

## Estuary Live Lesson Plan: Time, Tide, and Quahogs Waquoit Bay National Estuarine Research Reserve

Students will learn about tidal cycles in coastal waters as they use tide data to determine the best time to go out to dig quahogs.

### Learning objectives:

1. Students will be able to describe how the positions and interactions of the sun and moon influence tides.
2. Students will be able to use tide data in table and graph form to determine the time of low tide.
3. Students will be able to construct graphs of tidal cycles using tide tables.
4. Students will be able to define an estuary and will know that estuaries are tidal.
5. Students will be able to describe two adaptive behaviors shown by estuarine animals in response to tides.

**Topics:** Tides; adaptations; graphing skills; estuaries

**Grade:** 4-10

### Introduction

If you were helping to prepare a Wampanoag clam bake, it might be your job to go out and dig quahogs for the feast. These hard-shelled clams are an important part of the meal, used in chowder and eaten whole. You can use the lesson plan “Clam Digs” to figure out where to find quahogs, but it’s also important to know when to go- quahogs are only dug at low tide! Let’s investigate tides and find out when the tide will be low enough for good clamming.



Quahog shells      Picture by Caroline Goldstein

### Tides

When you go to a salt water beach, there is always a lot of action. Waves roll in and sweep the beach, gulls glide and call overhead, and the wind ripples through the marsh grass. If you stay at the beach for an hour or more, you will notice another change- the tide, engulfing or uncovering large expanses of the shore.

Tides are caused by the moon’s gravitational pull on earth. Although the pull of the moon affects all earth’s surfaces, the oceans respond most noticeably because water can flow, and the oceans contain such a huge volume of water. The height and timing

of tides varies greatly from place to place around the oceans, with some areas experiencing one high and one low tide each day, called diurnal tides, others two high and low tides each day, called semidiurnal tides, and others a combination of these patterns. The magnitude of the tides, which is the height of the water at high tide and the distance it retreats at low tide, changes significantly according to the phase of the moon. The alignment of the moon's gravitational pull with the sun's gravitational pull causes the changes. When the moon and sun are lined up with earth during the full moon and new moon phases, the sun and moon interact to produce the highest high tides and the lowest low tides (spring tides). When the moon and sun are pulling at right angles to each other, the high and low tides are less extreme (neap tides). You can find an animation of this effect at

[http://www.oceanservice.noaa.gov/education/tides/tides06\\_variations.html](http://www.oceanservice.noaa.gov/education/tides/tides06_variations.html)

The range of tides, or difference in height between high and low, can be just a couple of feet or can be more than 38 feet, as in the Bay of Fundy along the coast of Maine. If a coastal area is steep, the tide will uncover a relatively narrow horizontal stretch of beach. If the coastal landform is relatively flat, the low tide will uncover a large area, often called a "tidal flat". These are great places to find quahogs!



An estuary at low tide

Image source: <http://www.photolib.noaa.gov/coastline/line1710.htm>

### Estuaries

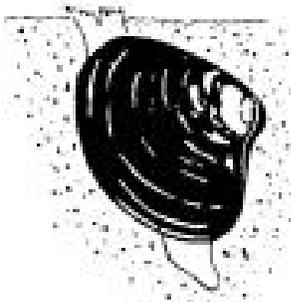
Estuaries are coastal areas where fresh water mixes with salt water in a river mouth or partly enclosed bay. Since they connect to the ocean, estuaries are tidal. They include many habitats and are full of an amazing abundance of life along their borders, in their water, and in their sandy or muddy sediments. At some high tides, plants in the salt marshes around the estuary are covered with salt water and at low tide they are entirely out of the water. Animals in the intertidal zone, the zone covered with water at high tide and uncovered at low tide, must move to stay in the water or change their behavior to survive the drying air and more extreme temperatures of low tides. You may have seen

barnacles or mussels at the shore closed up tight during a low tide, holding in moisture until the next high tide covers them.

If tides make life difficult for many estuarine animals, why do they live there? The answer is that estuaries are a rich source of food for the animals and estuarine waters are also well protected from the damaging high-energy waves of ocean beaches. For many organisms, the benefits of living in an estuary outweigh the challenges of surviving tidal cycles.

### Quahogs

Quahogs, a kind of clam, are hard-shelled bivalves (mollusks with two shells) found in the tidal waters of estuaries along the eastern coast of North America. For quahogs, high tide brings water full of plankton, which they eat by pulling water in through a tube-like siphon, filtering out the plankton, then expelling the filtered water through a second tube in the siphon. During low tide quahogs stay buried in the sandy mud, with the shell closed to hold in moisture. For people, low tide is clam-digging time!



This picture shows a quahog in the mud with its “foot” extended down and its siphon extended up to feed on plankton in the water.

Image source: <http://www.wellfleetshellfishdepartment.org/clams.htm>

### Tide data

You can use tide data to find out when the tide will be low, so you will know what time to dig quahogs in your local estuary. You can find and use tide data as a table or as a graph.

Tide tables for many locations may be found on the internet at <http://www.maine harbors.com/ma/tidemap.htm> . For this activity, you can use this link to find the tide table on the internet or use the copy of the same tide table that is included at the end of the lesson. Follow the steps below to figure out when you should go out to dig quahogs for the Wampanoag clambake:

1. Waquoit Bay doesn't have its own tide tables, so you can use the tables for Boston Harbor and add one hour. Use the link above to access the tide tables page. Click on the link for Boston Harbor and choose the month of September, or use the same table included at the end of this lesson.

2. The tide table gives times and heights of high and low tides for Boston. Check to identify which columns show the times of high tide and which show the times of low tide.
3. The tide at Waquoit Bay is about 1 hour after the tide in Boston, so add 1 hour to find the time for low tide on Wednesday September 22<sup>nd</sup> and Thursday September 23<sup>rd</sup>.
4. When is the best time during the day on September 22 or 23 to go clamming?
5. Make a graph of the tides for Waquoit Bay on September 22 and 23, 2004, using the time and height data given in the table. Remember to add 1 hour to the times given for Boston.

### Tide graphs

Another way to find what time is best for clamming is to look at a graph of the tides. The national Oceanic and Atmospheric Administration (NOAA) has extensive information about tides available on line. You can find the data on the internet or look at the graph of the tides for September 22 and 23 included in this lesson. To make a tide graph like this for yourself, follow these steps:

1. Go to [http://co-ops.nos.noaa.gov/data\\_res.html](http://co-ops.nos.noaa.gov/data_res.html) . This is a page of the NOAA tide data web site with many choices of different types of data.
2. Find the section of the page marked “Other” and click on “Predicted 6 min data” . This will take you to a page where you can choose predicted tide levels for dozens of designated stations around the coasts of the US.
3. On the predictions page, choose Boston, station #8443970, and under the chosen station set the display options for Feet, Local standard time (LST), and Hourly for the display. Next, enter a start date of 20040922 and an end date of 20040923 to view the graph for September 22 and 23, 2004, and click on “View plot”. This generates a graph of the time and heights of the tides for Boston, Massachusetts. The following link takes you to the tide predictions page:

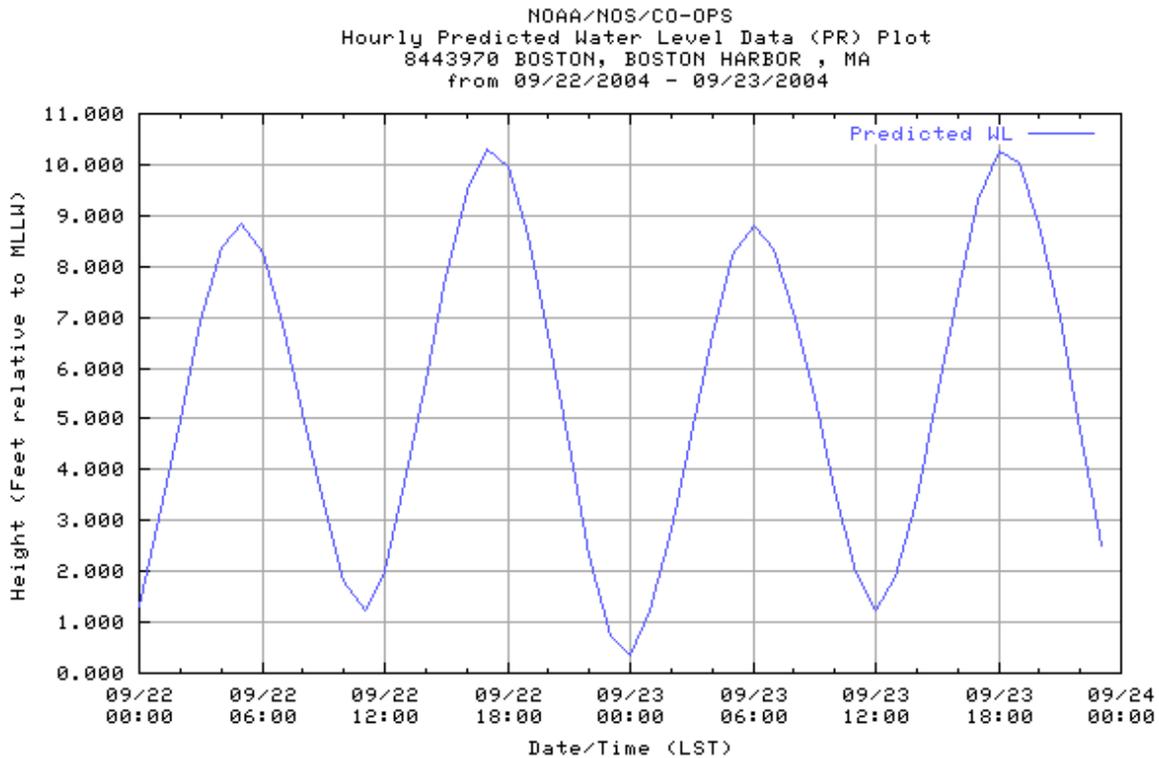
[http://co-ops.nos.noaa.gov/pred\\_retrieve.shtml?input\\_code=100001101ppr&type=pred](http://co-ops.nos.noaa.gov/pred_retrieve.shtml?input_code=100001101ppr&type=pred)

4. Look at the graph you made (or at the copy included below) and find the times for high and low tides at Boston Harbor. Time is given along the X axis at the bottom of the graph. How many hours are represented by each tick mark?

Some of the times are labeled as “18:00”. This is the same as 6:00 pm, as described using a 24-hour clock system. In this system, after 12:00, each additional hour is numbered from 13:00 to 23:59 until at midnight the clock turns to 00:00.

The tides at Waquoit Bay are 1 hour later than the tides at Boston. Find the time of the low tides at Boston on the graph for September 22 and 23, 2004, and add 1 hour. What time are the low tides at Waquoit Bay on those days? How do you know whether the tides are occurring during the day or at night?

5. When should you go out to dig quahogs for the clambake on September 23?



Tide graph for Boston Harbor, September 22 and 23, 2004. Add 1 hour for Waquoit Bay

You can use the tide predictions web site to investigate many different aspects of the tides. Try these activities:

- Make a graph of the tides at the nearest designated tide observing station to your school (stations are listed by map and by name). Are the tides diurnal or semidiurnal?
- Graph the tides at another estuary and compare them with the tide graphs for Waquoit Bay on the same days. Where is the tidal range greater? How do the times of high and low tides compare at the different locations?
- Graph the tides at a location of your choice for an extended time of a week or longer.

Information

Find out more about estuaries at your school or public library or on line at <http://www.estuaries.gov/> . Find out more about Waquoit Bay National Estuarine Research Reserve at [www.waquoitbayreserve.org](http://www.waquoitbayreserve.org)

If you have questions, please contact Pat Harcourt at (508) 457-0495 x 106 or e-mail [pat.harcourt@state.ma.us](mailto:pat.harcourt@state.ma.us)

**September 2004 Tide Table for Boston Harbor**

DATE		HIGH				LOW			
		AM	hgt	PM	hgt	AM	hgt	PM	hgt
1	Wed	1:12	11.1	1:39	10.7	7:24	-0.6	7:45	-0.4
2	Thu	2:00	10.7	2:23	10.5	8:08	-0.2	8:33	-0.1
3	Fri	2:47	10.2	3:07	10.3	8:53	0.3	9:21	0.3
4	Sat	3:35	9.6	3:52	9.9	9:38	0.9	10:10	0.7
5	Sun	4:25	9.0	4:40	9.5	10:25	1.5	11:02	1.1
6	Mon	5:18	8.5	5:31	9.2	11:15	2.0	11:58	1.5
7	Tue	6:14	8.1	6:26	9.0	-	-	12:09	2.3
8	Wed	7:14	7.9	7:24	9.0	12:56	1.7	1:06	2.5
9	Thu	8:12	8.0	8:21	9.1	1:55	1.7	2:03	2.4
10	Fri	9:06	8.2	9:14	9.4	2:50	1.5	2:56	2.1
11	Sat	9:55	8.5	10:03	9.7	3:39	1.2	3:46	1.7
12	Sun	10:38	8.9	10:47	10.0	4:23	0.8	4:31	1.3
13	Mon	11:17	9.3	11:28	10.3	5:03	0.5	5:15	0.8
14	Tue	11:55	9.8	-	-	5:42	0.2	5:57	0.4
15	Wed	12:09	10.4	12:32	10.2	6:21	0.0	6:38	0.0
16	Thu	12:49	10.5	1:10	10.5	7:00	-0.1	7:21	-0.2
17	Fri	1:31	10.4	1:49	10.7	7:40	-0.1	8:06	-0.4
18	Sat	2:16	10.2	2:31	10.8	8:23	0.1	8:53	-0.4
19	Sun	3:03	9.9	3:18	10.8	9:08	0.4	9:44	-0.2
20	Mon	3:55	9.5	4:10	10.7	9:59	0.7	10:40	0.0
21	Tue	4:53	9.1	5:08	10.5	10:55	1.0	11:41	0.2
22	Wed	5:56	8.9	6:12	10.3	11:56	1.3	-	-
23	Thu	7:03	8.8	7:19	10.3	12:46	0.3	1:02	1.3
24	Fri	8:09	9.0	8:26	10.5	1:51	0.3	2:07	1.1
25	Sat	9:12	9.4	9:29	10.7	2:54	0.1	3:10	0.7
26	Sun	10:08	9.9	10:26	10.8	3:51	-0.2	4:08	0.2
27	Mon	10:58	10.3	11:18	10.9	4:42	-0.4	5:01	-0.2
28	Tue	11:44	10.6	-	-	5:29	-0.4	5:50	-0.4
29	Wed	12:06	10.8	12:27	10.8	6:13	-0.3	6:37	-0.5
30	Thu	12:51	10.5	1:08	10.7	6:56	0.0	7:21	-0.4

Source of table: <http://www.maineharbors.com/ma/tidemacp.htm>