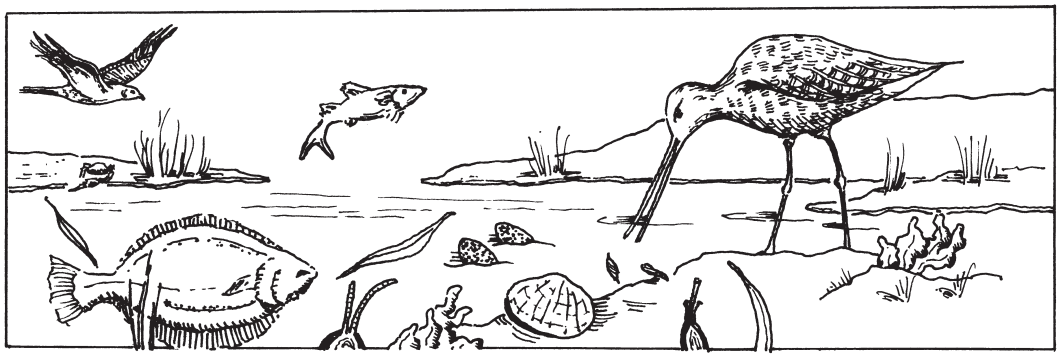


Activity #1: Graphing San Diego Tides

California Content Standard
Investigation and Experimentation 1i

Objectives:

To create a graph of monthly tides in San Diego, and label the phases of the moon on the graph.

Time:

This activity requires one 55-minute class period if the graph is produced on a computer, or 2 to 3 class periods if the graph is produced by hand.

Background:

One of the most important abiotic factors affecting the Tijuana Estuary each day is the tide. This Ecology section of the guide to the Tijuana Estuary gives a very good description of the causes of tides, which can be very complicated. In general, tides are caused by the gravitational pull of the sun and moon on the earth, and by the centrifugal forces due to the earth's spin on its axis.

When the sun and the moon are on the same side of the earth, which happens during the new moon, their combined gravitational pull causes high tides to be higher and low tides to be lower, during any given period of time. These tides are known as spring tides (which have nothing to do with the spring season). A second, lower spring tide occurs each month when the sun and the moon are on opposite sides of the earth from each other, which occurs during the full moon. During the first quarter and third quarter phases of the moon, the gravita-

tional pull of the sun and the moon are in opposition to each other, causing lower high tides and higher low tides. These tides are called neap tides.

In general, most areas of the earth's coastlines experience two high tides and two low tides each day. These changing water levels have a dramatic effect on coastal and estuarine organisms. For instance, sedentary organisms that can't move around are exposed during low tides and submerged during high tides. These organisms must find means of adapting to these changing environmental conditions. San Diego has mixed tides, which means there are two low tides and two high tides each day, but they are uneven. One low tide is lower than the other and one high tide is higher than the other each day. This activity will give students a visual representation of the tides in San Diego during a one-month period. Students will be able to see the highest tides and lowest tides for the month, and will mark the spring tides, neap tides, and phases of the moon on their graph.

Materials:

Each student will need a copy of the Tide Chart (attached), and either a computer or graph paper. If computers are available for student use, they will need to have a software application such as Excel or any other application that can produce graphs. The activity can also be completed by hand on graph paper. These instructions are for graphs produced by hand. Each student will need three half-sheets of graph paper, cut vertically.

Procedure:

1. Students will need to pay close attention to the instructions to prepare their graph paper correctly. It may be helpful to make a graph paper transparency that you can use to aid students in setting up their graphs.

2. If your students are preparing the graphs by hand and you have access to a computer, make a transparency of a computer-generated graph to show to the students. You can also include a paper copy of this graph on a test and have the students fill in the phases of the moon, and the spring tides and neap tides.

3. Students frequently become confused about the blank spaces on the tide chart, and aren't sure where the next tide should be. Remind them that tides occur about every 6 hours, so they should calculate the approximate time the next tide should occur, determine if the next tide should be a high or low tide, and look in the appropriate columns for a tide that occurs close to the approximate time.

<u>Answers to student questions</u>:
Note: You can have the students answer these questions on a separate piece of paper or on the back of their graphs.

1. Using your graph, describe San Diego tides.
   San Diego has mixed tides. One high tide each day is higher than the other high tide, and one low tide each day is lower than the other.

2. Some species in the estuary, such as barnacles, are sessile (they don't move). Barnacles cement themselves to rocks or other hard surfaces, and stay there their entire lives. Describe how barnacles would be affected by the tides in San Diego. What stresses would these animals need to cope with due to high tides? Low tides?

Students should recognize that these animals will be exposed to the elements during low tides, and submerged under water during high tides. They will need to be able to breath, stay cool (or warm), and avoid predators during low tides, and resist strong wave action during high tides.

3. Other species, such as worms and some crabs, burrow into soft sediments such as sand and mud. How would these animals' lives be affected each day by the tides? Describe how predator/prey relationships would be affected by changing water levels each day.

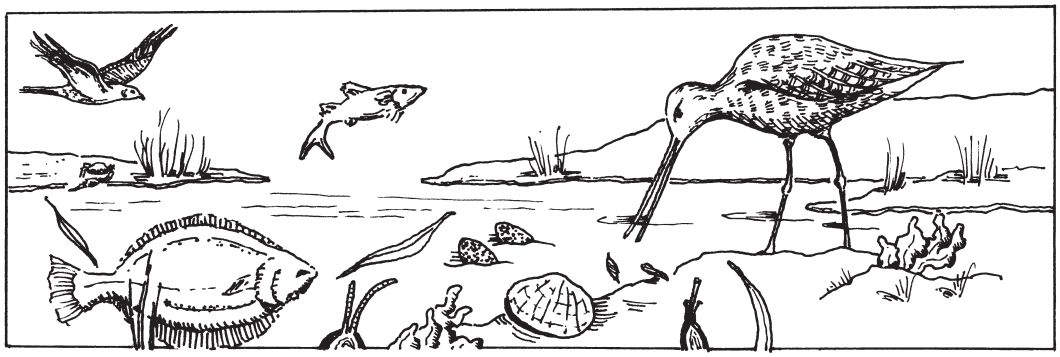
During high tides, these animals' burrows would be flooded. Air-breathers, such as some smaller crabs, frequently climb on plants to avoid the water. During low tides, waterbreathers need to be able to breath until the tide returns. During each tide, these animals must deal with different predators - water breathers during high tides and air breathers during low tides. They must find some means of protecting themselves (such as a crab's hard outer shell).

4. Some months have two full moons in them - the second full moon is called a "Blue Moon". Why do you think there are two full moons during these months?

A lunar month is 28 days. If a full moon occurs on the first or second day of a month, another full moon will occur on the 29th or 30th day of that month.

5. How long is one "lunar day" (the amount of time it takes the moon to revolve completely around the earth? Why do you think the length of a lunar day is different than the length of a solar day?

A lunar day is 24 hours and 50 minutes. Because the earth is rotating on its axis in the same direction as the moon is revolving around the earth, the moon requires an extra 50 minutes to "catch up" to the same location on the earth each day. The location has "moved" while the moon is revolving around the earth.



Activity #1: Graphing San Diego Tides

PURPOSE:

You will be constructing a graph of San Diego tides for one month, determining and labeling the dates for the four phases of the moon, and labeling the spring tides and neap tides for the month.

INTRODUCTION:

Read the Tides section of the guide to the Tijuana Estuary in the Ecology chapter. This will give you a very good idea about the causes of tides. In general, there are two main forces that cause tides - the gravitational pull of the sun and the moon on the earth, and the centrifugal force due to the earth's rotation on its axis.

When the sun and the moon are on the same side of the earth, which happens during the new moon, their combined gravitational pull causes high tides to be higher and low tides to be lower. These tides are known as spring tides (which have nothing to do with the season spring). A second, lower spring tide occurs each month when the sun and the moon on opposite sides of the earth from each other, which occurs during the full moon. During the first quarter and third quarter phases of the moon, the gravitational pull of the sun and the moon are in opposition to each other, causing lower high tides and higher low tides. These tides are called neap tides.

In general, most areas of the earth's coastlines experience two high tides and two low tides each day. These changing water levels have a dramatic effect on coastal and estuarine organisms. For instance, sedentary organisms that can't move around are exposed during low tides and submerged during high tides. These organisms must find means of adapting to these changing conditions.

San Diego has mixed tides, which means there are two low tides and two high tides each day, but they are uneven. One low tide is lower than the other and one high tide is higher.

MATERIALS:

Three half-sheets of graph paper, clear tape, and the attached tide chart.

PROCEDURE:

1. It is very important that you prepare your graph paper correctly. Line up the 3 half sheets of graph paper lengthwise, overlapping slightly, and tape them together on the back of the paper. Be sure the horizontal lines are straight across all three sheets.

2. To begin, you need to draw your y-axis 6 lines in from the left edge of the paper.

3. Next, draw your x-axis 5 lines up from the bottom edge of the paper.

4. Draw a vertical line from the top edge to the x-axis 4 lines from the y-axis, and every 4 lines after that until you have drawn 31 vertical lines. Label each of these lines 12A. Write the number under the x-axis. These lines represent Midnight for the start of each day.

5. Label 12 noon for each day by writing 12P two lines to the right of every vertical line. Again, write the number just under the x-axis.

6. Label each day by writing a number, starting with 1 and ending with 31, between every two vertical lines and just above the x-axis.

7. Label your y-axis. The y-axis line is 0. Each line above and below the y-axis represents 0.5 meters. Label every other line from -2 to +8. The y-axis on your graph represents the mean low low3 water line (MLLW).

8. You are now ready to graph San Diego's mixed tides. Using the Tide Table, mark a dot on the graph for each high and low tide.

Notes:

Remember, a low tide follows every high tide, and a high tide follows every low tide. It is very easy to get a.m. and p.m. mixed up, so be sure to double check that you are placing your dot in the correct place.

After you place each dot, draw a line from the previous dot to the next dot. It is easy to get mixed up if you draw several dots before you connect them with a line

9. Mark the four phases of the moon, the spring tides, and the neap tides on your graph.

QUESTIONS:

1. Using your graph, describe San Diego tides.

2. Some species in the estuary, such as barnacles, are sessile (they don't move). Barnacles cement themselves to rocks or other hard surfaces, and stay there their entire lives. Describe how barnacles would be affected by the tides in San Diego. What stresses would these animals need to cope with due to high tides? Low tides?

3. Other species, such as worms and some crabs, burrow into soft sediments such as sand and mud. How would these animals' lives be affected each day by the tides? Describe how predator/prey relationships would be affected by changing water levels each day.

4. Some months have two full moons in them - the second full moon is called a "Blue Moon". Why do you think there are two full moons during these months?

5. How long is one "lunar day" (the amount of time it takes the moon to revolve completely around the earth? Why do you think the length of a lunar day is different than the length of a solar day?

California, San Diego, Point Loma Tide Table **August 2003**
N 32° 40', W 117° 14'

Date	High Tide	Ht.	High Tide	Ht.	Low Tide	Ht.	Low Tide	Ht.
1 F	12:37pm	+4.4	11:59pm	+5.2	6:16am	-0.3	6:08pm	+1.7
2 Sa	1:17pm	+4.6			6:51am	+0.0	7:10pm	+1.7
3 Su	12:53am	+4.6	2:02pm	+4.8	7:29am	+0.6	8:28pm	+1.5
4 M	2:03am	+3.8	2:55pm	+5.0	8:12am	+1.1	10:01pm	+1.2
5 Tu	3:43am	+3.3	3:57pm	+5.3	9:07am	+1.7	11:34pm	+0.7
6 W	5:44am	+3.1	5:04pm	+5.6	10:19am	+2.2		
7 Th	7:17am	+3.4	6:08pm	+5.9	12:48am	+0.0	11:40am	+2.3
8 F	8:18am	+3.7	7:06pm	+6.3	1:46am	-0.5	12:51pm	+2.3
9 Sa	9:03am	+4.0	7:57pm	+6.6	2:35am	-0.9	1:50pm	+2.1
10 Su	9:41am	+4.2	8:44pm	+6.7	3:18am	-1.1	2:39pm	+1.9
11 M	10:16am	+4.4	9:26pm	+6.6	3:57am	-1.1	3:24pm	+1.7
12 Tu	10:50am	+4.5	10:06pm	+6.4	4:33am	-1.1	4:06pm	+1.5
13 W	11:21am	+4.6	10:43pm	+5.9	5:07am	-0.8	4:47pm	+1.5
14 Th	11:52am	+4.6	11:20pm	+5.4	5:37am	-0.3	5:28pm	+1.5
15 F	12:23pm	+4.6	11:57pm	+4.7	6:06am	+0.0	6:11pm	+1.6
16 Sa	12:54pm	+4.6			6:33am	+0.6	6:59pm	+1.7
17 Su	12:38am	+4.1	1:28pm	+4.5	6:59am	+1.2	7:59pm	+1.8
18 M	1:29am	+3.4	2:08pm	+4.5	7:24am	+1.7	9:23pm	+1.8
19 Tu	2:55am	+2.9	3:02pm	+4.5	7:52am	+2.3	11:10pm	+1.6
20 W	5:49am	+2.7	4:14pm	+4.5	8:41am	+2.6		
21 Th	7:41am	+3.1	5:26pm	+4.7	12:33am	+1.1	10:41am	+2.9
22 F	8:16am	+3.4	6:24pm	+5.0	1:24am	+0.7	12:12pm	+2.8
23 Sa	8:40am	+3.6	7:11pm	+5.5	2:03am	+0.2	1:07pm	+2.6
24 Su	9:03am	+3.8	7:51pm	+5.8	2:36am	-0.1	1:50pm	+2.3
25 M	9:26am	+4.1	8:29pm	+6.1	3:07am	-0.4	2:28pm	+2.0
26 Tu	9:51am	+4.4	9:06pm	+6.3	3:36am	-0.6	3:05pm	+1.6
27 W	10:16am	+4.6	9:44pm	+6.3	4:06am	-0.7	3:43pm	+1.3
28 Th	10:44am	+4.8	10:23pm	+6.0	4:35am	-0.6	4:24pm	+1.1
29 F	11:14am	+5.1	11:06pm	+5.6	5:05am	-0.3	5:09pm	+0.9
30 Sa	11:47am	+5.3	11:54pm	+4.9	5:37am	+0.0	6:00pm	+0.8
31 Su	12:25pm	+5.4			6:09am	+0.6	6:59pm	+0.8