

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Marine Fisheries Service

Lesson 10: Tides

Overview

Lesson 10 describes the basic causes of tides and defines the fundamental terminology scientists use to categorize and characterize tides. Students observe tidal charts and describe reasons tides are important to humans and marine life. In the activity, students research creatures of the intertidal zone and describe the types of physical and behavioral adaptations that allow organisms to thrive in this harsh environment.

Lesson Objectives

Students will:

1. Identify the gravitational effects of the sun and the moon on the Earth as the primary determinants of tides
2. Differentiate spring and neap tides
3. Define the intertidal zone and describe adaptations of common organisms that live in these zones

Lesson Contents

1. Teaching Lesson 10
 - a. Introduction
 - b. Lecture Notes
 - c. Additional Resources
2. Teacher's Edition: Creatures of the Intertidal
3. Student Activity: Creatures of the Intertidal
4. Student Handout
5. Mock Bowl Quiz

Standards Addressed

National Science Education Standards, Grades 9-12
Physical science
Life science

Ocean Literacy Principles
The Earth has one big ocean with many features

DCPS, High School Earth Science
ES.5.3. Identify and explain the mechanisms that cause and modify the production of tides, such as the gravitational attraction of the moon, the sun, and coastal topography

Lesson Outline¹

I. Introduction

To introduce the students to the concept of tides, lead them through a brief presentation of NOAA tide prediction data (slide 3). Ask students if they have ever heard of tides and if they can define them. A **tide** is the periodic rise and fall of a body of water due to gravitational interactions between the sun, moon and Earth.

Display slide 3. This is a graph of tide prediction data from NOAA for Dauphin Island, AL. The y-axis shows water levels in feet and the x-axis shows time in hourly increments over the course of a day. Ask students what happens to the water level over the course of a day. They will see that the sea level rises and falls each day. This regular rise and fall of sea level represents an ocean tide. Ask students how many high tides and how many low tides occur at this location per day. They should observe one high tide and one low tide.

Lead a brief discussion that emphasizes the following concepts:

- Tides are predictable in terms of timing and water levels
- The times and heights between tides vary for different locations around the world
- There are many important reasons to know tidal patterns, for example: navigation, recreation (surfing, swimming, looking at tide pools) and commercial activity (fishing).

II. Lecture Notes

Use the PowerPoint for Lesson 10 (File: Lesson 10 – Tides.ppt) to present the following information. Distribute the Student Handout before you begin for students to take notes on key information.

What is a tide? (slides 5 and 6)

1. A tide is the periodic rise and fall of a body of water due to gravitational interactions between the sun, moon and Earth.
2. Tides vary around the world. Some places have greater **tidal ranges** (the difference between the water level at high tide and low tide) than others. Tide frequency and height may also vary by location.
3. There are special terms to describe the number of tides and the magnitude of tides that occur in a given location each day:
 - a. **Diurnal tide** means a location has one low tide and one high tide each day².

¹ Unless otherwise indicated, all websites provided or referenced in this guide were last accessed in November 2010.

² For complete technical accuracy, the type of day referred to in the definitions for diurnal, semidiurnal and mixed (semidiurnal) tides is a lunar day (also referred to as a tidal day). A lunar day is 24 hours and 50 minutes compared to the typical solar day which is 24 hours. It refers to the time required for a spot on earth to make a full rotation from a specific location under the moon to the same location (under the moon). For a

- b. **Semidiurnal tide** means a location has two low tides and two high tides each day with the low tides equal in size and the high tides equal in size.
- c. **Mixed (semidiurnal) tide** means that a location has two low tides and two high tides each day but the low tides are unequal in size and the high tides are unequal in size.

What causes tides? (slides 8-11)

1. The relative positions of the sun and moon compared to the Earth have a major influence on tides.
2. The gravitational pull of the moon causes “bulges” on the Earth. As a location moves into these bulges due to the rotation of the Earth, the tide rises. The tide falls when the location rotates out of the bulge.
3. When the sun and moon form a straight line with respect to the Earth, **spring tides** occur. Spring tides typically have the highest tidal ranges.
4. When the sun and moon form a 90 degree angle with the Earth, **neap tides** occur. During these tides, high tide is lower and low tide is higher compared to spring tides.

Tide exercise (slides 13-19)

1. This series of slides quizzes students on their knowledge of diurnal, semidiurnal and mixed semidiurnal tides. The slides show tide prediction data from NOAA (they have seen two of these graphs in the first 3 slides!). Students are asked to answer several questions and determine what type of tide they see.
2. As you advance the slides, ask the students the quiz questions listed in the Notes section of the PowerPoint and below. Answers are provided for students in subsequent slides.

Slide 14

What time does the first low tide occur? **8:00 a.m.**

What time does the first high tide occur? **8:00 p.m.**

How many high tides and low tides occur? **One high tide and one low tide**

What type of tide do you think this is? **Diurnal**

Slide 16

What is the tidal range (distance between high and low tide) for first high and low tide (round to nearest foot)? **2 feet**

more in depth explanation of a lunar day, see:

http://oceanservice.noaa.gov/education/tutorial_tides/tides05_lunarday.html; Accessed, May 2011.

What is the tidal range for the second high and low tide (round to nearest foot)? **2 feet**

What type of tide is this? Semidiurnal: **Two high and low tides of about equal heights**

Slide 18

How many high tides are present? **2**

What times do they occur? **~4:00 a.m. and ~6:00 p.m.**

How many low tides are present? **2**

What times do they occur? **11:00 a.m. and 11:00 p.m.**

What is the tidal range (distance between high and low tide) for first high and low tide (round to nearest foot)? **10 feet**

What is the tidal range for the second high and low tide (round to nearest foot)? **4 feet**

What type of tide is this? **Mixed semidiurnal: two high and low tides of unequal heights**

III. Additional Resources

1. Background information:
<http://co-ops.nos.noaa.gov/restles3.html>
<http://www.crd.bc.ca/watersheds/protection/geology-processes/Tides.htm>
<http://oceanservice.noaa.gov/education/kits/tides/>
2. Bay of Fundy:
http://www.srh.noaa.gov/jetstream//ocean/fundy_max.htm

Creatures of the Intertidal

Overview

In this activity, students research five organisms that live in the harsh intertidal zone. Students describe adaptations that allow each organism to survive in its environment. Each group will research one organism and then prepare a short presentation to the class.

An alternative lesson that focuses less on ecology and more on the physical nature of tides is found at the link below:

http://www.srh.noaa.gov/jetstream/ocean/ll_moonphase.htm

Background

Have you ever noticed waves crashing on a beach and wondered what it would be like to live in this type of environment? It might get a little rough! An organism would need to be prepared for strong waves and currents, rising and falling water level and rapid changes in moisture and temperature. Can you think of some organisms that live in these types of environments, along the shoreline?

We call the area where the land meets the sea between low and high tides the **intertidal zone**. These communities are found along very rocky or sandy beaches and along estuaries like the Chesapeake Bay. Today we're going to learn about **adaptations**, those traits that evolve over time that increase organisms' potential to survive and reproduce in their environments.

In today's activity, students research organisms that live in the intertidal zone. Each group will be assigned one organism to research. The group will then prepare a short (5min) presentation to teach other students about their findings. Students can use visual aids if they want. The most important thing is students explain to their classmate **how their creature is adapted to live in the harsh intertidal environment**.

Materials

- Intertidal Zone Creature Profile (1 per group, included in this file)
- Construction paper
- Markers, pens and pencils

Procedure

1. Divide the class into no more than 5 groups (4 might be better, if possible) to allow this activity to be completed relatively quickly.
2. Distribute the Student Activity.
3. Give each group one "Intertidal Zone Creature Profile" worksheet to complete.

4. Students will research their creature. Provide students with computers (if you want to let them use the internet) or biology textbooks to help them with their research. Handouts with answers to the questions for each organism are included in this file. You can use this information to guide your students in their research and presentations. If every group will not have internet access, or you want to save time, you can give the answer keys to the groups to use when making their presentations.
5. Students will use their research to make a short presentation for their fellow students. Allow students about 10-15 minutes to research their creature. Provide them with large construction paper, pens and pencils to make visual aids for their presentation. Tell them to stick to the four questions that are asked. Make sure students keep their presentations no longer than five minutes.

Intertidal Zone Creature Profile³(Answer key)

Rock boring sea urchin



1. Name the kingdom and phylum of these creatures. **Animalia, Echinodermata**
2. How do they protect themselves from drying out during low tides?
By boring holes into rocks that collect water and provide moisture during low tide.
3. How do they protect themselves from crashing waves?
They have tough exoskeletons and tube feet that allow them to hold tight to rocks and prevent them from being crushed or carried out to sea by strong waves or currents.
4. How do they protect themselves from predators?
They can hide in holes and use their tube feet for locomotion. Their sharp spines also make them difficult to eat.

³ All photos from NOAA Photo Library unless otherwise indicated.

Intertidal Zone Creature Profile (Answer key)

Hermit crab



1. Name the kingdom and phylum of these creatures. **Animalia, Arthropoda**
2. How do they protect themselves from drying out during low tides?
They are highly mobile and can move quickly into tide pools, rocks and crevices that contain water during low tide.
3. How do they protect themselves from crashing waves?
Their shells allow them protection from crashing waves. They can wedge themselves tightly into crevices in rocks and retreat into their shells to avoid being harmed or pulled out to sea.
4. How do they protect themselves from predators?
They can hide in their shells and in rocky crevices. They can move rapidly and can use their front claws to eat and to defend themselves against predators.

Intertidal Zone Creature Profile (Answer key)

Sea anemone



1. Name the kingdom and phylum of these creatures. **Animalia, Cnidaria**
2. How do they protect themselves from drying out during low tides?
They can retract all their tentacles inside their body column (like a drawstring purse) to hold in moisture.
3. How do they protect themselves from crashing waves?
The bottom of their bodies act as “suction cups” allowing them to hold tight to rocks, or even bury in the mud or sand, to prevent them from being washed out to sea. Their jelly-like bodies allow them the flexibility to withstand the force of waves and currents.
4. How do they protect themselves from predators?
They can retract tightly for protection and slide slowly to change location. Many species of anemone have evolved tentacles that can help protect them from predators and can also paralyze prey.

Intertidal Zone Creature Profile (Answer key)

Limpet



1. Name the kingdom and phylum of these creatures. **Animalia, Mollusca**
2. How do they protect themselves from drying out during low tides?
They latch themselves tightly to rocks and secrete a slime to keep themselves moist during low tides. They have a foot that allows them to move into tide pools or crevices.
3. How do they protect themselves from crashing waves?
They have a muscular foot that allows them to cling very tightly to rocks to prevent them from being washed out to sea. Their hard shells prevent their soft bodies from being harmed by rough waves, debris and currents.
4. How do they protect themselves from predators?
Their hard shells tend to blend in with their environment, making them difficult for predators to find. Also, their muscular foot makes it difficult for predators to pry them off of rocks.

Intertidal Zone Creature Profile (Answer key)

Blenny (Blennioid)



1. Name the kingdom and phylum of these creatures. **Animalia, Chordata**
2. How do they protect themselves from drying out during low tides?
They can burrow into crevices in rocks or move into tide pools to maintain moisture.
3. How do they protect themselves from crashing waves?
They typically shelter themselves in crevices, rocks or corals to withstand the force of waves and currents. They have even been observed to hide in the shells of other organisms.
4. How do they protect themselves from predators?
They can hide as described above or burrow into the sand. Many species have evolved to blend in with their environment, making them difficult for predators to spot.

Creatures of the Intertidal⁴

Have you ever noticed waves crashing on a beach and wondered what it would be like to live in this type of environment? It might get a little rough! An organism would need to be prepared for strong waves and currents, rising and falling water level and rapid changes in moisture and temperature. Can you think of some organisms that live in these types of environments, along the shoreline?

We call the area where the land meets the sea between low and high tides the **intertidal zone**. These communities are found along very rocky or sandy beaches and along estuaries like the Chesapeake Bay. Today we're going to learn about **adaptations**, those traits that evolve over time that increase organisms' potential to survive and reproduce in their environments.

In today's activity your group is going to meet a creature that lives in the intertidal zone. You are going to research your creature and prepare a short (5min) presentation to teach your classmates about what you have learned. You can use visual aids that you draw to help explain your findings. The most important thing is that you teach your classmates **how your creature is adapted to live in the harsh intertidal environment**.

Procedure

1. Take an Intertidal Creature Profile from your teacher.
2. Use the resources provided by your teacher to research your creature.
3. Develop a 5min presentation that answers the question: How is this organism adapted to live in the intertidal environment?
4. Include the following four pieces of information in your presentation:
 - a. To what *kingdom* and *phylum* does your creature belong?
 - b. How do they protect themselves from drying out during low tides?
 - c. How do they protect themselves from crashing waves?
 - d. How do they protect themselves from predators?
5. Develop visual aids to use in your presentation. Pictures can be very helpful to show behaviors or physical traits to your classmates! You can have some group members draw pictures as others continue to work on the research.

⁴Images from NOAA Photo Library unless otherwise indicated.

Intertidal Zone Creature Profile

Rock boring sea urchin

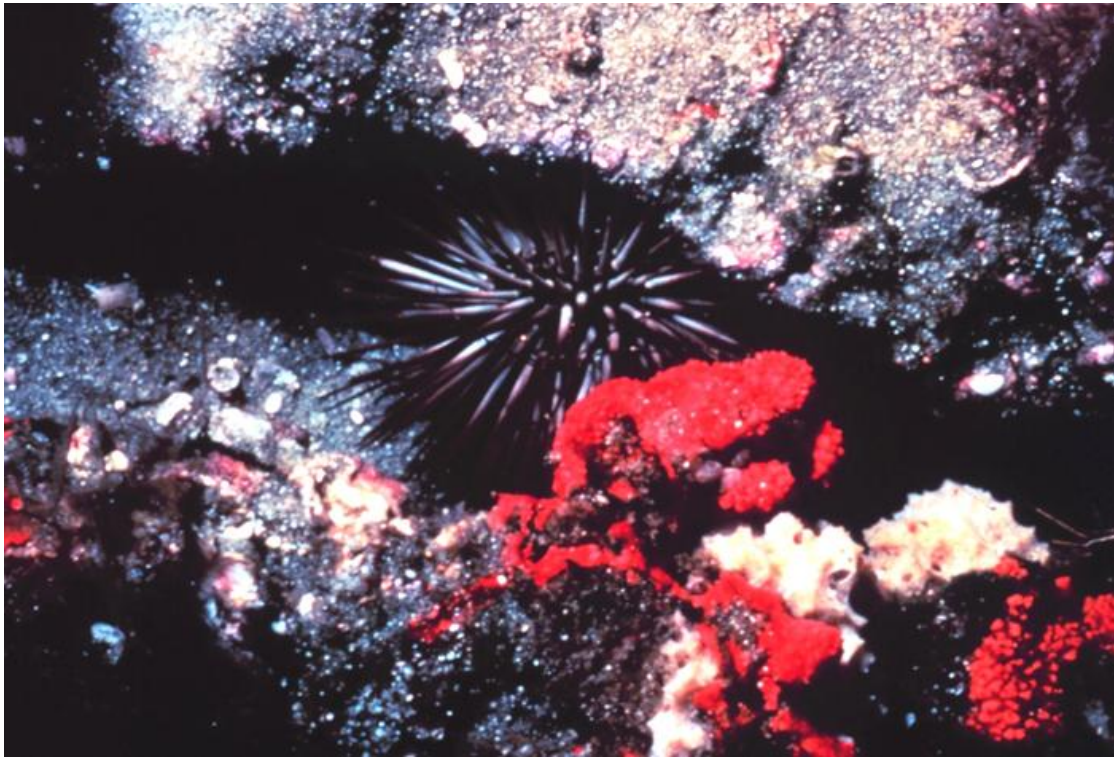


Image ID: sanc0522, NOAA's Sanctuaries Collection
Location: Georgia, Gray's Reef National Marine Sanctuary

Use the following questions to guide your presentation.

1. Name the kingdom and phylum of these creatures.
2. How do they protect themselves from drying out during low tides?
3. How do they protect themselves from crashing waves?
4. How do they protect themselves from predators?

Intertidal Zone Creature Profile

Hermit crab



Image ID: reef0750, NOAA's Coral Kingdom Collection

Location: Northwest Hawaiian Islands

Photo Date: 2004 September

Photographer: Dr. Dwayne Meadows, NOAA/NMFS/OPR

Use the following questions to guide your presentation

1. Name the kingdom and phylum of these creatures.
2. How do they protect themselves from drying out during low tides?
3. How do they protect themselves from crashing waves?
4. How do they protect themselves from predators?

Intertidal Zone Creature Profile

Sea anemone



Use the following questions to guide your presentation

1. Name the kingdom and phylum of these creatures.
2. How do they protect themselves from drying out during low tides?
3. How do they protect themselves from crashing waves?
4. How do they protect themselves from predators?

⁵ Photo: NOAA, http://www8.nos.noaa.gov/coris_glossary/index.aspx

Intertidal Zone Creature Profile

Hawaiian limpet



Use the following questions to guide your presentation

1. Name the kingdom and phylum of these creatures.
2. How do they protect themselves from drying out during low tides?
3. How do they protect themselves from crashing waves?
4. How do they protect themselves from predators?

⁶ Photo: NOAA, http://coris.noaa.gov/about/eco_essays/nwhi/gardener_pinnacles.html

Intertidal Zone Creature Profile

Blenny (Blennioid)



Image ID: sanc0408, NOAA's Sanctuaries Collection

Location: Flower Garden Banks National Marine Sanctuary

Photographer: Jackie Reid

Use the following questions to guide your presentation

1. Name the kingdom and phylum of these creatures.
2. How do they protect themselves from drying out during low tides?
3. How do they protect themselves from crashing waves?
4. How do they protect themselves from predators?

Tips for the Bowl - Tides

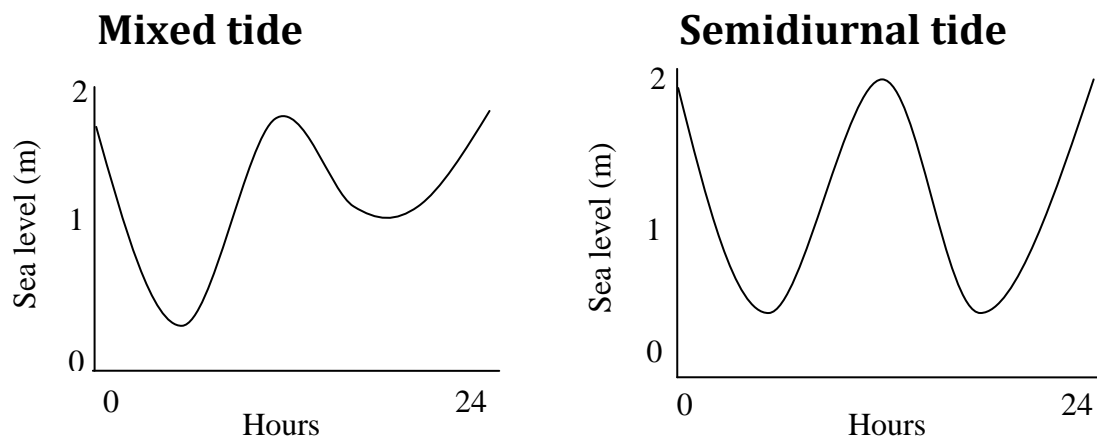
Lunar cycle

Some questions on the bowl require that you know how the lunar cycle relates to the types of tide you learned about today:

1. **Spring tides** occur around the **new** or **full moon**
2. **Neap tides** occur when the moon is at **first quarter** or **third quarter**

Mixed tides vs. semidiurnal tides

You learned that a semidiurnal tide means that there are two high and two low tides in one day. You should also know that the height of low and high tides is the same (think “s,” semidiurnal = same) in a semidiurnal tide. A mixed semidiurnal tide also has two high and two low tides during one day, but the tidal ranges are different. The figure below shows sketches of tide diagrams where the y axis is sea level and the x axis shows time over one day. The left figure is a mixed semidiurnal tide, with two high and two low tides at different heights. The right figure is a semidiurnal tide with two high and two low tides of the same heights.



The Theories

You learned that the sun and the moon primarily control the tides. This is a simplistic explanation for the tides known as Isaac Newton's *equilibrium theory*. This theory assumes that Earth is uniform and has no land.

In reality, the Earth is more complex. Pierre-Simon Laplace's theory for tides is known as the *dynamic theory of tides*. For the Bowl, you should know that this theory shows that there are other factors besides the sun and moon that influence tides. These other factors include: the imperfect spherical shape of Earth, seasons, time of month, land masses, shape of ocean basin and the Coriolis Effect.

Tides

1. Which of the following has the strongest influence on tides:
 - w. Sun
 - x. Mars
 - y. Moon**
 - z. Wind

2. The highest and lowest tides which occur when the moon and sun are lined up with the Earth are:
 - w. Neap tides
 - x. Winter tides
 - y. Spring tides**
 - z. Summer tides

3. In semidiurnal tides, high and low tides occur:
 - w. Once a day
 - x. Twice a day**
 - y. Three times a day
 - z. Four times a day

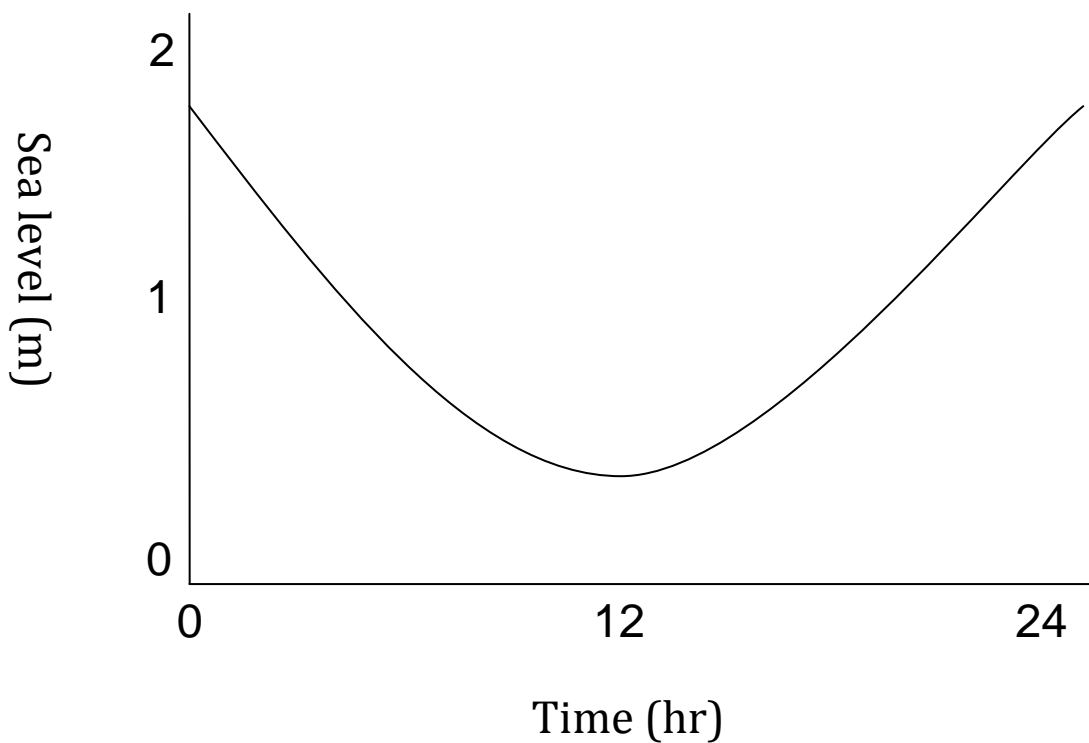
4. The difference in the height of the water surface between high and low tides is:
 - w. Neap tide
 - x. Spring tide
 - y. Tidal range**
 - z. Tidal current

5. Which of the following areas has the world's greatest tidal range of up to 50 feet:
 - w. Chesapeake Bay
 - x. Gulf of Mexico
 - y. Gulf of Alaska
 - z. Bay of Fundy**

6. Which of the following factors can affect tides?
 - w. Path of the Moon around the Earth
 - x. Earth's tilt
 - y. Water depth
 - z. All of the above**

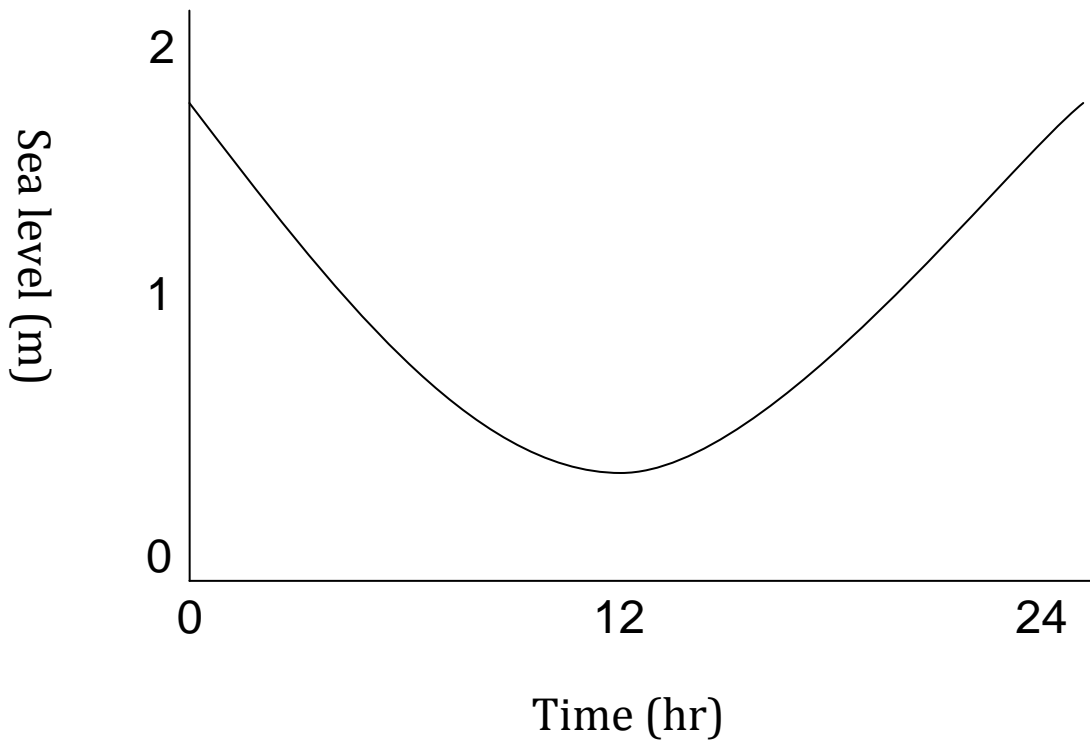
7. Short answer: Tidal range is typically greatest during which type of tide?
Answer: Spring tides

8. Parts of the Gulf of Mexico have diurnal tides. This means that high and low tides occur:
- w. **Once a day**
 - x. Twice a day
 - y. Three times a day
 - z. Four times a day
9. What type of tide occurs when the sun and moon form a right angle as when we see a half moon:
- w. Spring tide
 - x. **Neap tide**
 - y. Mixed tide
 - z. Semidiurnal tide
10. Team challenge question



1. What type of tide is represented in the chart above? (2pt)
2. What difference would you expect if the tide in the same location was semidiurnal? (2pt)

ANSWER



a. What type of tide is represented in the chart above? (2pt)

Diurnal

b. What difference would you expect if the tide in the same location was semidiurnal? (2pt)

Two high and two low tides would occur in the same time period