

1. Have the student predict and then verify the tides for his/her birthday.

2. View the film Ocean Tides - Bay of Fundy. This film shows the impact other features have on time and size of tides.

BIBLIOGRAPHY:

Curriculum
1. Teachers Ocean Study Kit, 1966, United States Naval Oceanographic Office, Washington, D.C. 20390.

2. Oceanography: A Teacher's Sourcebook for a Seventh Grade Activity Centered Oceanography Unit, 1961, Bellevue Public Schools, Maudsten, Linda; Hansler, Donald D.

Films
1. Ocean Tides - Bay of Fundy, 16mm, color, 14 minutes. Encyclopedia Britannica Films, Inc. 425 N. Michigan Ave., Chicago, Illinois 60611.

NAME ____________________
DATE ____________________
PERIOD __________________

Tides, Charts and Predictions

Tides are due to the gravitational attraction of the moon and the sun to the earth as the earth rotates on its axis. This gravitational attraction produces two bulges of water on the earth--one facing the tide raising body, the other facing in an opposite direction on the other side of the earth.

The water closest to the moon is attracted more to the moon than the earth. The earth is attracted more than the water on the opposite side of the earth. Low tides result when the water is drawn away from the points halfway between the high tides. As the earth rotates, each meridian comes in turn beneath the positions of high and low tide nearly twice a day; not exactly twice, because allowances must be made for the forward movement of the moon along its orbit.

The effect of the sun is similar to that of the moon, but is only about half as powerful because the distance of the sun is much greater than that of the moon.

Kinds of Tides

SPRING TIDES: When the moon and sun are in a straight line with the earth, tides will be highest and lowest during this time, and are called Spring Tides. These tides occur when water "springs" up (the term spring has nothing to do with the season of the year) or rises.

NEAP TIDES: When the moon, sun, and earth form a right angle to the earth, the pulls oppose each other and the water is "nipped" or lowered. These are called Neap Tides. They occur at the first and last quarters of the moon.

Classification of Tides:

1. SEMIDIURNAL type, which has two high waters and two low waters each day with little or no difference between consecutive high and low water heights. Tides along the east coast of the United States, for example, are of the semidiurnal type.

2. DIURNAL type, which has only one high water and one low water each day. The tides along the Vietnam-China coast are diurnal, as well as those in the Gulf of Mexico.

3. MIXED type, which has both diurnal and semidiurnal characteristics. That is, there are two high waters and two low waters each day but with considerable difference between heights of successive high waters of successive low waters. These differences are called DIURNAL (daily) INEQUALITIES. The tides along the Pacific Coast of the United States are mixed.

In the open ocean, the differences in tide level are only a few feet. In shallow seas, however, especially if the tide is concentrated between converging shores, ranges of 20-30 feet are common. Strong tidal currents are often generated when large volumes of water must enter and exit through narrow channels. Examples of strong currents are to be found in the channel at Deception Pass, where currents average 7.2 knots, and in the Tacoma Narrows, where the inflowing tide has a speed of more than 5.5 knots.

In extreme cases, where the tidal stream is crowded into a narrow end of a shallowing channel, such as the Bay of Fundy, the water advances with a wave-like front of roaring surf, called a bore. This bay is also an example of extremely high tides which sometimes exceed 60 feet.

A graphical representation of the rise and fall of the tides can be made by plotting a curve on a graph from predictions of times in minutes, and heights in feet, for specific days. Predictions of tides occurring in the future are made mathematically from past tide observations and from knowledge of the motions of the earth, moon, and sun in space.

Tides are one of the easiest things to observe about Puget Sound. However, the factors that cause the tidal variations are so complex that without the aid of a tide chart, it would be difficult to compute the daily tides.

Teacher Information Sheet #2
Tides, Charts and Predictions

Part A. (Teacher's Copy)

Answer the following questions concerning the graph of tides in the Seattle area of Puget Sound.

1. Generally, how many high and how many low tides can you assume there will be every day?

   (Two high and two low tides)

2. On which day do you find the greatest difference between a high and a low tide?

   (Sept. 26 - between full moon and third quarter)

3. On which day do you find the least difference between a high and a low tide?

   (Sept. 17 - day after first quarter)

4. On what day do you find the highest tide? What is this tide called?

   (Sept. 8 - new moon, called Spring Tide)

5. On what day do you find the lowest tide? What is this tide called?

   (Sept. 26 - between full moon and third quarter. This tide is Neap Tide.)

6. On which day do you find the high tides to be about equal and the low tides to be nearly equal?

   (Sept. 9 - the day after the new moon or Sept. 22 - the day before the full moon)

7. What would your predictions be if you were asked what the tides were going to be like in October around the following phases of the moon?

   New moon - *(Large change between high and low tides, but both highs close to the same as are both lows)*

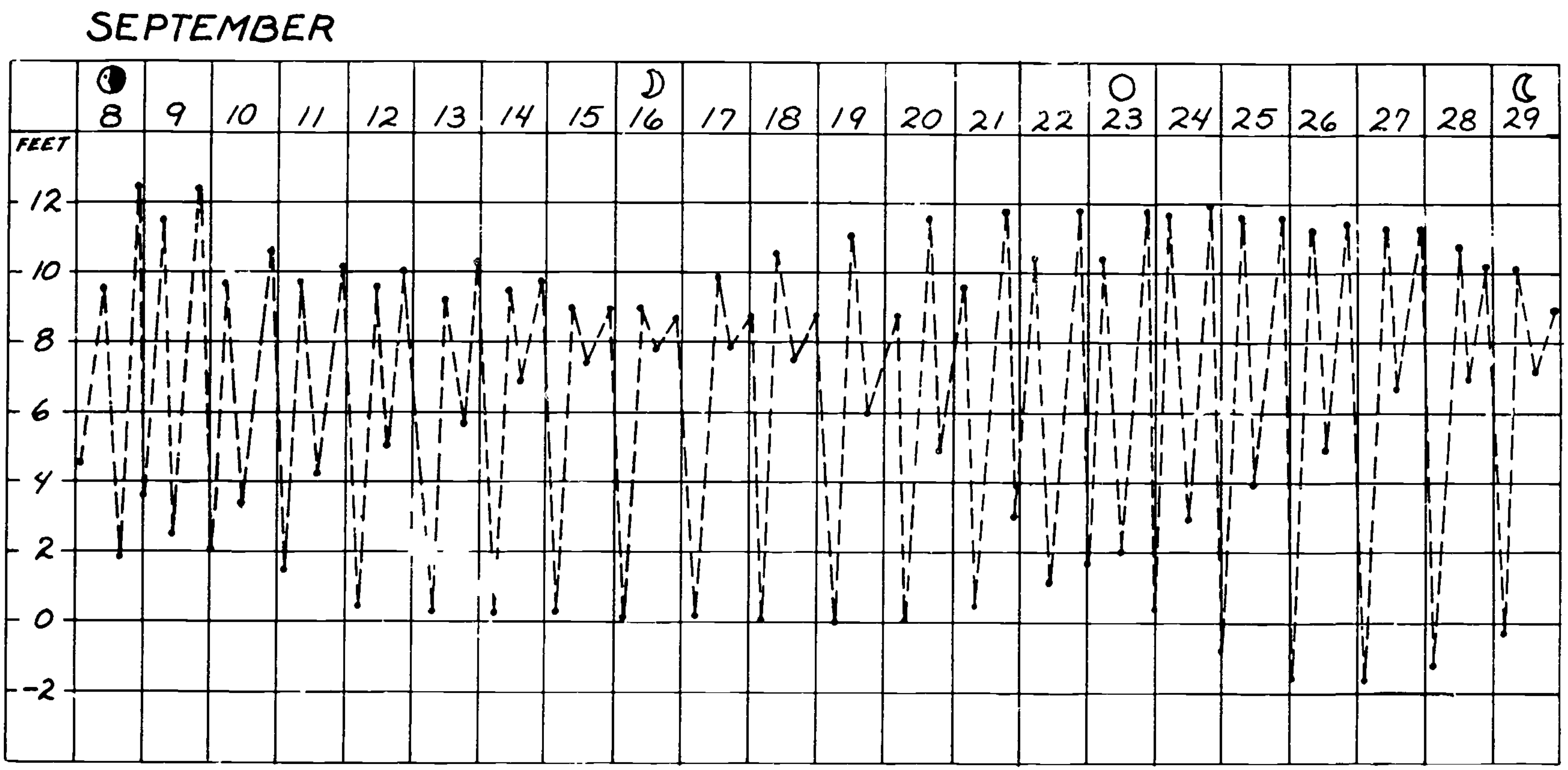
   First Quarter - *(Both high tides about the same but a great difference between the low)*

   Full Moon - *(About like new moon but lower low tides - could get some minus tides)*

   Third Quarter - *(About like first quarter)*

PART A
TIDES, CHARTS AND PREDICTIONS
(continued)

A GRAPH OF TIDES IN THE SEATTLE AREA OF PUGET SOUND



Teacher Information Sheet #2
Tides, Charts and Predictions

Part B.

1. Plot a tide curve from the predictions given in the chart.

2. Complete the tide curves for Day 2, 3, and 4 by plotting the tides' heights and connecting all points; then try to answer the questions.

TIDE PREDICTIONS			
DAYS	TIME*		HEIGHTS*
	Hours	Minutes	Feet
1	01	15	1.0
	07	30	4.1
	16	00	1.0
	20	15	4.0
2	02	00	1.0
	08	30	6.5
	14	15	2.0
	21	00	5.0
3	04	15	0.0
	16	00	7.0
4	04	30	1.0
	10	00	3.0
	16	00	1.0
	22	00	2.9

*The are divided into 24 hours (0 to 24), midnight to midnight.
Hei re measured from the zero reference line or tide datum.
This rence datum is Mean Lower Low water in our area.

Once you have drawn the tide curve, answer the following questions:

a. During what day is the tide diurnal? *Day 3*

b. During what day is the tide mixed? *Day 2*

c. During what days is the tide semidiurnal? *Day 1 and Day 4*

d. During what day is the range largest? *Day 3*

e. What is the smallest range and on what day? *1.9 feet on Day 4*

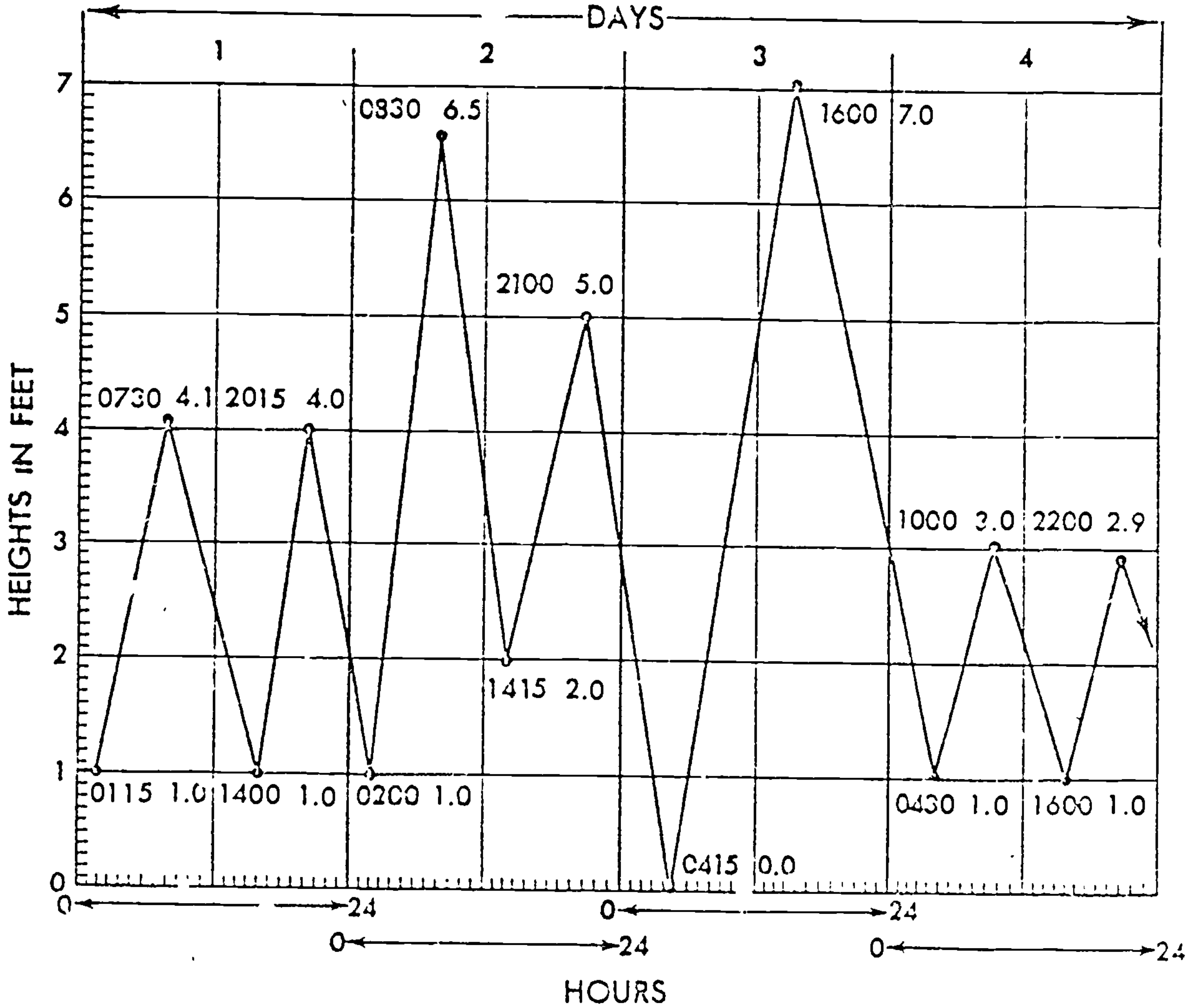
f. What is the largest diurnal inequality shown? *4.0 ft.* On what days? *Day 3 and 4*

PART B
Teacher Information Sheet #2

DRAWING A TIDE CURVE

SOLUTION

EXERCISE I



Student Handout
Tides, Charts and Predictions

NAME ______________________
DATE ______________________
PERIOD ____________________

Part A.

Answer the following questions concerning the graph of tides in the Seattle area of Puget Sound. Use the attached tide graph.

1. Generally, how many high and how many low tides can you assume there will be every day?

2. On which day do you find the greatest difference between a high and a low tide?

3. On which day do you find the least difference between a high and a low tide?

4. On what day do you find the highest tide? What is this tide called?

5. On what day do you find the lowest tide? What is this tide called?

6. On which day do you find the high tides to be about equal and the low tides to be nearly equal?

7. What would your predictions be if you were asked what the tides were going to be like in October around the following phases of the moon?

   New Moon -

   First Quarter -

   Full Moon -

   Third Quarter -

NAME ____________________
DATE ____________________
PERIOD ____________________

Part B

1. Plot a tide curve from the predictions given in the chart.

2. Complete the tide curves for Day 2, 3, and 4 by plotting the tides' heights and connecting all points; then try to answer the questions.

	TIDE PREDICTIONS		
DAYS	TIME*		HEIGHTS*
	Hours	Minutes	Feet
1	01	15	1.0
	07	30	4.1
	16	00	1.0
	20	15	4.0
2	02	00	1.0
	08	30	6.5
	14	15	2.0
	21	00	5.0
3	04	15	0.0
	16	00	7.0
4	04	30	1.0
	10	00	3.0
	16	00	1.0
	22	00	2.9

*The days are divided into 24 hours (0 to 24), midnight to midnight. Heights are measured from the zero reference line or tide datum. This reference datum is Mean Lower Low water in our area.

Once you have drawn the tide curve, answer the following questions:

a. During what day is the tide diurnal? ____________________

b. During what day is the tide mixed? ____________________

c. During what days is the tide semidiurnal? ____________________

d. During what day is the range largest? ____________________

e. What is the smallest range and on what day? ____________ ft., ____________ day.

f. What is the largest diurnal inequality shown? ____________ ft.

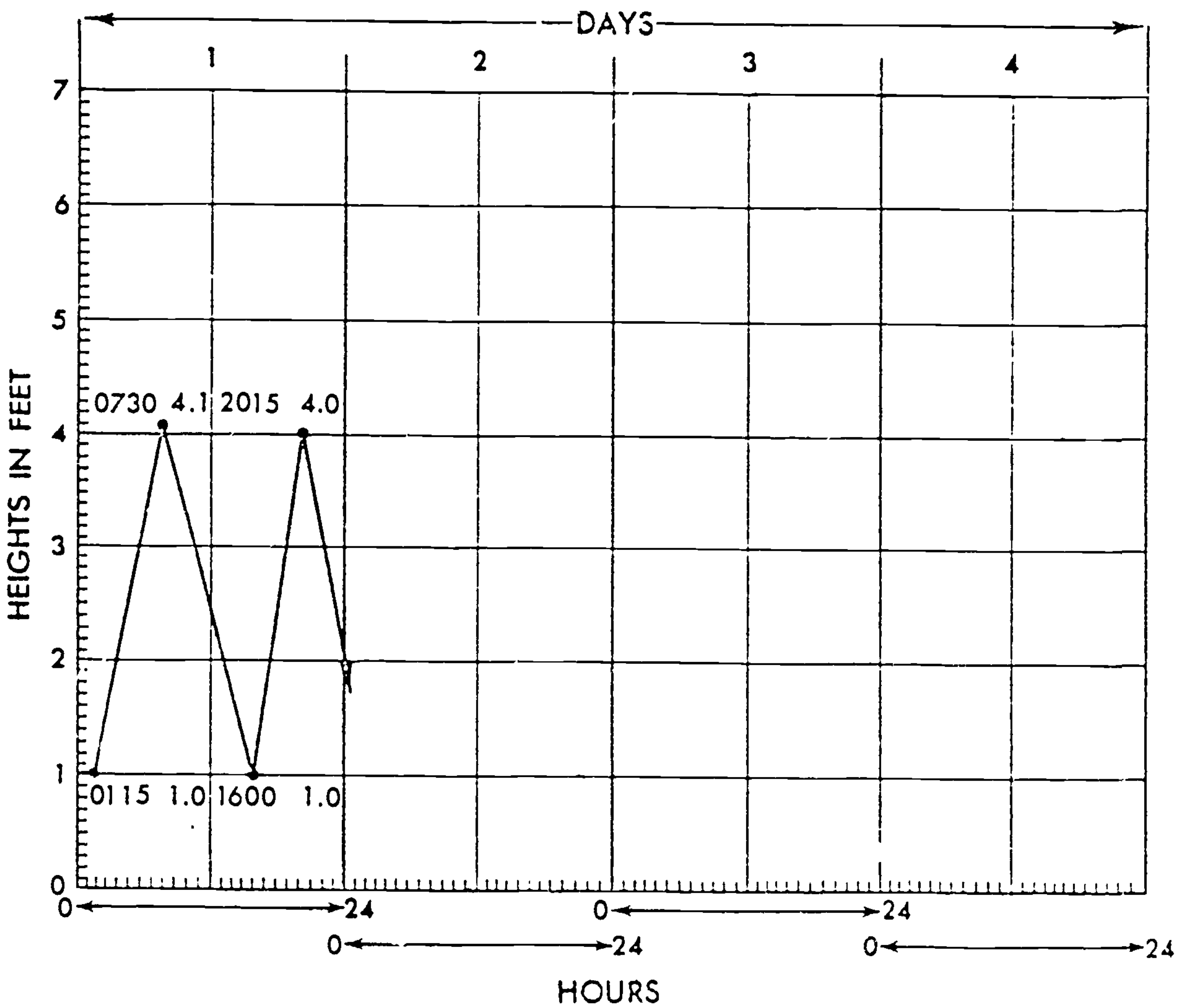
On what days? ____________ and ____________.

STUDENT HANDOUT
TIDES, CHARTS AND PREDICTIONS
PART B

DRAWING A TIDE CURVE

SOLUTION

EXERCISE 1



ACTIVITY 3:

TIDES AND TIMES OF PUGET SOUND

(1 day)

ACTIVITY 3: TIDES AND TIMES OF PUGET SOUND (1 day)

CONCEPTS: The tides arrive at different times in different parts of Puget Sound. The differences in time are due to the geological formation of the Sound. All the ocean water, hence the tidal surge, must enter through Admiralty Inlet and Deception Pass and then travel the distance of the Puget Sound Basin.

OBJECTIVES: Following this activity the learner will demonstrate his/her ability to:

1. read a tide chart for tidal data.
2. define and use the term "diurnal range."
3. explain the time differences for high tides for various locations.

TEACHER PREPARATION:

1. Be certain you and the students understand these terms: diurnal, semi-diurnal, mixed, mean higher high tide, mean lower low tide, diurnal range of the tide (the last three are defined within the activity).

MATERIALS:

1. 30 copies of the Times and Tides of Puget Sound worksheets.
2. 30 rulers with millimeter (mm) divisions
3. 30 red pencils (pens)
4. one transparency map of Puget Sound or a navigational chart of Puget Sound.

PROCEDURES:

1. Review with the students all the factors that influence the size and time of the tides.
2. Have students view a map (transparency) of Puget Sound. Ask them if they can see anything about the Puget Sound Basin which might have an influence on either the size of the tides or the arrival time of the tides. Help them to see:
   a. all the ocean water must come in and go out of two narrow openings into the Sound. The two openings are Admiralty Inlet and Deception Pass.
   b. in narrow places the water must rush fast to fill in the lower Sound region (for example at Tacoma Narrows).
   c. Any given particle of water will go past Seattle prior to going past Tacoma. Therefore, the arrival time of high tide will be earlier in Seattle than in Tacoma. (Before doing this step it might be useful to see "Extended Activities" for other ways to approach this activity.)
3. Hand out the Times and Tides of Puget Sound. Prior to doing the activity it might be useful to clearly define diurnal range of the tide for your students.
4. After completing the activity, review with students what they have learned about tides, especially in reference to Puget Sound. Then hand out the student evaluation.

EXTENDED ACTIVITIES:

1. For the Tides and Times of Puget Sound some other approaches might be useful. For example, hand out the assignment prior to having the discussion about the features of Puget Sound. The data they obtain from the worksheet may lead them to the conclusions stated in Step 2 of the procedures.

2. Have the students compute the velocity of the tidal crest. The nautical mile distance from Port Angeles to Shelton by water route is 115 N.M. The formula is knots = N.M. and every 6 minutes is 1/10 of an hour.

3. Of extreme value in understanding Puget Sound tides is a visit to the Puget Sound Tides Model in the Pacific Science Center. Assistants at the P.S.C. demonstrate the tides model and provide useful instruction.

   The model is to scale and "tides" are generated by a mechanical computer and plunger. The model allows students to visually see the currents caused by the incoming ocean water.

BIBLIOGRAPHY:

Curriculum

"Tide Lab" from the Marine Science Center, Poulsbo, Washington - (the Times and Tides of Puget Sound activity was adapted from this activity by permission from Dave Borden).

Times and Tides of Puget Sound

EQUIPMENT:
- a current tide table or tidal difference data sheet
- a map of Puget Sound
- red pencil (pen)
- ruler with millimeter (mm) divisions

DEFINE:
- diurnal tide: *a tide that has one high tide and one low tide daily*
- semi-diurnal tide: *a tide that has 2 high tides and 2 low tides daily. The 2 high tides are about equal in size, as are the 2 lows.*
- mixed tides: *has 2 high and 2 low tides daily. The 2 highs are of unequal value, as are the 2 lows.*

NEW TERMS:
- mean higher high water (M.H.H.W.) - the average height the daily higher high tides reach over a period of time.
- mean lower low water (M.L.L.W.) - the average depth the daily lower low tides reach over a period of time.
- diurnal range of the tide - the difference between the mean higher high water and the mean lower low water. It is ar average value that reveals the difference between the higher of the 2 highs and the lower of the 2 lows each day.

Note to the teacher: It might be useful to have students compute the mean higher high water and the mean lower low water for a given month. Do this by using the tide calendar. Take, for each day, the height in feet of the higher high tide. Add them up and divide by the number of days for the month. By subtracting the average or mean lower low tide value from the average or mean higher high tide value the student can get the diurnal range of the tide for that month. Repetition of this activity for each month and a final average would gain an average value for an entire year. This figure is what is represented on the "Tidal Differences and Other Constants" chart.)

PROCEDURE: Part A: The Size of Puget Sound Tides

Note to the teacher: Be certain students can read the tidal differences and other constants chart. See the Teacher Information Sheet on this.)

1. From the data given you on the "Tidal Differences and Other Constants" Chart, transfer the diurnal range data onto the Puget Sound Map at the identified locations.

2. Using the scale one foot of diurnal range equals one mm, draw a red vertical line next to each site. The vertical line, drawn like this | represents the diurnal range for that site. Therefore it is important that the length of the line is accurate. For example, the diurnal range for Port Angeles is 7.2 feet. A vertical line 7.2 mm long should be drawn next to Port Angeles.

3. On the back of this sheet summarize what this presentation of the tide data tells you about the size of tides in all of Puget Sound.

Part B: The Times of Puget Sound Tides

1. Determine the time for the higher high tide (H.H.) in Seattle for the date January 8th, 1977. The time will be *7:15 a.m.*.

2. Determine the time for the higher high tide in Port Townsend for that same date. Do this by subtracting 22 minutes from the Seattle time. The time for H.H. tide will be *6:53 a.m.*

3. Using the time of the high tide at Port Townsend and Seattle given to you, determine the time of high tide arrival at each of the sites identified on your map. Record the times on your map.

IMPORTANT NOTE: In the data supplied to you on the Tidal Differences and Other Constants Chart Port Angeles, Dungeness, Smith Island, and Port Townsend are referenced to Port Townsend Tidal data. In other words, you determine the arrival time of the high tide by subtracting or adding minutes to the time of tide arrival at Port Townsend. For example, Admiralty Head is referenced to Port Townsend. From the time of tide arrival at Port Townsend you would subtract 4 minutes. All other sites are referenced to Seattle.

4. Next to the sites on your map, number each site in order of the arrival of the high tide. Do not include the Hood Canal sites--Port Gamble, Bangor Wharf, Zelatched Point, Seabeck, Pleasant Harbor, or Union.

5. With the Hood Canal sites letter the sites in sequence of the arrival of the high tide. Begin with the letter A at Port Ludlow. Continue through letter G. Port Ludlow will have both a letter and a number.

6. How much time passes from the passage of the tide at Port Angeles until its arrival at Shelton? *(3 hours)*

7. Were there any illogical time reversals in this part of the lab? Identify each out of sequence site.

(Yes, Port Ludlow before Port Townsend
Allyn before Vaughn
Pleasant Harbor before Zelatched Point)

Teacher Infoımation Sheet
(continued)

It is very important to instruct students on how to read and use this chart. It might be useful to make an overhead transparency of the chart to point out the things students will need to know. Otherwise, rely on students to read their own copy of the chart included in their worksheets.

TABLE 2 - TIDAL DIFFERENCES AND OTHER CONSTANTS

PLACE	POSITION		DIFFERENCES				RANGES		Mean Tide Level
	Lat.	Long.	Time		Height		Mean	Diurnal	
			High Water	Low Water	High Water	Low Water			
Puget Sound			h m	h m	feet	feet	feet	feet	feet
				on Seattle					
Hansville----------------	47 55	122 33	-0 07	+0 04	-1.0	-0.1	0.7	10.3	6 1
Point No Point----------	47 55	122 32	-0 16	-0 16	*0.92	*0.92	6.7	10.3	6.1
Edmonds-----------------	47 49	122 23	-0 05	+0 02	-0.4	0.0	7.2	10.0	0.4
Port Madison------------	47 42	122 32	-0 08	-0 08	+0.1	0.0	7.7	11.4	6.6
Poulsbo, Liberty Bay----	47 44	122 39	+0 02	+0 08	+0.6	+0.1	8.1	11.9	6.9
Brownsville, Port Orchard	47 35	122 37	+0 02	+0 08	+0.4	0.0	8.0	11.7	6.8
Seattle (Madison St., Elliott Bay)----------	47-36	122 20	Daily predictions				7.0	11.3	6.6

Place - the location of a site by name

Position - by degrees and minutes latitude (lat.) and longitude (long.)

Differences - Time - the difference in hours (h.) and/or minutes (m) it takes the high or low tides to arrive. These are in comparison to Seattle. For the daily tides for Seattle consult a current tide calendar or table. For example, to determine the high tide time at Edmonds, you would subtract (-) 5 minutes from the Seattle high tide time. For low tide time you would add (+) 2 minutes.

Differences - Height - the relative sizes of the tides as compared to Seattle. The height of the daily tides for Seattle must be obtained from a current tide table or calendar. Then add (+) or subtract (-) feet according to the chart. For example, at Edmonds the high tide is -0.4 feet less than the Seattle high tide. The low tide level is the same as Seattle, hence the 0.0.

Ranges - Mean - the average difference between high and low tide in Seattle is 7.0 feet. In Edmonds it is 7.2. This figure includes the daily inequality of a mixed tide. In other words, it averages the range of extreme tides (the high high and low low) with the range of the low high tide to high low tide.

Ranges - Diurnal - this figure represents the annual average range of higher high tides and lower low tides.

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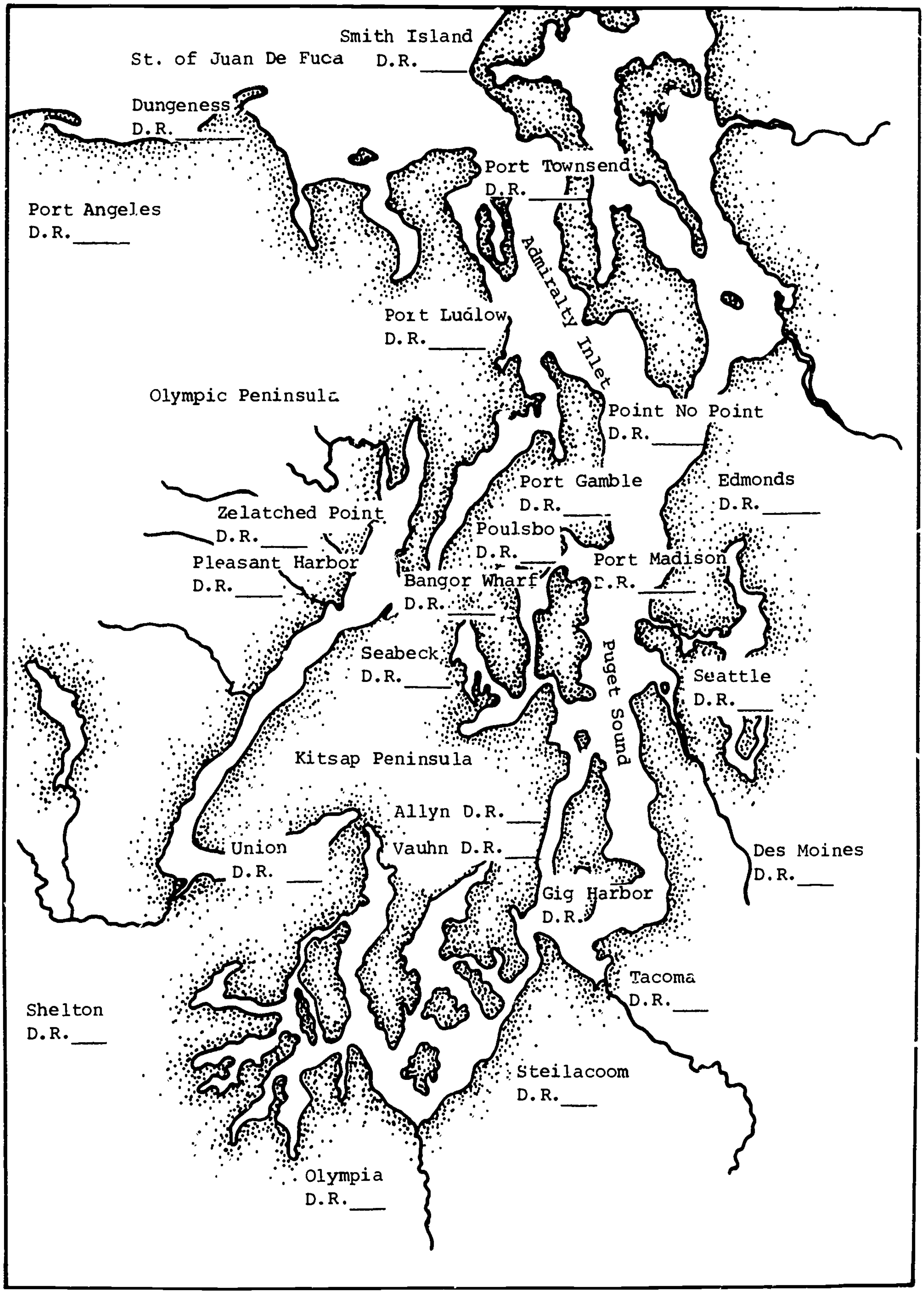
* ratio

Mean Tide Level - this is a point that is halfway between the mean high tide level and the mean low tide level.

"on Seattle" - the tides are referenced to the Seattle tide data.

Teacher Information Sheet
(continued)

PLACE	DIURNAL RANGE	TIME OF TIDE*	SEQUENTIAL RANK
Port Angeles	7.2	4:27 a.m.	1
Dungeness	7.6	6:06 a.m.	2
Port Ludlow	9.9	6:48 a.m.	3
Smith Island	7.0	6:53 a.m.	4
Port Townsend	5.1	6:53 a.m.	5
Point No Point	10.4	6:59 a.m.	6
Port Madison	11.4	7:07 a.m.	7
Edmonds	10.9	7:10 a.m.	8
Seattle	11.3	7:15 a.m.	9
Poulsbo	11.9	7:17 a.m.	10
Des Moines	11.7	7.18 a.m.	11
Gig Harbor	11.8	7:21 a.m.	12
Tacoma	11.8	7:22 a.m.	13
Steilacoom	13.1	7:37 a.m.	14
Allyn	14.1	7:42 a.m.	15
Olympia	14.4	7:46 a.m.	16
Vaughn	14.1	7:50 a.m.	17
Shelton	14.2	8:27 a.m.	18
On Hood Canal			
Port Ludlow	9.9	6:48 a.m.	A
Bangor Wharf	10.9	6:55 a.m.	B
Port Gamble	10.3	6:59 a.m.	C
Pleasant Harbor	11.6	7:01 a.m.	D
Zelatched Point	11.5	7:06 a.m.	E
Union	11.8	7:11 a.m.	F
Seabeck	11.6	7:12 a.m.	G


Smith Island
D.R.____
St. of Juan De Fuca
Dungeness
D.R.____
Port Angeles
D.R.____
Port Townsend
D.R.____
Admiralty Inlet
Port Ludlow
D.R.____
Olympic Peninsula
Point No Point
D.R.____
Port Gamble
D.R.____
Edmonds
D.R.____
Zelatched Point
D.R.____
Poulsbo
D.R.____
Pleasant Harbor
D.R.____
Bangor Wharf
D.R.____
Port Madison
D.R.____
Seabeck
D.R.____
Puget Sound
Seattle
D.R.____
Kitsap Peninsula
Allyn D.R.____
Vauhn D.R.____
Union
D.R.____
Des Moines
D.R.____
Gig Harbor
D.R.
Tacoma
D.R.____
Shelton
D.R.____
Steilacoom
D.R.____
Olympia
D.R.____

Student Worksheet

NAME________________________

DATE________________________

PERIOD______________________

Times and Tides of Puget Sound

EQUIPMENT:
- a current tide table or tidal difference data sheet
- a map of Puget Sound
- red pencil (pen)
- ruler with millimeter (mm) divisions

DEFINE:
- diurnal tide
- semi-diurnal tide
- mixed tides

NEW TERMS:
- mean higher high water (M.H.H.W.) - the average height the daily higher high tides reach over a period of time.
- mean lower low water (M.L.L.W.) - the average depth the daily lower low tides reach over a period of time.
- diurnal range of the tide - the difference between the mean higher high water and the mean lower low water. It is an average value that reveals the difference between the higher of the 2 highs and the lower of the 2 lows each day.

PROCEDURE: Part A: The Size of Puget Sound Tides

1. From the data given you on the "Tidal Differences and Other Constants" chart, transfer the diurnal range data onto the Puget Sound Map at the identified locations.

2. Using the scale one foot of diurnal range equals one mm, draw a red vertical line next to each site. The vertical line, drawn like this | represents the diurnal range for that site. Therefore it is important that the length of the line is accurate. For example, the diurnal range for Port Angeles is 7.2 feet. A vertical line 7.2 mm long should be drawn next to Port Angeles.

3. On the back of this sheet summarize what this presentation of the tide data tells you about the size of tides in all of Puget Sound.

Part B: The Times of Puget Sound Tides

1. Determine the time for the higher high tide (H.H) in Seattle for the date January 8th, 1977. The time will be __________.

2. Determine the time for the higher high tide in Port Townsend for that same date. Do this by subtracting 22 minutes from the Seattle time. The time for H.H. tide will be _________.

3. Using the time of the high tide at Port Townsend and Seattle given to you, determine the time of high tide arrival at each of the sites identified on your map. Record the times on your map.

Student Worksheet

IMPORTANT NOTE: In the data supplied to you on the Tidal Differences and other Constants Chart, Port Angeles, Dungeness, Smith Island, and Port Townsend are referenced to Port Townsend Tidal data. In other words, you determine the arrival time of the high tide by subtracting or adding minutes to the time of tide arrival at Port Townsend. For example, Admiralty Head is referenced to Port Townsend. From the time of tide arrival at Port Townsend you would subtract 4 minutes. All other sites are referenced to Seattle.

4. Next to the sites on your map, number each site in order of the arrival of the high tide. Do not include the Hood Canal sites--Port Gamble, Bangor Wharf, Zelatched Point, Seabeck, Pleasant Harbor, or Union.

5. With the Hood Canal sites, letter the sites in sequence of the arrival of the high tide. Begin with the letter A at Port Ludlow. Continue through letter G. Port Ludlow will have both a letter and a number.

6. How much time passes from the passage of the tide at Port Angeles until its arrival at Shelton? ___________

7. Were there any illogical time reversals to this part of the lab? Identify each out of sequence site.

TABLE 2 - TIDAL DIFFERENCES AND OTHER CONSTANTS

PLACE	POSITION		DIFFERENCES				RANGES		Mean Tide Level
	Lat.	Long.	Time		Height		Mean	Diurnal	
			High Water	Low Water	High Water	Low Water			
			h m	h m	feet	feet	feet	feet	feet
					ON PORT TOWNSEND				
Crescent Bay----------	48 10	123 44	-2 44	-0 00	*0.81	*0.81	4.1	6.7	4.1
Port Angeles----------	48 07	123 26	-1 26	-1 21	*0.87	*0.87	4.2	7.2	4.4
Dungeness-------------	48 10	123 07	-0 47	-0 36	*0.92	*0.92	4.4	7.6	4.7
Sequim Bay------------	48 05	123 03	-0 32	-0 05	*0.95	*0.95	4.8	7.9	4.8
Gardiner, Discovery Bay----------------	48 04	122 55	-0 40	-0 15	*0.95	*0.95	4.8	7.9	4.8
Smith Island----------	48 19	122 50	-0 06	-0 23	*0.84	*0.84	4.2	7.0	4.5
Point Partridge-------	48 14	122 46	-0 04	-0 13	*0.93	*0.93	4.5	7.7	4.7
Port Townsend---------	48 08	122 40	Daily Predictions				5.1	8.3	5.0
HOOD CANAL					ON SEATTLE				
Port Ludlow-----------	47 55	122 41	-0 27	-0 18	*0.88	*0.88	6.4	9.9	5.9
Port Gamble-----------	47 52	122 35	-0 16	-0 08	*0.91	*0.91	6.7	10.3	6.1
Bangor Wharf----------	47 45	122 44	-0 20	+0 04	-0.3	0.0	7.3	10.9	6.4
Zelatched Point-------	47 43	122 49	-0 09	-0 05	+0.1	+0.1	7.6	11.5	6.7
Seabeck---------------	47 38	122 50	-0 03	+0 03	+0.3	+0.1	7.8	11.6	6.8
Pleasant Harbor-------	47 40	122 55	-0 14	+0 01	+0.2	+0.1	7.7	11.6	6.8
Union-----------------	47 21	122 00	-0 -4	+0 10	+0.4	+0.1	7.9	11.8	6.9
PUGET SOUND									
Point No Point--------	47 55	122 32	-0 16	-0 16	*0.92	*0.92	6.7	10.4	6.1
Edmonds---------------	47 49	122 23	-0 05	+0 02	-0.4	0.0	7.2	10.9	6.4
Poulsbo---------------	47 44	122 39	+0 02	+0 08	+0.6	+0.1	8.1	11.9	6.9
Seattle---------------	47 36	122 20	Daily Predictions				7.0	11.3	6.6
Port Blakely----------	47 36	122 30	+0 02	+0 03	+0.2	0.0	7.8	11.5	6.7
Bremerton-------------	47 33	122 38	+0 07	+0 12	+0.4	0.0	8.0	11.7	6.8
Des Moines------------	47 24	122 20	+0 03	+0 09	+0.4	0.0	8.0	11.7	6.8
Gig Harbor------------	47 20	122 35	+0 06	+0 14	+0.6	0.0	8.2	11.8	6.9
Tacoma----------------	47 17	122 25	+0 07	+0 06	+0.5	0.0	8.1	11.8	6.8
Steilacoom------------	47 10	122 36	+0 22	+0 35	+1.8	0.0	9.4	13.1	7.5
Vaughn----------------	47 20	122 46	+0 35	+0 47	+2.8	+0.2	10.2	14.1	8.1
Allyn-----------------	47 23	122 49	+0 27	+0 46	+2.8	+0.2	10.2	14.1	8.1
Shelton---------------	47 13	123 05	+1 12	+1 54	+2.8	-0.2	10.6	14.2	7.9
Olympia---------------	47 03	122 54	+0 31	+0 46	+3.1	+0.2	10.5	14.4	8.2

* ratio

EVALUATION

VOCABULARY

BIBLIOGRAPHY

Teacher Informatio.. Sheet
Evaluation

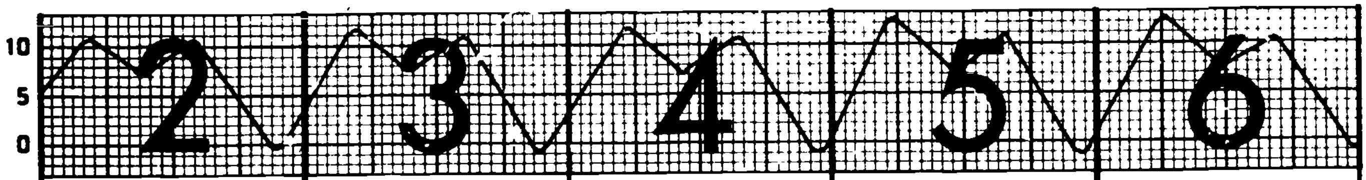
1. Explain how the relative positions the sun and moon have to the earth affect the tides of Puget Sound.

   (The alignment of the sun and moon with the earth is what is important. When the sun, moon and earth form a straight line the gravitational pull is stronger and the diurnal tides are higher--or lower. These tides, the spring tides, occur at New and Full moon phases. When the moon and sun are at right angles, either 1st or 3rd quarter phases, the gravitational pull is offset and the tidal range is not so large. These tides are called Neap tides.)

2. What type of daily tide do we have on Puget Sound? How does this tide differ from the other 2 types of tides?

   (On Puget Sound we experience two high and low tides a day. The 2 high tides are of unequal value and the 2 low tides are of unequal value. Daily Puget Sound experiences a higher high tide (HH), a lower low tide (LL), a lower high tide (LH), and a higher low tide (HL). The 2 other types of tides are the Diurnal tide, which has one high and one low tide a day, and the Semi-diurnal tide, which has 2 high tides of equal size and 2 low tides of equal size.)

3. Using this portion of a tide calendar, answer the following questions



4:14	9:03	**1:53**	**9:18**	4:51	9:47	**2:33**	**9:50**	5:21	10:29	**3:11**	**10:24**	5:51	11:04	**3:50**	**10:59**	6:18	11:43	**4:32**	**11:32**
10.8	7.5	**10.5**	**-0.3**	11.3	7.4	**10.5**	**-0.7**	11.7	7.3	**10.5**	**-1.0**	12.1	7.0	**10.5**	**-1.1**	12.3	6.7	**10.4**	**-1.0**

   a. Are the tides Neap or Spring? *(Spring)*
   b. On the 4th, what time is the high high tide? *(5:21 a.m.)*
   c. How high is that tide on the 4th? *(11.7 feet)*
   d. On the 3rd at 6:00 p.m., how high will the tide be? *(5 feet)*
   e. What kind of tide could one expect on the 19th? *(Spring)*
   f. What is the diurnal range on the 5th? *(13.2 feet)*

4. You are a resident of Port Angeles and are visiting relatives in Shelton. As you prepare to go clam digging you make some observations about the tides at Shelton as compared to the tides at Port Angeles. What are the differences?

(The tides arrive nearly 3 hours later at Shelton and the diurnal range is greater.)

Student Evaluation

NAME____________________

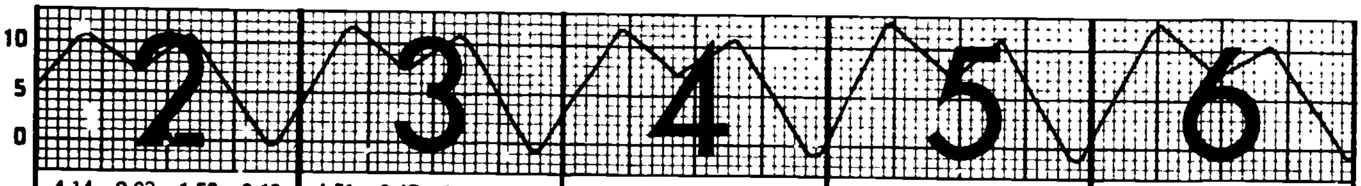
DATE____________________

PERIOD____________________

1. Explain how the relative positions of the sun and moon to the earth affect the tides of Puget Sound.

2. What type of daily tide do we have on Puget Sound? How does this tide differ from the other 2 types of tides?

3. Using this portion of a tide calendar, answer the following questions:



4:14	9.03	**1:53**	**9:18**	4:51	9:47	**2:33**	**9:50**	5:21	10.29	**3:11**	**10:24**	5 51	11 04	**3:50**	**10:59**	6 18	11 43	**4:32**	**11:32**
1C	7.5	**10.5**	**-0.3**	11 3	7.4	**10:5**	**-0.7**	11.7	7 3	**10.5**	**-1.0**	12 1	7 0	**10.5**	**-1.1**	12 3	6 7	**10.4**	**-1.0**

a. Are the tides Neap or Spring?
b. On the 4th, what time is the high high tide?
c. How high is that tide on the 4th?
d. On the 3rd at 6:00 p.m., how high will the tide be?
e. What kind of tide could one expect on the 19th?
f. What is the diurnal range on the 5th?

4. You are a resident of Port Angeles and are visiting relatives in Shelton. As you prepare to go clam digging you make some observations about the tides in Shelton as compared to the tides of Port Angeles. What are the differences?

Student Handout
Vocabulary

NAME ____________________

DATE ____________________

PERIOD ____________________

Neap Tide

Spring Tide

Diurnal Tide

Semi-diurnal tide

Mixed Tide

Mean Higher high tide

Mean Lower low tide

Diurnal range

Mean tide level

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Problem Series - Tides, Charts and Predictions Activity

Maudslien, Linda, IBID
Strain, Jerry
U.S. Naval Oceanographic Office, Teachers' Ocean Science Study Kit, Washington, D.C. 20390.

Teacher Reading - adapted from

Osis, Vicki and Don Giles, 4-H Marine Science, reprinted by W.S.U. Cooperative Extension Service, February 1975.

Optional Materials - film

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"Tide Lab", Marine Science Center, Dave Borden, Director, North Kitsap School District, Poulsbo, WA 98370

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Carter, Samuel, Kingdom of the Tides, Hawthorn Books, New York, 1966.