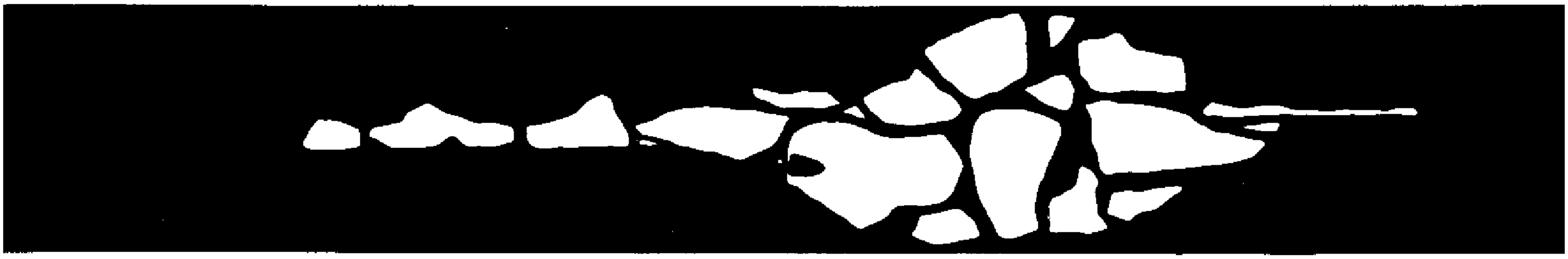
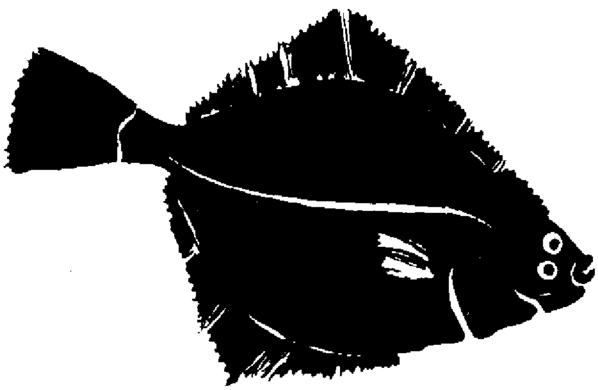


TIDES



By

Judy McDonald

Marine Science Curriculum Aid No. 5
Sea Grant Report 80-2
December, 1980

MARINE ADVISORY PROGRAM
University of Alaska
2651 Providence Avenue
Anchorage, Alaska 99504

T I D E S

by

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PREFACE

This project manual is designed as a curriculum aid for use by Alaskan institutions of learning. It is one of a continuing series whose goal is to provide basic information about the marine environment and Alaskan marine resources. This manual has been developed for use in secondary schools and by other groups who focus on working with young Alaskans ages 13-18.

ACKNOWLEDGMENTS

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INTRODUCTION

Alaska has an extensive coastline. Most of the population is found along the southern and southcentral coasts. Many of these Alaskans are involved in boating, fishing, clamming, and beachcombing. To safely participate in these activities an understanding of tides is important. The objective of this project manual is to give a general explanation of tidal phenomena in Alaska.

WHAT IS A TIDE?

A tide is the alternate rising and falling of the surface of the ocean and other bodies of water that occurs twice a day over most of the earth.

WHAT CAUSES TIDES?

Before you can understand what causes tides, you must understand the effects of the moon's and sun's gravitational attraction on the earth. In the 17th century, Sir Isaac Newton developed his Law of Gravitation. This law defines gravity as a force that attracts objects to each other.

The gravitational attraction between objects depends on two things: 1) The mass[1] of the objects. The bigger the mass, the stronger the attraction. Mass is not the same as weight. 2) The distance between the objects. The shorter the distance, the stronger the attraction (Figure 1). In our solar system, the sun has the greatest mass and the

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[1]Definition of underlined words can be found in the Glossary.

moon is the closest heavenly body to the earth. Therefore, both the sun and the moon have a large gravitational attraction on the earth. Why do you suppose the other planets and other stars in the solar system which are much more massive than the sun do not have much gravitational effect on the earth? The answer is distance. The planets and stars are so far away that their mass has very little gravitational effect on the earth.

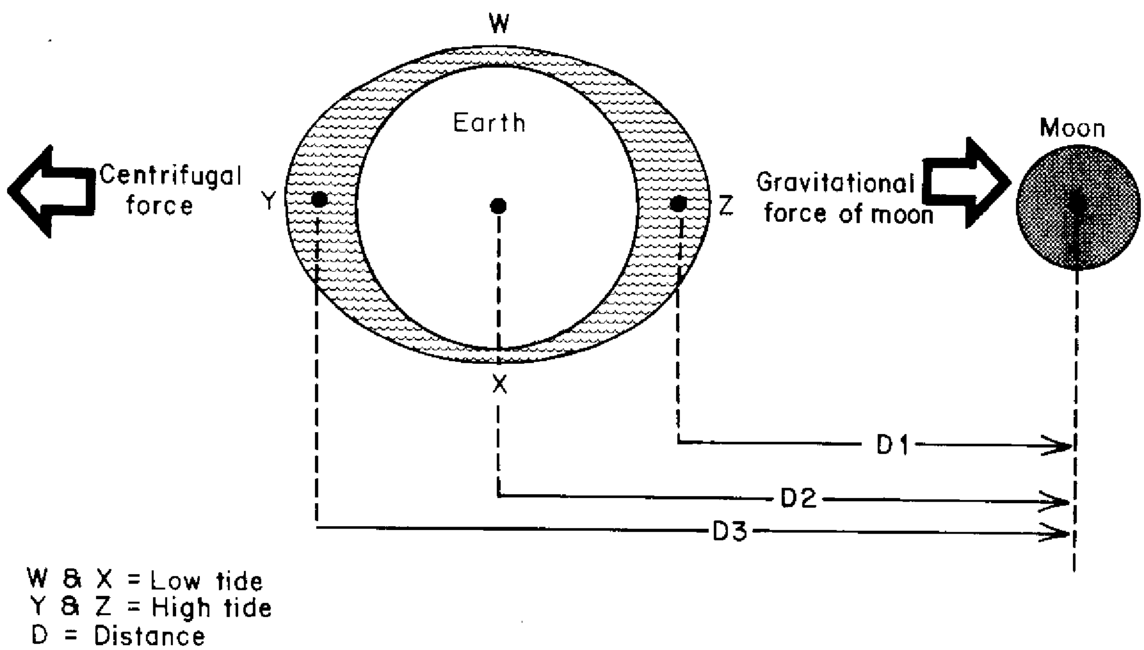


Figure 1. Center of Gravity Distance Differences.

If gravitational attraction were the only force acting on two objects, they would be pulled into each other. Fortunately for us there is another force which influences the movement of objects <u>revolving</u> around each other or when an object <u>rotates</u> around a center. This is the <u>centrifugal force</u>, which acts outward on an object. For a good example of centrifugal force in action you can run directly behind someone riding a bike down a muddy road. Mud will be thrown from the rotating bicycle wheel onto your body in a nice brown stripe.

While the gravitational attraction pulls the earth and the moon toward each other, centrifugal force throws them away from each other. At the center of the earth and the moon these forces balance each other. But, the two forces are not equal on the surface of these bodies. On the side of the earth it faces, the moon is closer to the water than it is to the earth's center. Since gravitational attraction increases as distance decreases, the gravitational pull is stronger than centrifugal force. On the opposite side of the earth the moon is farther away, so the gravitational attraction decreases and the centrifugal force is stronger. The forces in play are not enough to pull the water off the earth's surface, but they are strong enough to cause water movement (Figure 1).

The result of centrifugal force and the gravitational attraction of the sun and the moon on the earth can be illustrated by the use of a model--an imaginary world which is similar to the earth but less complicated. Imagine a world completely covered by an ocean that is the same depth everywhere. (Most of the illustrations in this manual use this world as the earth.)

In Figure 1, D1 illustrates water being pulled toward the moon because the gravitational force is stronger than the centrifugal force. On the opposite side of the earth, D3, the water is thrown away from the direction of the moon because the centrifugal force is stronger. The pull of the earth's gravity keeps the water on the earth's surface. The interaction of these forces results in deeper water at points Y and Z in

Figure 1 and shallower water at points W and X. This is a simple tidal wave. The high points at Y and Z are the crest and the low points at W and X are the trough. High tides occur at the crests and low tides occur at the troughs (Figure 2).

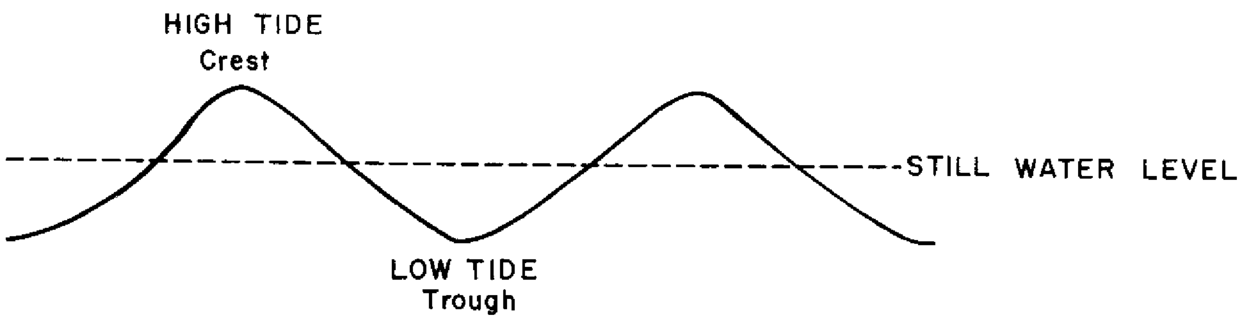


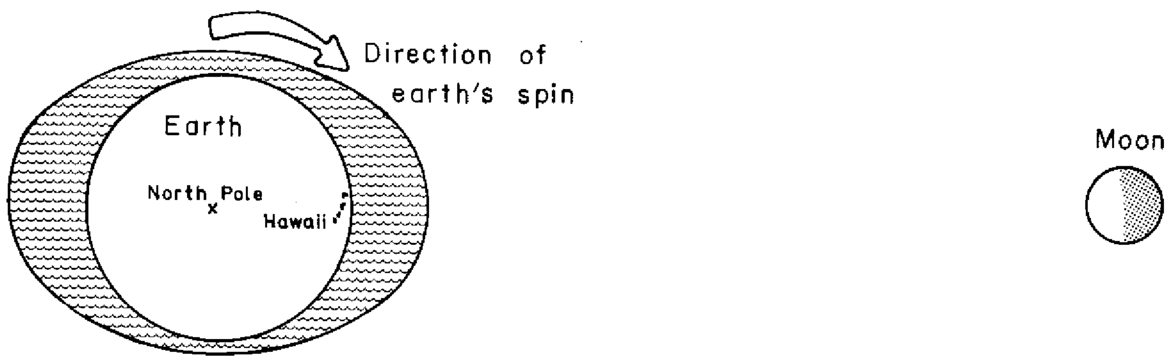
Figure 2. Parts of a wave.

Do not confuse the term "tidal wave" with the kind of wave produced by earthquakes. The Japanese word tsunami (sue NAMEE) is the proper term when speaking of sea waves generated by submarine earth movement or volcanic eruption. Tidal waves are crests and troughs of the tides (Figure 2).

The difficulty is that we don't live on a world covered completely by water, and the solar system is in constant motion. The earth spins on its axis, called rotation. The tidal wave stays aligned with the moon while the earth rotates under it. This changes the position of the high and low tides relative to the earth. In Figure 3A, Hawaii is under the crest and experiences a high tide. Six hours and 12 minutes later the earth has rotated a quarter of the way around placing Hawaii under a trough. Hawaii then has a low tide as in Figure 3B.

The reason the tides are about 50 minutes later each day is because they are related to the lunar day. While the earth is rotating on its axis, the moon is revolving around the earth. So, a spot on the earth will face the sun once every 24 hours. But, the same spot needs 24 hours and 50 minutes to face the moon. This 24 hour and 50 minute period is called a lunar day.

A. Hawaii at high tide:



B. Hawaii at low tide six hours later:

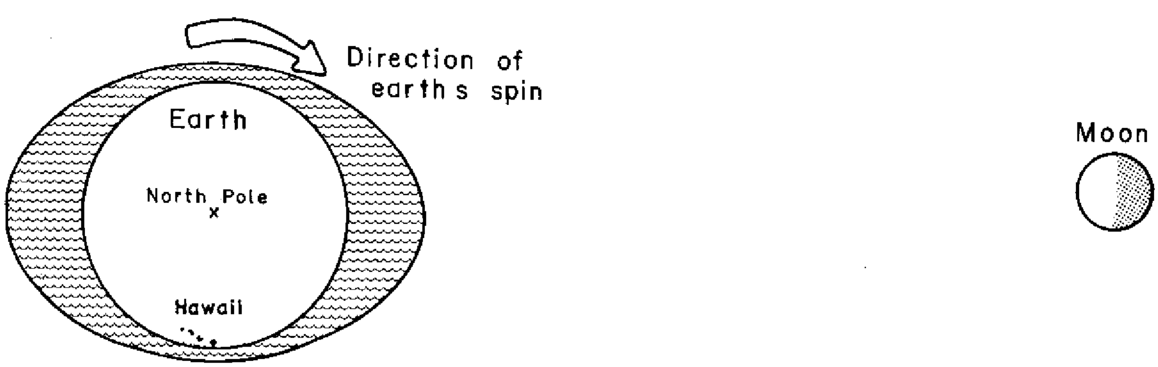


Figure 3. The earth rotates faster than the tidal wave moves.

The earth and the moon can be considered twin planets revolving around a common center. The center of the earth-moon system is 2,900 miles from the center of the earth. The radius of the earth is 3,963.5 miles. Therefore, the common center for this earth-moon system is located within the earth (Figure 4).

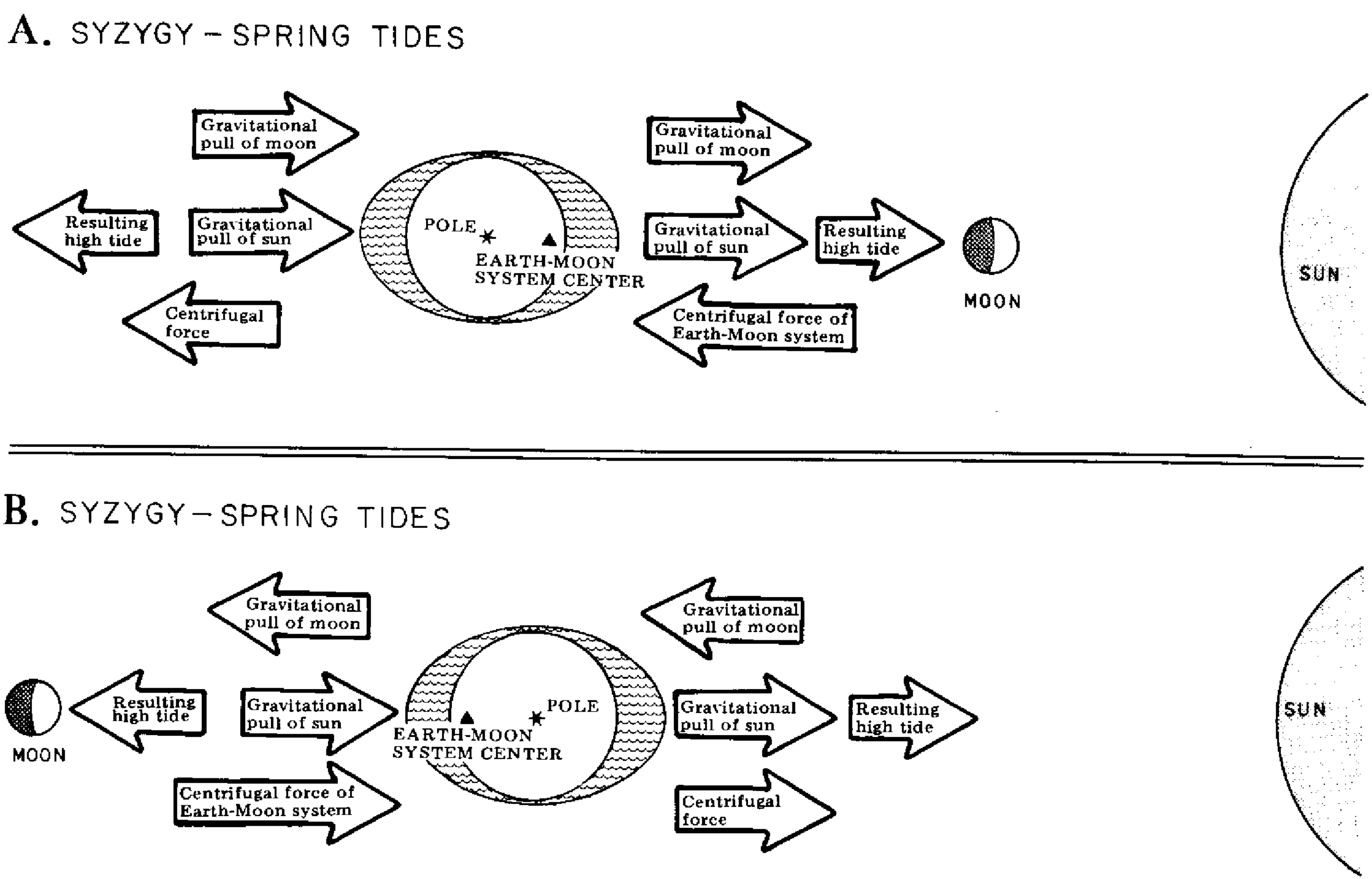


Figure 4. Forces producing tides. Gravity works from the center of these bodies.

The earth revolves around the sun in an <u>elliptical</u> or elongated orbit. The sun's gravity affects the tides in much the same way as the moon's gravity. But since it is so far away, it has only about half the effect of the moon (Figure 4).

C. QUADRATURE-NEAP TIDES

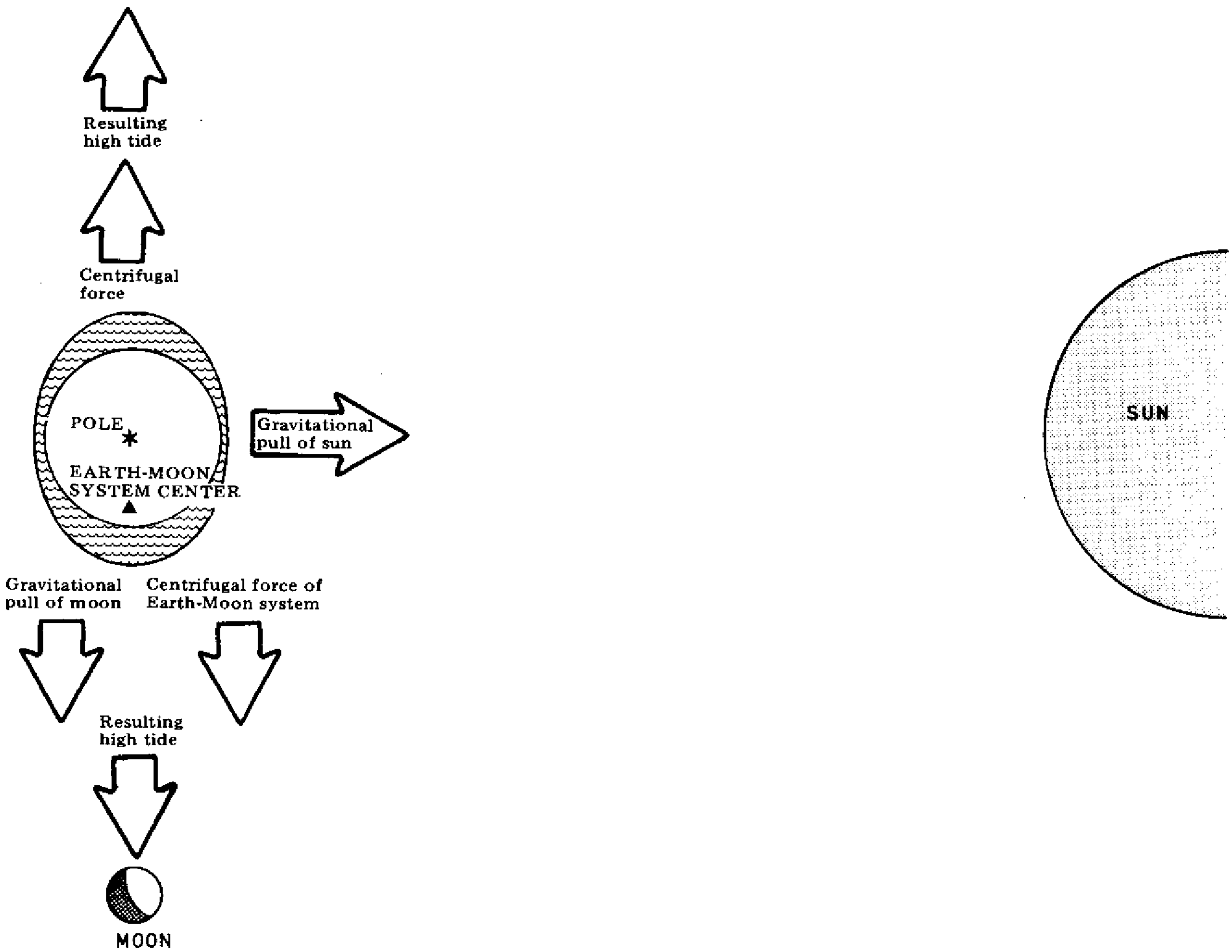


Figure 4. (Continued)

COMPLICATING FACTORS

Our world does not have a uniform topography. There are irregular shaped pieces of land above the surface of the ocean which act as a barrier to the movement of the tidal wave around the earth. The ocean bottom is not smooth, and the water is not all the same depth. There are underwater mountains, ridges and canyons which also interrupt the wave's movement. These interruptions and friction between the water and the earth's surface influence the position and speed of the tidal wave.

TYPES OF TIDES

There are three types of tidal cycles in the world and two types in Alaska. They are:

1) SEMIDIURNAL (semi DIE earnal): Semidiurnal tides have two equal high tides and two equal low tides each day. Semidiurnal tides occur on the Atlantic coasts of the United States and in Europe (Figure 5). This is the type of tidal cycle which would be expected from looking at the model of the water covered earth.

2) DIURNAL (DIE earnal): Because of the complicating factors mentioned in the previous sections, some places on earth have only one high tide and one low tide each day. These are called diurnal tides and occur in the northern Gulf of Mexico and southeast Asia, and occasionally in the Aleutian Islands (Figure 5; Project 3).

3) MIXED TIDES: Mixed tides occur when components of both diurnal and semidiurnal tides are present. The mixing of semidiurnal and diurnal components produce unequal high and low tides which are common along the Gulf of Alaska, and the Pacific coasts of the United States and Asia (Figures 5 and 6).

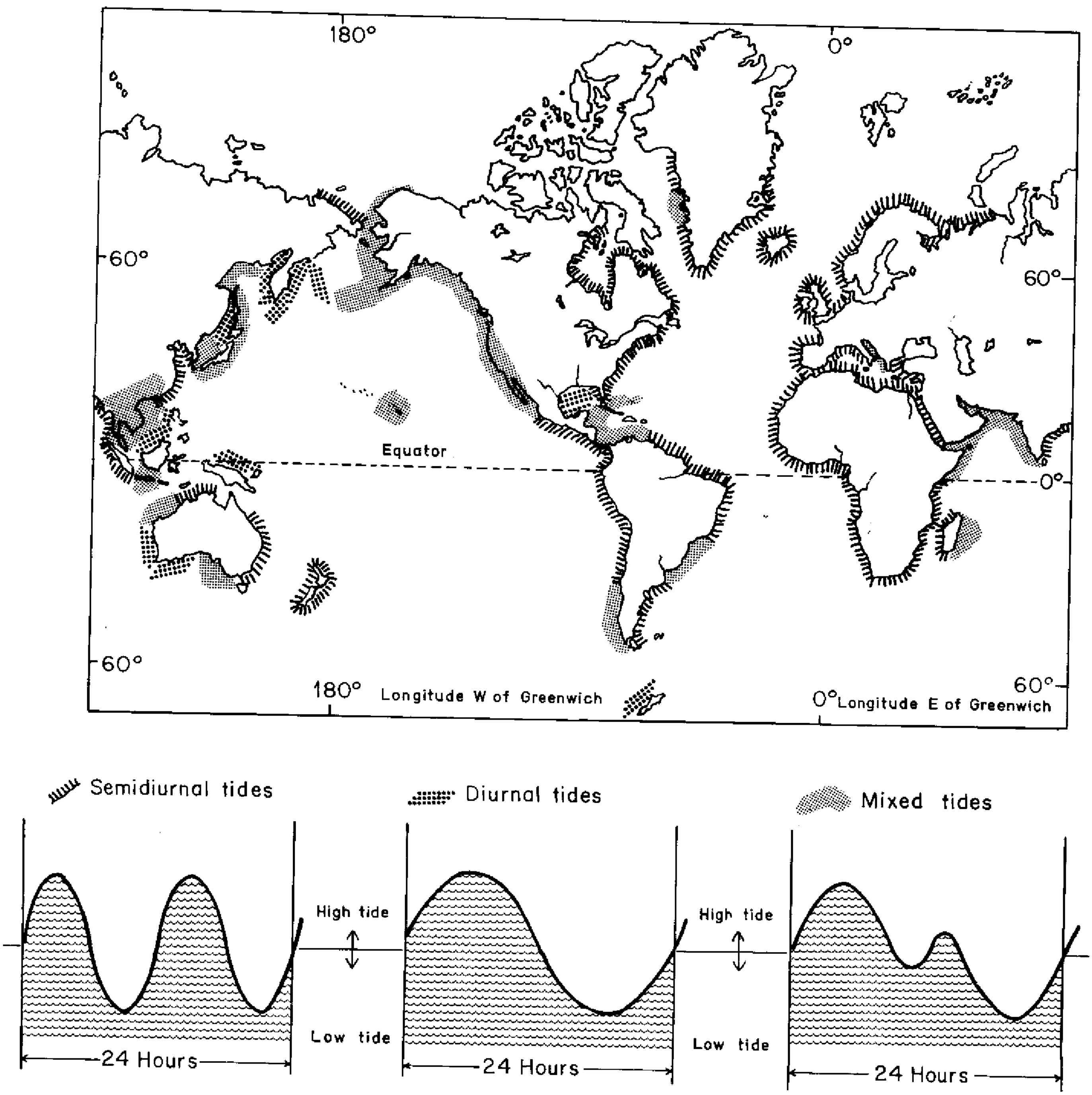


Figure 5. Tidal Cycles in the World

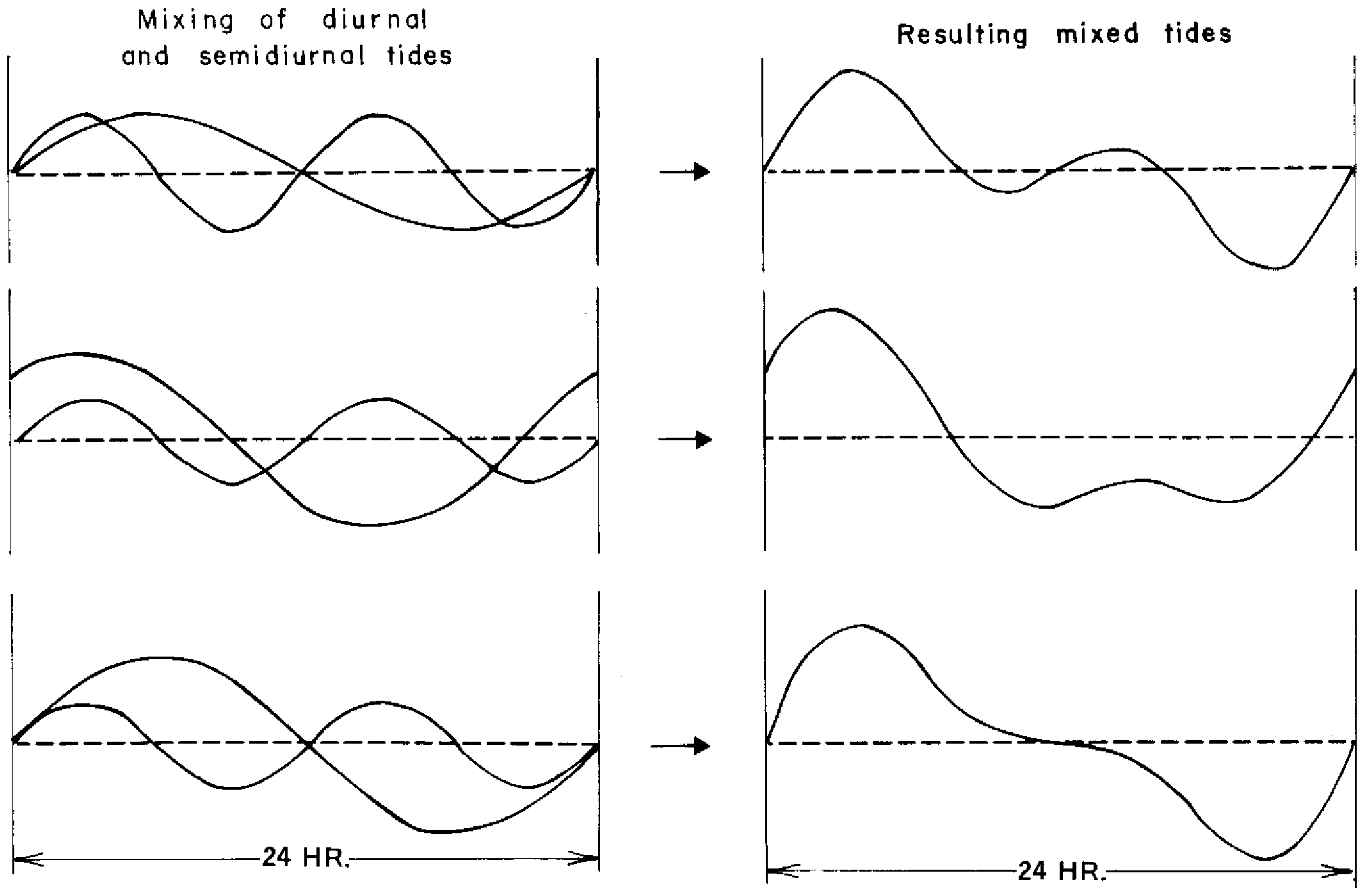


Figure 6. Some examples of the different shapes mixed tides can assume.

TIDAL RANGE

The daily position of the moon and sun relative to the earth affects the tidal range, which is the difference in height between high and low tides.

When the earth, moon and sun are all in a line, called syzygy (SIZ e gee), the sun and moon pull together on the sea. This produces a tidal range of higher and lower than normal tides, called spring tides. Syzygy occurs every 14 days (Figure 7A-B) with the full and new moon.

When the moon, earth and sun are at right angles to each other, called quadrature, the gravitational pulls of the sun and moon counteract each other. This causes neap tides, or the time period when the tidal range is not so great (Figure 7C-D). Quadrature occurs every 14 days with the first and last quarter moon.

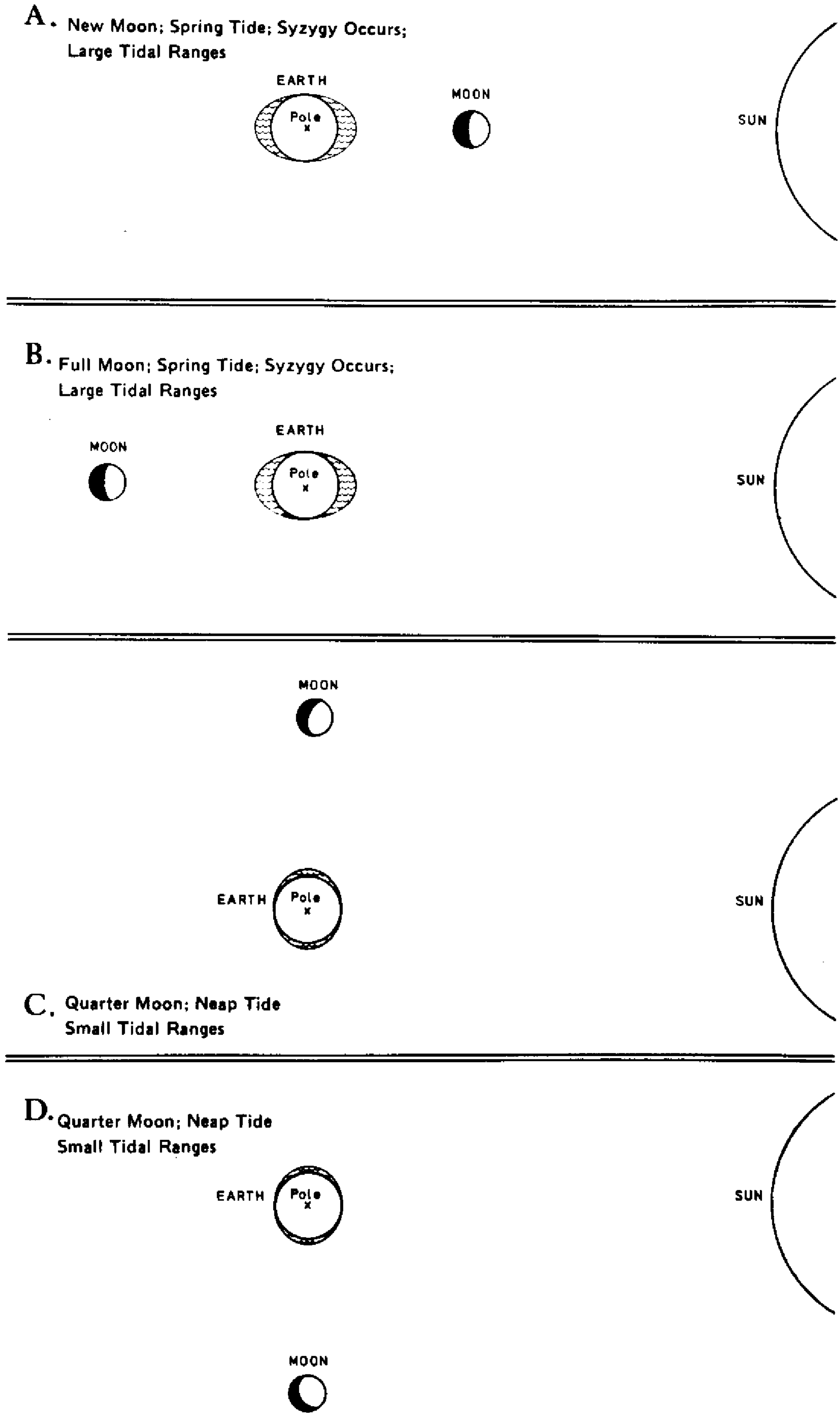


Figure 7. Positions of the sun, moon and earth during spring and neap tides.

The moon's path about the earth is an elliptical orbit, (like the earth's path around the sun) with the point closest to the earth called perigee (PAIR a gee) at 221,000 miles and the farthest point called apogee (AP o gee) at 253,000 miles (Figure 8). Perigee produces a larger tidal range. The moon is at perigee once every 27.5 days.

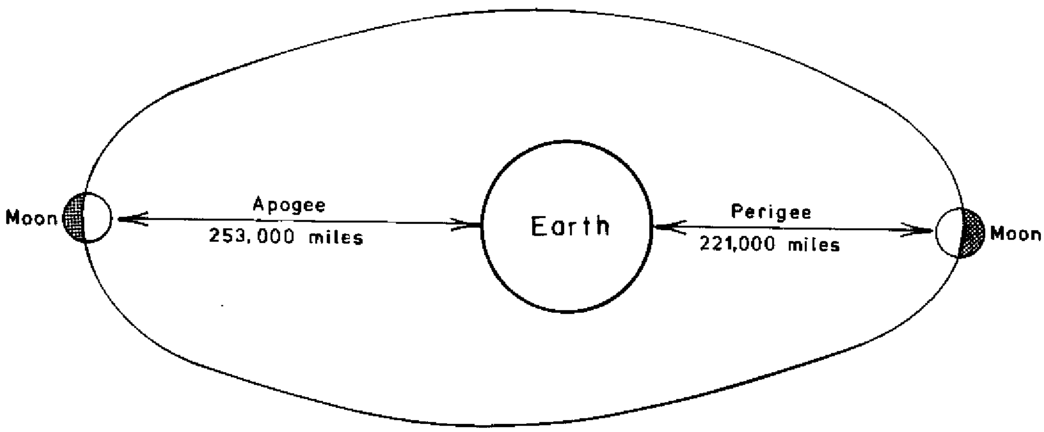


Figure 8. The moon's elliptical orbit about the earth.

The moon has another movement that affects tidal range. The moon's position relative to the earth's equator, called angle of declination, changes. This angle extends 28.5° north and 28.5° south of the equator (Figure 9). The result is a change in position of the tidal waves in relation to the equator (Figure 9).

The earth's orbit brings it closest to the sun in January, producing tides that are higher than normal. In July the earth is farthest from the sun and the tides are lower than normal.

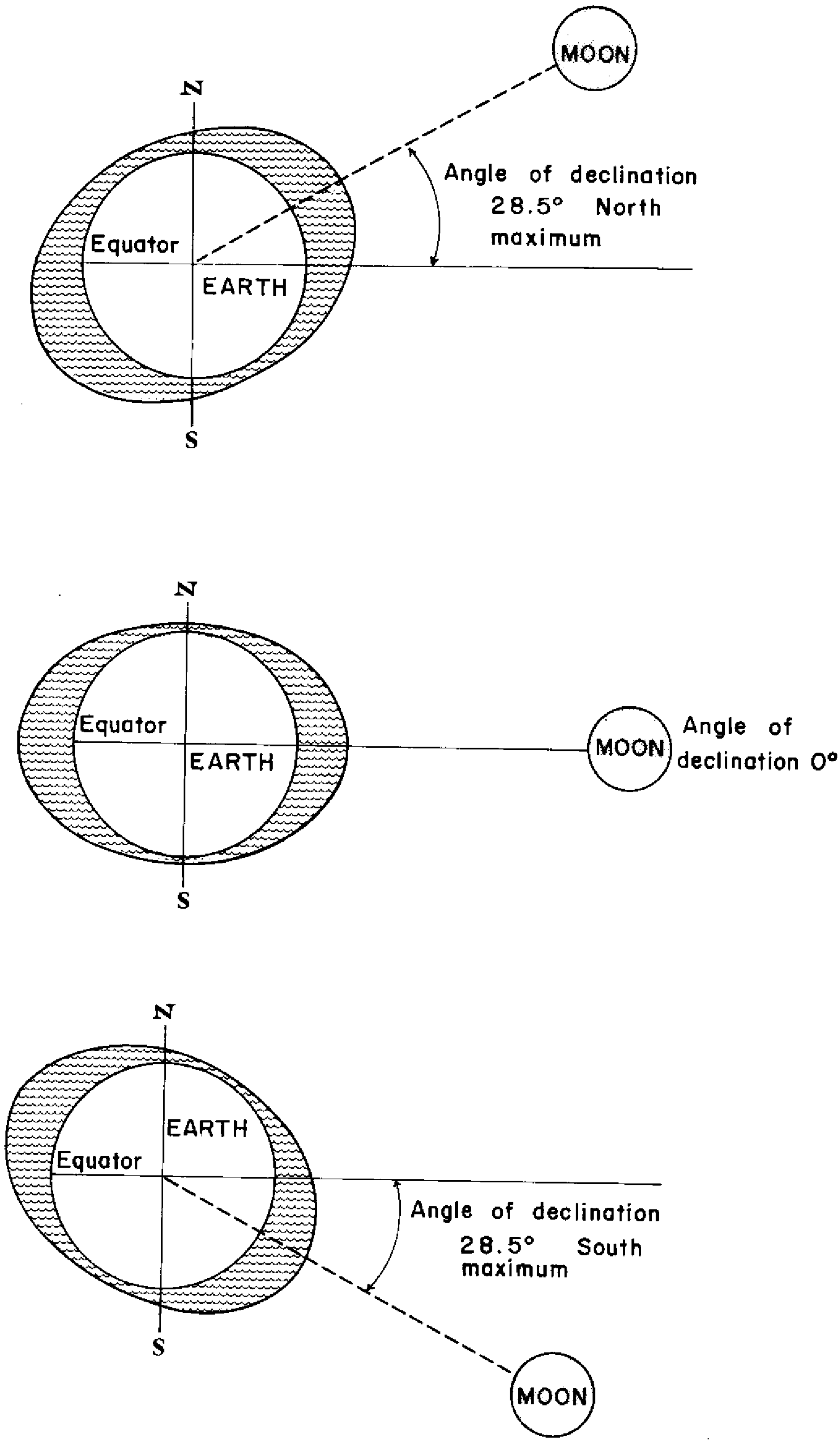


Figure 9. The angles of declination of the moon in relation to the earth.

Tidal ranges vary greatly at different places on the Alaskan coast. Point Barrow has a 6-inch tidal range, while Anchorage has a 30-foot tidal range. The differences in Alaskan tide ranges are created by many factors. One factor is distance from the equator. The gravitational pull of the moon and sun is greatest at the quator and decreases as you go north and south toward the poles (Figures 7 and 9). The reason is that the distance to the sun and moon increases because the earth curves away from these bodies.

Topography was mentioned in the section on Complicating Factors. Cook Inlet is a good example of how the shape of the shoreline and depth of the water can influence tides and their ranges. The Inlet is fairly wide and deep where it meets the Gulf of Alaska. But it gets narrower and shallower as it goes northeast toward Anchorage (Figure 10). A tidal wave coming into Cook Inlet has a certain height at Homer, where there is a large area in which the water may spread out. As the wave moves toward Anchorage, the Inlet gets smaller but the volume of water stays the same. So, the tidal wave must get higher, causing a larger tidal range at Anchorage than at Homer.

The topography of Cook Inlet acts to increase the tidal range in another way. Cook Inlet is just the right shape and size so that a tidal wave enters the Inlet from the Gulf just in time to meet the previous high tide on its way back out to the Gulf. When waves cross they add together. The high tides get higher and the low tides get lower. This adding of tidal waves is called <u>resonance</u> (Figure 11).

Nautical charts have their depth started at <u>mean lower low tide</u>. If an area has a large tidal range, boat operators navigating by these charts in shallow water must allow for the changing tide heights to avoid running aground. Boat operators anchoring near the shore must also be aware of the tide range to prevent stranding at low tide or not having enough line at high tide to keep the anchor on the bottom.

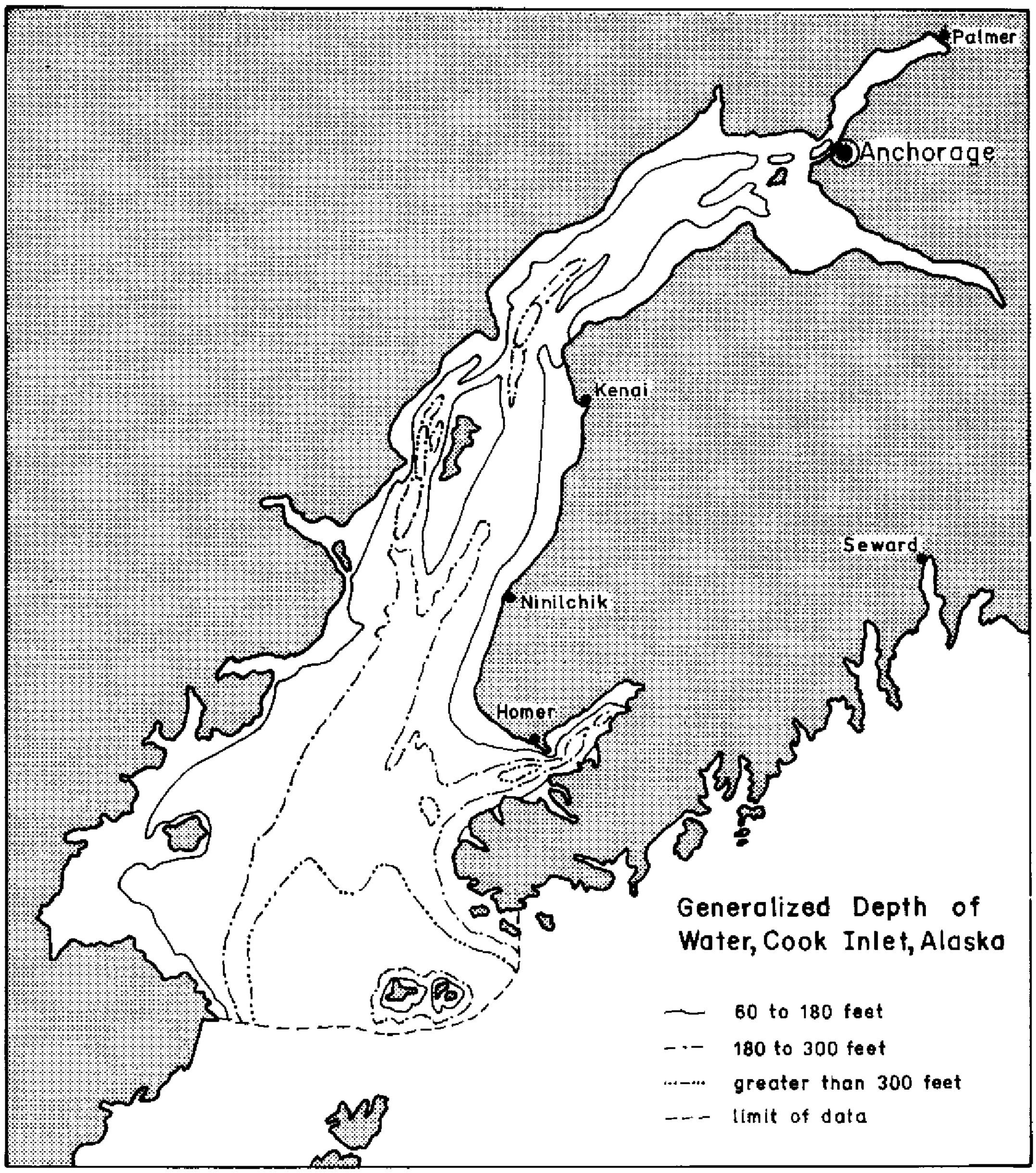


Figure 10. Topographical map of Cook Inlet.

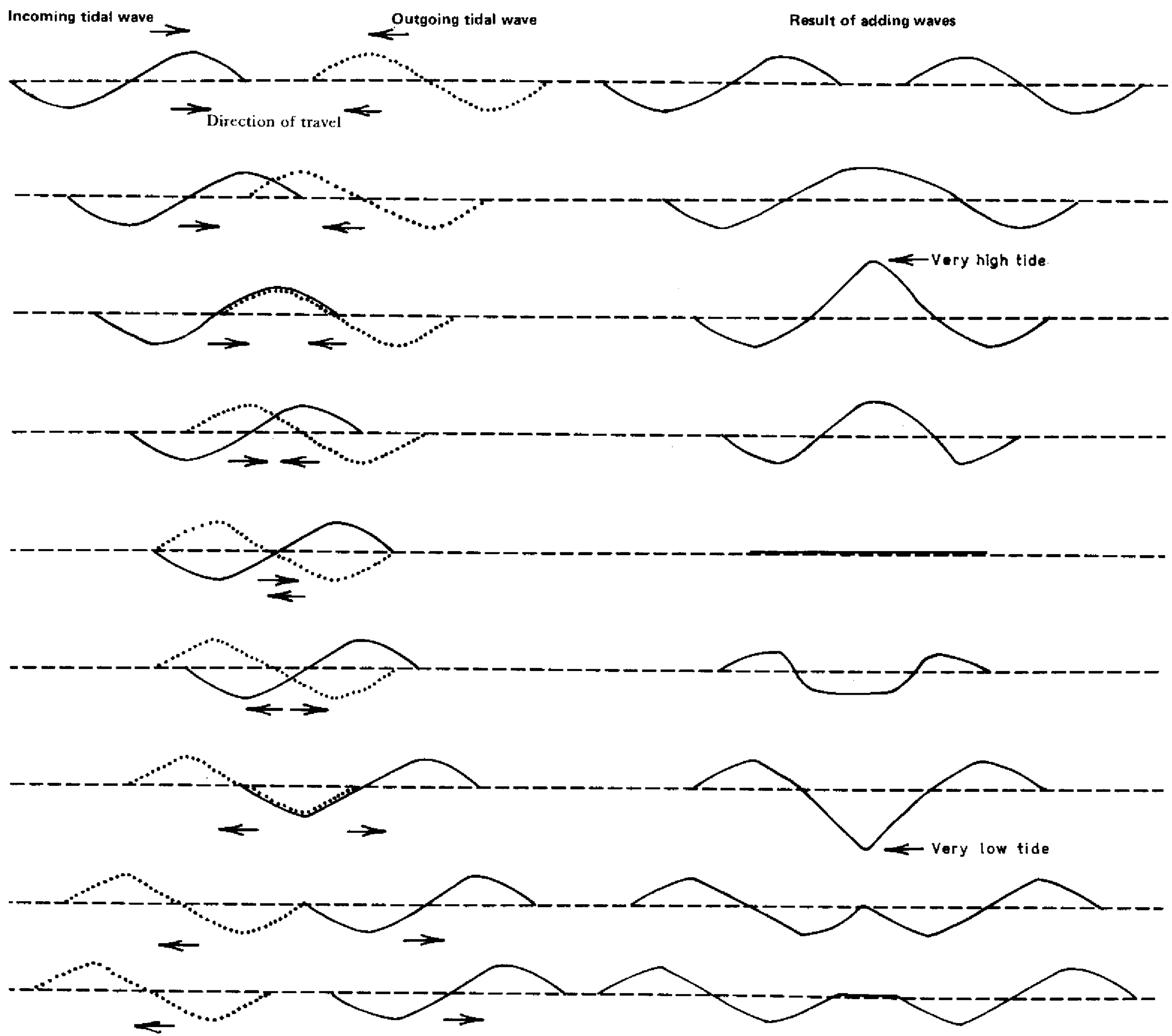


Figure 11. Resonance of tidal waves.

TIDE PREDICTION

Tide prediction is done mostly by applying known information, which is called the empirical method. Throughout the world there are tide stations where daily high and low tides have been measured for many years. This information is carefully recorded. The historic information of tide height, along with information on the estimated position of the moon and sun on a given day, are used to predict tidal ranges for future dates. This information is available in tide table books.

TIDE BOOKS

There are two kinds of tide tables available.

One of them, "Tide Tables: High and Low Water Predictions: West Coast of North and South America Including the Hawaiian Islands", is large and detailed. It is published each year by the National Ocean Survey. The last page of this tide book lists astronomical data, including Greenwich mean time of the moon's phases, apogee, perigee, greatest north and south angle of declination, moon on the equator, and the solar equinoxes and solstices. Many projects are possible using the extensive information found in National Ocean Survey's tide tables. The National Ocean Survey sells this tide table for $3.75 (1980 price). The address is:

National Ocean Survey
701 "C" Street
Anchorage, AK 99513

The second kind of tide table is published for smaller areas. For example, the tide table book for southcentral Alaska has separate sections for the districts of Anchorage, Seldovia, Kodiak and Cordova. Using the correction tables in the back of the book, tides can be determined from the Copper River Delta to the Arctic Ocean, including the Aleutians. The tide predictions are taken from the tide tables produced by the National Ocean Survey. Dot's Fishing Guide uses big dots to indicate full moon, which is supposed to mean "good fishing". One of the first pages of the tide table has a calendar that gives the dates for the phases of the moon each month. Many local businesses have these tide tables available free or at a nominal fee.

TIDAL CURRENTS

Tidal currents are the horizontal movements of water caused by the changing tide heights. Ebb currents can occur when the water level decreases as the tides change from high to low. Flood currents occur when the water level increases during the change from low to high tide. The velocity of ebb and flood currents is proportional to the change in tide height. Slack water occurs when the tidal currents change from ebb to flood, or flood to ebb.

Direction and velocity of tidal currents change with the tides. Each area has its own unique topography and therefore, each area's tidal currents have different directions and velocities. For example, southeast Alaska's Wrangell Narrows has maximum tidal currents of 6 knots flowing either north or south depending on the tidal stage. The ebb current comes from the north and the flood current comes from the south.

Unimak Pass has maximum tidal currents of 5 knots. The ebb current comes from the east and the flood current comes from the west. Slack water velocities in these two areas are zero. Along the open coast, things are a bit different. Topography does not restrict the water's flow. The current's direction changes all the way around the compass points twice a day where mixed or semidiurnal tides occur. The velocities are generally less than 1.5 knots. Slack water velocities in open coast conditions range from zero to less than 1 knot.

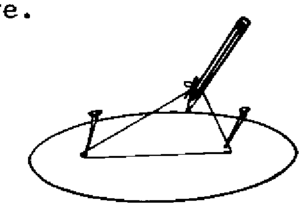
Understanding tidal currents is important to all boaters. Pretend that you are going someplace in a fishing boat that's making 9 knots. If you go with a tidal current of 6 knots, then your actual speed is 15 knots. If you go against a tidal current of 6 knots, then your actual speed is 3 knots.

TIDAL CURRENT BOOKS

Tidal current information is available in the National Ocean Survey's "Tidal Current Tables: Pacific Coast of North America and Asia." The Tidal Current Tables are published each year. Included are dates and times of slack water, maximum ebb and flood currents for each change of the tide. The velocity and direction of each ebb and flood current is also given. Correction tables are in the back of the publication to make the necessary calculations for your location. The National Ocean Survey sells this tidal current table for $3.75 (1980 price). The address is the same given in the Tide Book section.

GLOSSARY

Angle of Declination	The angle in space made between a heavenly body and the extended earth's equator.
Apogee	The point in the orbit of the moon when it is farthest from the center of the earth. There is also an apogee in the earth's orbit around the sun.
Axis	An imaginary line running through the center of the earth and connecting the geographic north and south poles. The earth rotates around this line.
Centrifugal Force	The force acting outward when a body is rotating or revolving rapidly around a center; an example is mud being thrown from a rotating bicycle wheel.
Diurnal Tide	One high and one low tide a day.
Ebb Current	Current resulting when tide changes from high to low.
Elliptical	An ellipse is an elongated circle. The earth's orbit around the sun is elliptical and so is the moon's orbit around the earth. You can draw an ellipse using a pencil, 2 pins and a string as shown in the figure.



Empirical	Based on observation or experience.
Equinox	The day occurring twice a year when there are exactly 12 hours between sunrise and sunset. Vernal equinox is in March and autumnal equinox is in September.
Flood Current	Current resulting when tide changes from low to high.
Full Moon	The moon is seen as round from the earth (see Figure 7). Spring tides occur during the full moons.

Gravity	The force which pulls objects toward each other. An example is the force which pulls a ball to the ground no matter how hard you throw it. The gravitational force gets stronger as the objects become more massive. The gravitational force also gets stronger as the objects get closer together.
Greenwich Mean Time	The time at Greenwich, England, which is located at 0° longitude and is used as a standard time all over the world. For your local time, add 1 hour for every 15° longitude west from Greenwich.
Knot	A velocity measured in nautical miles per hour. A nautical mile is equal to 1 minute of latitude on a nautical chart, and 6,076 feet.
Lunar Day	The period of the earth's rotation about its axis with respect to the moon; 24 hours and 50 minutes. (That is why the moon rises 50 minutes later each day and why the tide is about 50 minutes later each day.)
Mass	The property of an object which is a measure of how difficult it is to change the object's motion. Think of a bowling ball and a basketball. Since it is easier to change the speed or direction of movement of the basketball than it is to change the movement of the bowling ball, the basketball has less mass than the bowling ball. Mass is not the same as weight. The weight of something depends on where it is and how much gravitational force is acting on it. You would weigh less on the moon than you do on the earth, but your mass is the same no matter where you are.
Mean Lower Low Tide	0.0 feet in tide tables. All nautical charts have the soundings started from mean lower low tide.
Mixed Tide	Two unequal high and two unequal low tides a day.
Neap Tides	Tides with a smaller than average tidal range which occur about every 14 days.

New Moon	The moon is seen as all black from the earth (see Figure 7). Spring tides occur during new moons.
Perigee	The point in the orbit of the moon when it is nearest to the center of the earth.
Period	The time interval between successive occurrences of an event which repeats itself.
Quadrature	The sun, the moon and the earth at right angles to each other (see Figure 4).
Quarter Moon	The moon is seen as half dark and half light from the earth (see Figure 7). Neap tides occur during quarter moons.
Resonance	Waves crossing each other add together to form a wave with a shape different from the original waves (see Figure 11).
Revolve	The act of a celestial body going around in an orbit.
Rotate	To turn on an axis (like the earth).
Semidiurnal Tide	Two equal high and two equal low tides a day.
Slack Water	The period at the turn of the tide when there is little or no horizontal movement of the water.
Solstice	Summer solstice: the longest day of the year. Winter solstice: the shortest day of the year.
Spring Tides	Tides with a larger than average tidal range which occur about every 14 days.
Syzygy	The earth, sun and moon all in a straight line.
Tidal Cycle	Pattern of rising and falling water caused by tidal forces that occur in 24-hour and 50-minute cycles.
Tidal Range	The difference in height between high and low tides for one location.
Tidal Wave	The two crests and troughs that pass over the earth each day as high and low tides.

Tide	The alternate rising and falling of the surface of the ocean and other water bodies occurring twice daily over most of the earth; caused by the gravitational attraction of the sun and moon occurring unequally on different parts of the earth.
Topography	The shape of the earth's surface, including physical features such as mountains, canyons, and flat plains both above and below the surface of the oceans.
Tsunami	Sea waves generated by submarine earthquakes, land slides, or volcanic eruption.

TIDE PROJECTS

PROJECT 1

Making a Corrected Tide Table for Your Area

The back of tide table books has correction tables for each district. Find your location. Write down the correction factors for that location. The following examples of how to make a corrected tide table should have all the kinds of math problems you will encounter. Watch out for some of the tricky problems like:

* adding and subtracting hours and minutes
* adding a number to a negative number
* subtracting a number from a negative number
* multiplication with a negative number
* multiplication using decimal places

Every locality along the Alaskan coast has its own unique tides. The tide ranges are different and so are the times and heights of high and low tides. Remember to think of tides as waves. A wave cannot occur at the same time everywhere because it takes time for it to travel from one place to another.

Prove this uniqueness for yourself. Compare the corrected tide table for your location to the corrected tide table for someplace nearby.

PROJECT 1. Examples

		HIGH TIDES				LOW TIDES			
		AM		PM		AM		PM	
Date	Day	Time	Feet	Time	Feet	Time	Feet	Time	Feet

CORDOVA DISTRICT Correction Factors from Tide Book for Seward

Time High	Time Low	Feet High	Feet Low
-0:09	-0.01	-1.9	-0.1

Date	Day	AM Time	AM Feet	PM Time	PM Feet	AM Time	AM Feet	PM Time	PM Feet
7	Thur	11:24	9.5	11:11	12.2	5:06	-0.5	4:58	2.4
Corrected		-0:09	-1.9	-0:09	-1.9	-0:01	-0.1	-0.01	-0.1
for Seward		11:15	7.6	11:02	10.3	5.05	-0.6	4:57	2.3

KODIAK DISTRICT Correction Factors from the Tide Book for Marmot Island

Time High	Time Low	Feet High	Feet Low
+0:22	+0:10	+1.2	-0.1

Date	Day	AM Time	AM Feet	PM Time	PM Feet	AM Time	AM Feet	PM Time	PM Feet
10	Sun	1:03	9.7	2:14	7.3	7:49	-1.8	7:49	1.8
Corrected		+0:22	+1.2	+0.22	+1.2	+0.10	+0.1	+0:10	+0.1
for Marmot Is.		1:25	10.9	2:36	8.5	7:59	-1.7	7:59	1.9

KODIAK DISTRICT Correction Factors from the Tide Book for Point Barrow

Time High	Time Low	Feet High	Feet Low
-0:33	-0:23	x0.05	x0.05

(tide book has * = x)

Date	Day	AM Time	AM Feet	PM Time	PM Feet	AM Time	AM Feet	PM Time	PM Feet
20	Wed	11:02	6.3	10:57	9.1	4:53	-0.3	4:28	1.8
Corrected		-0:33	x0.05	-0:33	x0.05	-0:23	x0.05	-0:23	x0.05
for Pt.Barrow		10:29	0.315	10:24	0.455	4:30	-0.015	4:05	0.090

SELDOVIA DISTRICT Correction Factors from the Tide Book for North Foreland

Time High	Time Low	Feet High	Feet Low
+3:48	+4:01	(x1.19 + 0.2)	

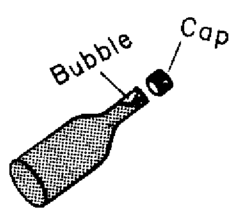
Date	Day	AM Time	AM Feet	PM Time	PM Feet	AM Time	AM Feet	PM Time	PM Feet
7	Sat	9:18	14.2	10:00	16.8	3:15	2.8	3:26	1.7
Corrected		+3:48	+1.19	+3:48	x1.19	+4:01	+1.19	+4:01	x1.19
for North		1:06pm	16.898	1:48am	19.992	7:16	3.332	7:27	2.023
Foreland			+0.2		+0.2		+0.2		+0.2
			17.098		20.192		3.532		2.22

PROJECT 2

Marking Tide Heights on a Beach

Equipment needed:

1) Homemade level. (Take more than one to the beach in case one gets broken.) Fill a small bottle (like Tobasco sauce or Worcestershire sauce) almost full of water. Add a drop of ammonia and two drops of dark-colored food coloring. Put the cap of the bottle on so that a small bubble remains.



2) Tape.

3) Yardstick.

4) Marked stakes (wooden, rebar, or pipe) about three feet long.

5) Hammer or appropriate driving tool for stakes.

6) Two yards or more of strong cord.

7) Watch with the correct time.

8) Three people.

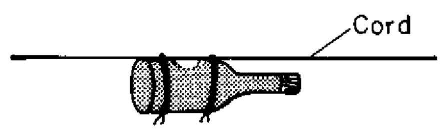
Methods:

Make a corrected tide table for your beach. Select a low tide like 0.0, 1.0, or 2.0 feet and a calm day. Go to the beach about half an hour before the tide reaches the selected level. Watch the time and the tide. When the water no longer retreats, the time should closely correspond with the time you have calculated.

1) Drive a stake at the waterline with the hammer.

2) Tie the cord at the one-foot mark on the yardstick.

3) Tape the homemade level to the cord within a foot or so of the yardstick.



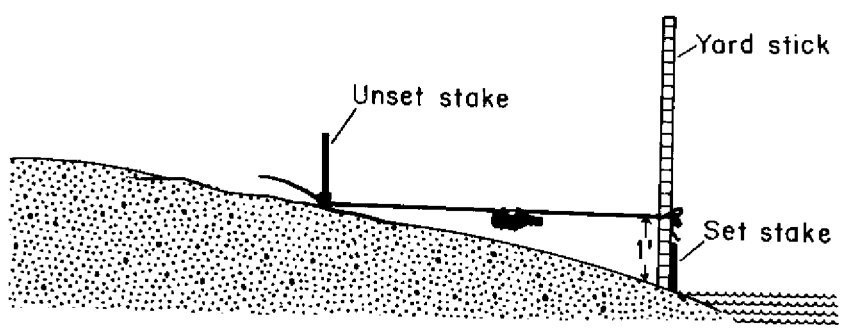
4) Have your helper hold the yardstick tight against the stake at the waterline.

5) Loop the other end of the cord around the bottom of an unset stake that is up the beach from the waterline.

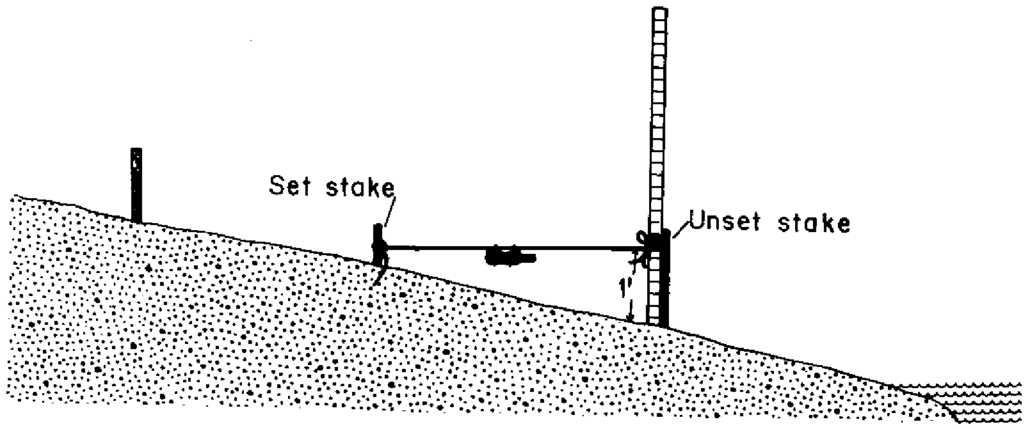
6) One person holds the yardstick in place; one person keeps the cord taut and moves the unset stake; and one person reads the level.

7) When the unset stake is one vertical foot from the set stake, the bubble in the level will be centered in the bottle.

8) Set the stake there. Move the yardstick up to it and repeat the procedure.



The procedure can be changed a little to set stakes below the initial stake during an outgoing tide.



If possible, mark the stakes so that each denotes a specific tide height; for example, red for 0.0, yellow for 1.0, and so forth.

If you live in an area with a small tide range, decrease the vertical distance enough to measure the differences in water levels. For example, at Point Barrow 0.2 vertical feet between stakes would be workable.

There are two purposes for this project:

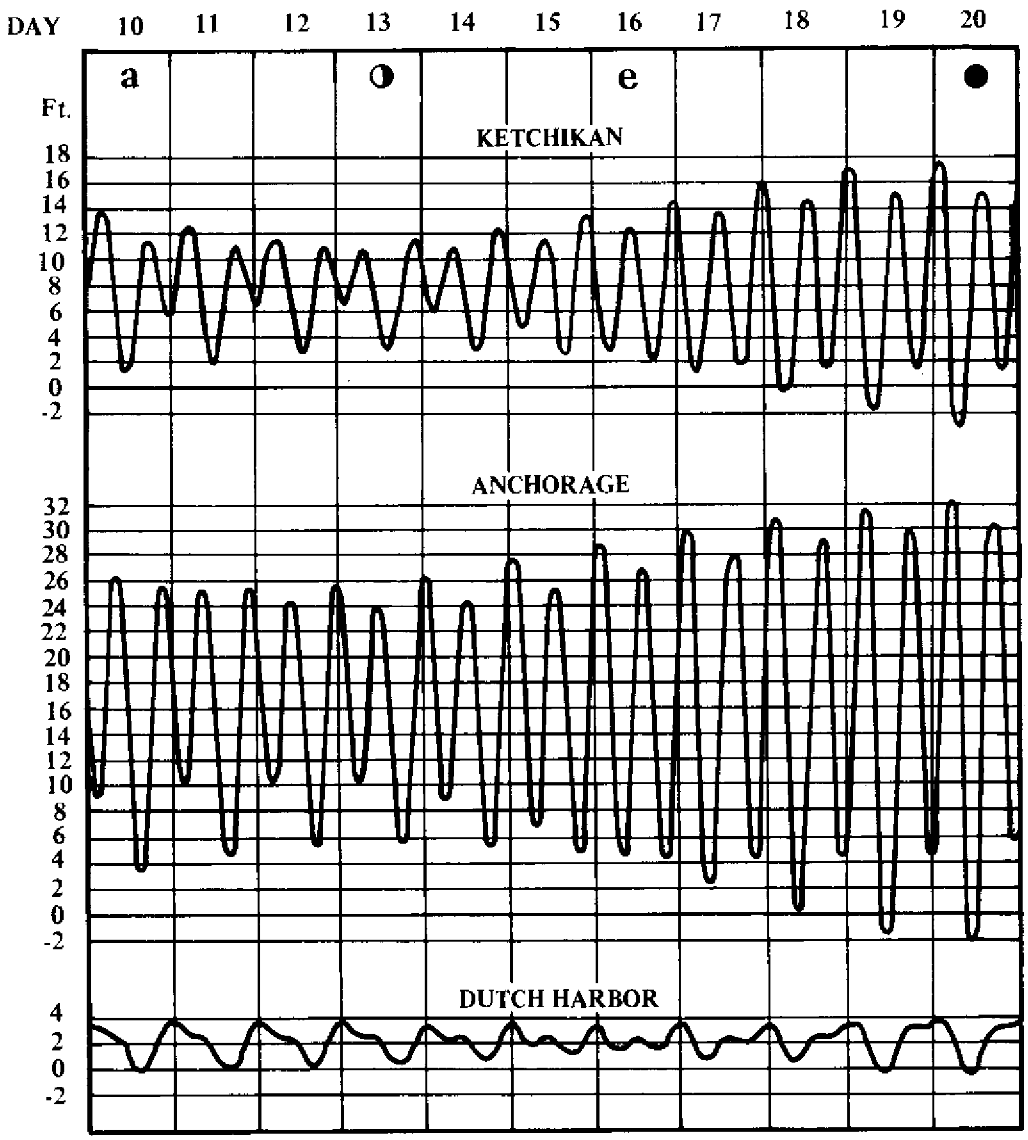
1) Looking at numbers in a classroom teaches about tides in an abstract way. Tides become real when you get wet feet because you dallied setting the marked stakes. The tide does not wait for anyone.

2) The marked beach gives you an opportunity to ask and answer your own questions about tides. For example, how long does the water remain at low tide? You will know immediately when the tide begins to move with the stakes as a stable reference point.

PROJECT 3

1) Using your corrected tide tables, make a tide curve for your location. Examples of tide curves for Project 3 taken from Tide Tables published by the National Ocean Survey are shown below.

TYPICAL TIDE CURVES FOR ALASKAN PORTS



Lunar data:
a Moon in apogee
◑ Last quarter
e Moon on Equator
● New Moon

Plotting a tide curve for your location will show what kind of tides there are where you live. Do you have semidiurnal, diurnal or mixed tides? Does your location have more than one kind of tide? Making a tide curve to cover two weeks should answer these questions. Be sure to allow enough space for the highest high tide and the lowest low tide of the year.

2) Winds can affect tide ranges. Use the beach you have marked to find actual tide heights for high and low tides when the wind blows. Mark your tide-height observations on your tide curve. Obtain local weather reports which include barometer readings, wind speed and wind direction. Keep careful records of the weather information with dates.

Do barometer readings make a difference in actual and predicted tide heights? What wind speeds and directions make a difference between observed and expected tides?

Some answers can be found below.

Higher high tides can be expected with high barometric readings and high onshore winds. Lower low tides can be expected with low barometric readings and high offshore winds. Every locality has a unique topography, so you have to discover the right barometer readings, wind speeds and wind directions that make predicted and observed tide heights different.

3) Make a tide curve for the five days before and after:

* Vernal equinox.
* Summer solstice.
* Autumnal equinox.
* Winter solstice.

Your tide curves should show that the sun affects tide ranges. The equinoxes result in the smallest tide ranges of the year. The winter solstice in the northern hemisphere causes the highest high tides of the year. The summer solstice causes the lowest low tides of the year.

4) Make a tide curve for one whole month. Predict when the phases of the moon occur using the tidal ranges on your curve.

This tide curve will show you that the phases of the moon will affect tide ranges. You can expect to see a new moon for full moon during spring tides. During the new moon you should have a larger tide range than during the full moon. Neap tides will occur during the one-quarter and three-quarter moon phases.

5) Make a tide curve for one month. Use the current National Ocean Survey Tide Tables to compare the position of the moon (perigee, apogee, angle of declination) to the tide ranges.

The tide curve example for Dutch Harbor shows how the moon's angle of declination can affect tides. When the moon is on the equator, mixed tides occur. When the moon is at the maximum north and south angles of declination, the tides become diurnal. The angle of declination changes from 28.5° north of the equator to 28.5° south of the equator and then back to 28.5° north in 27.2 days (see Figure 9).

PROJECT 4

Make arrangements to visit the National Ocean Survey Tide Station in your area and talk to the tide observer there.

You can write the National Ocean Survey in Anchorage (see Tide Book section for address) and ask for the location of the nearest tide station and the name and address of the tide observer.

PROJECT 5

Make a corrected tidal current table for your area.

The back of the tidal currents book has correction tables for each district. Find your location or one nearby. Write down the correction factors for that location. The following example of how to make a corrected tidal current table should have all the kinds of math problems you will encounter.

(see example next page)

Correction Factors

Place	Time Differences		Velocity Ratios	
	Slack Water	Maximum Current	Maximum Flood	Maximum Ebb
Blake Island	-0 10	-0 10	0.7	0.7

Wrangell Narrows District

Day	Slack Water	Maximum Current		Slack Water	Maximum Current	
	Time	Time	Velocity	Time	Time	Velocity
	H.M.	H.M.	Knots	H.M.	H.M.	Knots
1 TU	0152 -0010	0459 -0010	3.6E x0.7	0729 -0010	1054 -0010	4.2F x0.7
Corrected for Blake Island	0142	0449	2.52	0719	1044	2.94

H = hours; M = minutes; E= ebb current; and F = flood current

National Ocean Survey uses military time where 0000 equals midnight and 1200 equals noon. The times are easy to read. The first slack water occurs at 1:42 a.m. and the maximum ebb current occurs at 4:49 a.m. for Tuesday the first at Blake Island. Hours and minutes are shown as 0 00. For example, the above problem has a 0 hour and 10 minute correction factor and is written as 0 10.

PROJECT 6

Measuring Tidal Current Velocity

Equipment needed:

1) 6 oranges. (An orange weighs almost as much as the volume of sea water it displaces. As a result of their near equal weights, an orange just barely sticks up above the surface of the water. In

this position the orange's movement is controlled by the tidal currents and not the wind.)

2) 1 watch with a sweep second hand.

3) 1 tape measure.

4) 2 sticks.

5) 2 people.

Methods:

Measuring your stride. Rather than using a long tape measure to keep track of how far the currents carry the orange in a given period of time, it is much easier to measure how long your stride is, then pace off the distance the orange travels while you time it.

1) Put a stick vertically in the ground.

2) Starting with the toes of one foot by that stick, take four steps, and mark a line where your front foot is.

3) Measure the distance between the stick and the line.

4) Divide that distance by four to determine the average length of your stride.

Measuring Tidal Current Velocity:

1) Standing next to the water by your stick in the ground, throw an orange out into the water about 50 feet from shore, directly in front of you.

2) One person starts timing the orange as soon as it bobs back up to the surface.

3) The other person carefully steps off the distance it moves, being careful that you don't walk faster or slower than the current carries the orange.

4) If the beach is long enough, follow the orange for two minutes, counting your steps as you go. Put the second stick in the ground when the two minutes are up.

5) How many steps did you take in the two minutes you were following the orange? Did you lose count? That's why you put the sticks in the ground. If necessary you can go back and step off the distance between the sticks again.

6) Multiply the number of steps you took by the average length of your stride to find out how far the orange traveled.

Calculating Tidal Currents in Miles Per Hour or Knots:

Reference Numbers

1 mile = 5,280 feet

1 nautical mile = 6,076 feet

1 hour = 60 minutes

1 knot = 1 nautical mile/hour

To calculate current velocity, use your measurements in the following formula:

F = number of feet measured

M = number of minutes measured

Have:

$$\frac{F \text{ feet}}{M \text{ minutes}}$$

Need:

$$\frac{\text{miles}}{\text{hour}} \quad \text{or} \quad \frac{\text{nautical miles}}{\text{hour}}$$

$$\frac{\dfrac{F \text{ feet}}{5{,}280 \text{ feet/mile}}}{\dfrac{M \text{ minutes}}{60 \text{ minutes/hour}}} = \frac{\dfrac{F}{5{,}280} \quad \text{feet} \times \dfrac{\text{miles}}{\text{feet}}}{\dfrac{M}{60} \quad \text{minutes} \times \dfrac{\text{hour}}{\text{minutes}}}$$

$$= \frac{\dfrac{F}{5{,}280} \quad \text{miles}}{\dfrac{M}{60} \quad \text{hours}} = \frac{F}{5{,}280} \times \frac{60}{M} \frac{\text{miles}}{\text{hour}} = \frac{F}{M} \times \frac{60}{5{,}280} \frac{\text{miles}}{\text{hour}}$$

$$= \frac{F}{M} (0.011) \frac{\text{miles}}{\text{hour}} \quad \text{OR} \quad \frac{F}{M} \times \frac{60}{6{,}076} \frac{\text{nautical miles}}{\text{hour}} = \frac{F}{M} (0.010) \text{ knots}$$

Example

If you found that the orange traveled 57 feet in 2 minutes, the current velocity in miles per hour would be:

$$\frac{57}{2} \times 0.011 \frac{\text{miles}}{\text{hour}} = 28.5 \times 0.011 \frac{\text{miles}}{\text{hour}} = 0.314 \frac{\text{miles}}{\text{hour}}$$

or $\frac{57}{2} \times 0.010$ knots $= 28.5 \times 0.010$ knots $= 0.285$ knots

If the beach you are on is too short, measure only the distance traveled by the orange for one minute.

Did the orange move closer to shore, farther away, or stay about the same distance offshore while you were measuring its movement? Your answer will tell you whether the tidal currents at that spot were onshore, offshore, or parallel to the shoreline. The chances are good that at another spot on the beach the tidal currents will behave differently than they do where you measured their velocity. If more than one student is measuring tidal velocities at the same time, you might take your measurements in different places to find out if this is true on your beach. As you might guess, tidal current velocities change with the stage of the tide. Repeat the above steps every hour from low to high tide, or from high to low tide. Plot your measurements on graph paper to illustrate how tidal velocities change.

Tidal currents can also change directions, depending on whether the tide is coming in or going out. Use another orange after the tide has changed to determine if the current off your beach changes direction with the tide.