The Year of the Tides

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Key Concepts

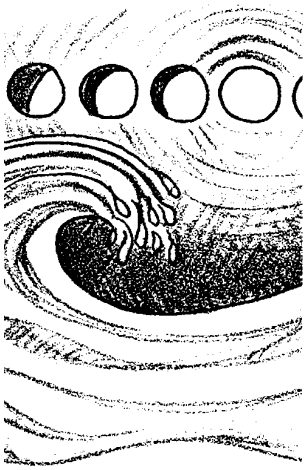
1. There is a consistent number of high and low tides per day in a given geographic region.

2. Tides are most extreme at times of new and full moon phases.

3. In a given location, tides occur approximately a hour later each day.

4. These patterns of tides correspond to patterns in the earth's orbit around the sun, the moon's orbit around the earth, and the earth's rotation in its axis.

5. The times and heights of the tides may be accurately predicted and are often recorded in chart form. Tide charts are useful to a wide variety of people.



Background

The following tidal cycles may be easily seen in the year-long tide calendar for an area which normally experiences two high and two low tides each day. You may discover others as you work with your local charts.

Cycles caused by earth rotation:

6 hrs 13 min - high to low

12 hrs 26 min - high to high

24 hrs 52 min - complete tidal day

Cycles caused by earth-moon revolution (27.3 days):

13 to 14 days- equatorial tide to equatorial tide

27.3 days- start from the day when either high tide “A” or high tide “B”, your choice, is the higher of the two high tides and shows the greatest diurnal inequality. Follow this same tide through the month. It will become the lower high tide in about 6 days, the lower by the greatest amount in about 13 days, and return to its original position in about 27 days.

Cycles caused by changing phases of the moon (29.5 days):

7 days- neap to spring

14-15 days- spring to spring

29.5 days- full cycle of moon phases and tides

Overlaid, but impossible to spot, are cycles caused by apogee and perigee (27.3 days) and aphelion and perihelion (365 days). These cycles often interact in late December (perihelion) to create some of the highest tidal ranges of the year.

You may not see all of these the first time you do the activity, but challenge the students to look for them. You will be amazed by what they do see.

For additional information about the patterns and causes of tides, please see the Teacher Background and Student pages for the subsequent activity "Oceans in Motion: The Tides".

Materials

For each student:

- weekly marigram record sheets, enough for every student plus extras
- year-long tide tables, available from sporting goods stores
- straight edge or ruler

Teaching Hints

In “The Year of the Tides”, students assemble a giant, year long tide calendar. On the surface, this activity is interesting simply in the doing, and the end product is almost a piece of art. On a deeper level, as students work, they will notice many of the mysteries of tides as they observe the slow yearly changes in tidal record. They will notice patterns and begin to ask questions.

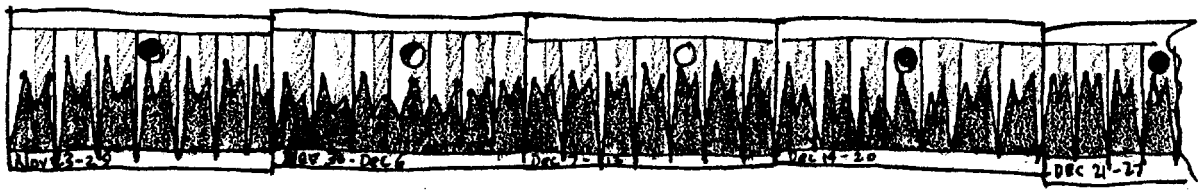
If your students need to know how to read 24-hour time in order to use the tide tables, consider the supplemental activity, “Using the 24-Hour Clock” which follows this lesson.

It is often possible to secure tide charts as a donation for public education. If you are unable to locate a donation, you can buy one, and reproduce the needed charts at school. There is an advantage to each. If students each have a chart, they will discover the wealth of other information contained in it. If they have reproductions, they can write on them without destroying their usefulness. Like calendars, tide charts don’t have any use beyond the year they are printed. (Hint: Later in the year you may find it easier to cadge a complete set of booklets. You do not need new sets each year.)

Give students plenty of time and help in getting the tides graphed. Assign each student one week of tides. Have students
work in pairs so they can help each other by reading from the tide charts. If you do not have a total of 52 students, let some students take extra weeks once they have the graphing skills mastered.

Cut circles of white paper to represent moon phases. Students can shade in the portion of the moon that represents the moon phase that occurs during the week they graph.

Have students trim left and right edges of the graphs so that you can easily attach them on the bulletin board. With luck, you will end up with a year-long



tide calendar that looks something like this:

You will need a day to assemble the chart for the last part of this activity. Collect the graphs and post them as quickly as possible. A film on tides might fill the gap. Just leave a blank space on the wall for incomplete graphs. Peer pressure gets pretty intense if blanks appear.

If your students are not familiar with the equinoxes and solstices, you may want to attach signs to the chart on the appropriate days.

Once the chart is complete, ask the students to notice patterns in the tide chart. If the students need prodding, ask them if they notice any relationships between tides and time of day, tides and moon phases, and tides and seasons.

Key Words

equatorial tide - tide which occurs twice each month as the moon passes over the equator, characterized by two nearly identical high tides

first quarter - phase of the moon during which the right half of the moon's disk is lighted as moon stands at right angles to the sun; half way between new and full moon

full moon - phase of the moon during which the moon's entire disk is lighted as the moon stands opposite the sun

last quarter - phase of the moon during which the left half of the moon's disk is lighted as the moon stands at right angles to the sun; half way between full and new moon

moon phases - changes in the appearance of the moon dependent upon its position relative to the earth and sun

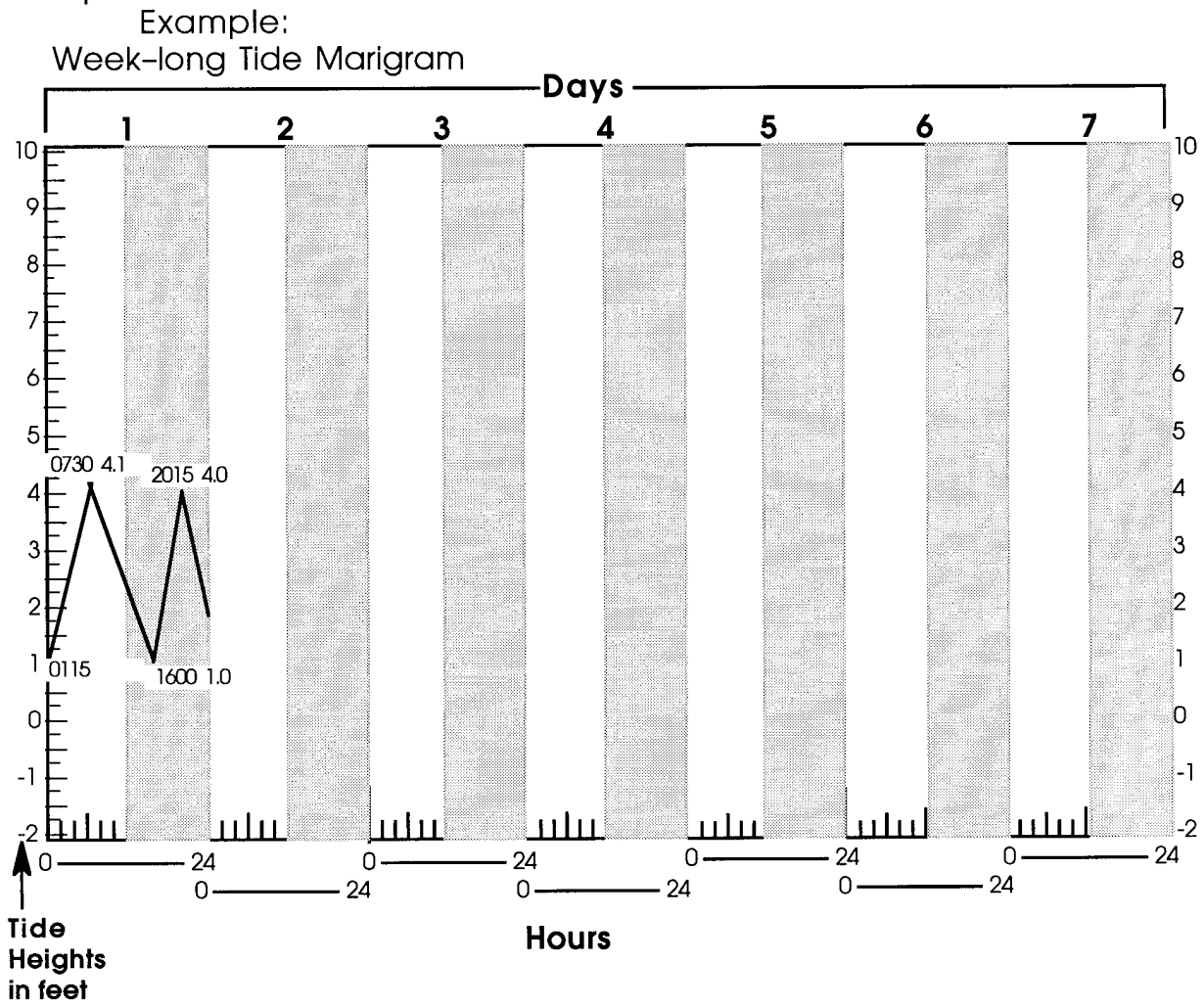
new moon - phase of the moon during which the moon's entire disk is dark as the moon stands between the earth and sun

tropic tide - tide which occurs twice each month as the moon reaches its maximum position above or below the equator, characterized by maximum diurnal inequality

Extensions

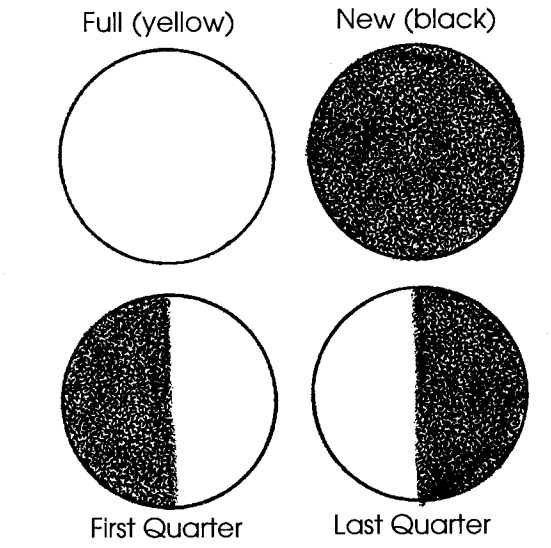
1. Make fish symbols and empty hooks to indicate good and poor fishing dates if you have that information available. Have students try to relate this to tidal cycles.
2. Find the tables that indicate the date for apogee and perigee each month. See how these affect the tidal pattern.
3. Have groups of students investigate a single problem from extension questions that appear in the student worksheet. These are quite challenging.
4. In Seattle, the telephone company publishes one year's worth of tidal information in their telephone books. If you live in a coastal area, you may wish to have students contact your local phone company to encourage them to duplicate the idea in your area.

Example:



Hours

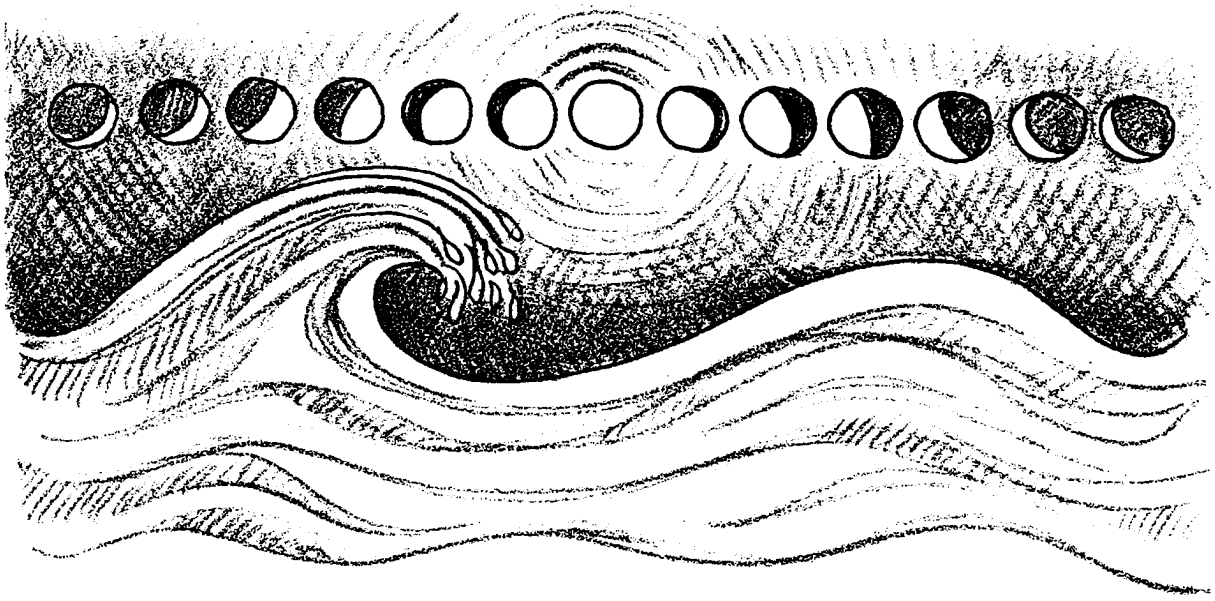
Moons



A P S E

(Apogee) (Perigee) (Solstice) (Equinox)

The Year of the Tides



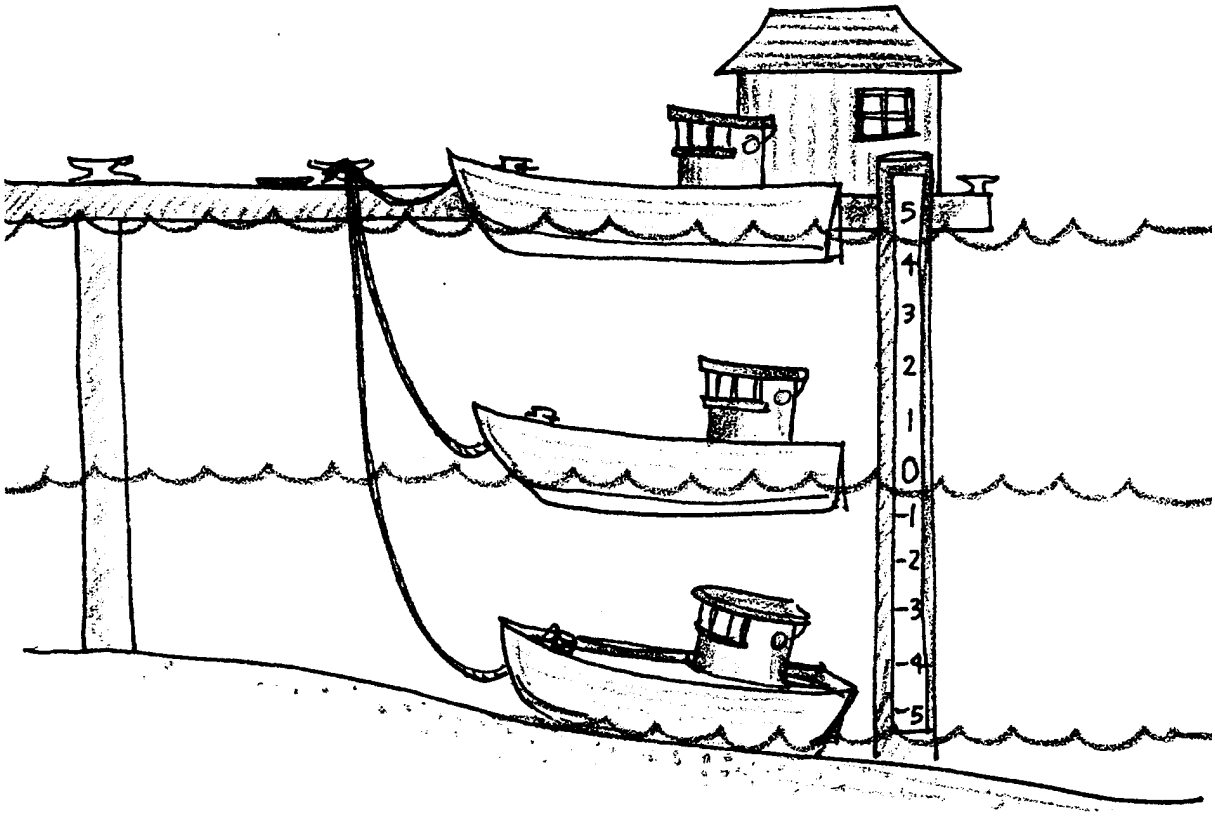
Tides occur in cycles. Moderate, or “neap”, tides and extreme, or “spring”, tides alternate about every seven days. This is an example of a tidal cycle. There are many such cycles seen in the tides. It is the interaction of these cycles that make tide prediction such a complex task. It is also the reason that one has to buy new tide charts every year. The tidal pattern that occurs this year will never be repeated exactly in the future.

In this activity you will be participating in the creation of a piece of natural art. The cycles of the tides are a rhythm that extends back to a time before life existed on the earth. We all are affected by the rhythm, whether or not we live by the sea. As you study this piece of art, try to feel the rhythm. You are a part of it, and it is a part of you.

Here is what you will need:

- a tide chart, or the portion of the chart that contains tides for your assigned week
- a straight edge or ruler, and a sharp pencil
- a copy of the week-long marigram

Oceanographers define a “0 foot” tide as the level of the water on a beach at mean lower low tide. Oceanographers have found the levels of the lowest of the low tides at that area and calculated the mean or average height of those lowest low tides. When the water is above that level on the beach, the tide is a plus tide. When the water is below that level on the beach, the tide is a minus tide.



Before you begin, look at the marigram and be sure you understand how to use it. This marigram includes minus tides. Be sure you understand how to plot the position of those tides which go below the level of mean lower low water (0.0 feet).

1. First, carefully graph the position of each of the high and low tides that occur each day. Use your straight edge to connect each point to the next as you go.

2. Label each point with the height of the tide. This will help you to spot mistakes if you have made any. Have someone check your results.

3. When you are satisfied that you have correctly graphed the tides, go over your lines with a darker pen or pencil line so that they show clearly.

4. Look at your tide chart and determine if any phase of the moon occurred during your assigned week. If one did occur, attach an appropriately colored moon circle to the top of your graph on that day.

5. Trim the edges of the graph away so that your graph can be attached to the graphs that precede and follow it.

6. Once the entire year's tides have been displayed, look for repeating patterns or cycles that occur in the marigram. Can you see the repeating cycle of spring tide, neap tide, spring tide, neap tide? What other patterns can you discover?

Extensions

Try to find the answer to these questions:

1. Does the position of the moon in its orbit (apogee, the point farthest from the earth in the orbit of the moon, or perigee, the point closest to the earth in the orbit of the moon) have an effect on tides? Explain.

2. Does perigee always coincide with full moon? Why or why not? How will this affect tide prediction?

3. How do the tides at solstice (summer solstice is longest day of the year, June 21 or 22; winter solstice is shortest day of year, December 21 or 22) compare to the tides at equinox (day and night of equal length, about March 21, September 23)? (Hint: In areas with four daily tides, look at the size of the diurnal inequality, the difference in height between successive high (or low) waters.)

4. When do the greatest tidal ranges occur? Are they exactly on the day of full and new moons?