



## TIDES LESSON PLAN

# Ups and Downs

### Focus

Forces that cause and affect tides

### Grade Level

9-12 (Earth Science)

### Focus Question

What causes tides and tidal currents?

### Learning Objectives

- Students will be able to explain and model forces that cause and affect tides.
- Students will be able to analyze variations in tidal patterns and water levels in selected areas, and infer and discuss some conditions that may have influenced these variations.
- Students will be able to describe how tides affect our lives and explain the importance of monitoring tides.

### Materials

- Access to the Internet and National Ocean Service education site (<http://www.nos.noaa.gov/education/tides/welcome.html>)
- Copies of Appendices A, B, and C, one copy for each student or student group
- Copies of “Tides and Water Levels Student Worksheet,” one copy for each student
- Materials for constructing models of the Earth-moon-sun system (optional, depending upon students’ approach to Part 2)

### Audio/Visual Materials

Optional, depending upon students’ approach to Part 2

### Teaching Time

**Part 1 (Researching and Exploring Tides):** One or two 45-minute class periods [Note: If Internet is not accessible, a classroom discussion using Background Information and

access to various text references may be used to complete Part I of the Tides and Water Levels Student Worksheet. Data for Part II can be found in Appendices A, B, and C]

**Part 2 (Explaining Tidal Phenomena):** Two or three 45-minute periods, plus time outside of class for research and preparation

### Seating Arrangement

Part 1: as appropriate for working with Internet resources

Part 2: groups of four or more students

### Maximum Number of Students

32

### Key Words

Tide

Tidal current

Ebb

Flood

Spring tide

Neap tide

Perihelion

Aphelion

Perigee

Apogee

Lunar cycle

### Background

Tides are the periodic rising and falling of ocean waters caused by the gravitational forces of the sun and moon. The vertical motion of tides is accompanied by a horizontal movement of ocean waters called tidal currents. Oceanographers say that tides rise and fall, while tidal currents ebb (during a falling tide) and flood (during a rising tide).

For a simple explanation of tides, it is sufficient to consider only the effects of the moon (the magnitude of the moon's effect is about twice that of the sun, since the moon is closer to the Earth). At any point in a day, one side of the Earth will be closer to the moon than the opposite side. Ocean waters on the closer side of the Earth will experience a greater gravitational

pull from the moon than waters on the opposite side of the earth (tide generating forces vary inversely as the cube of the distance from the tide generating object). This causes a “bulge” in the waters closest to the moon, and creates a high tide. At the same time, inertial forces on the opposite side of the Earth causes a similar “bulge” creating another high tide. Low tides occur at longitudes that are 90° from the longitudes of locations that are experiencing high tides.

The sun also exerts a gravitational force on ocean waters. Depending upon the positions of the sun and moon relative to the Earth, the sun’s gravity may enhance or diminish the tidal effect caused by the moon. When the sun and moon are aligned (at the time of full moon or new moon), their gravitational forces act in the same direction and produce more pronounced high and low tides that are called spring tides. When the sun and moon are at right angles relative to the earth, the gravitational force of the sun partially cancels out the gravitational force of the moon. The result is less pronounced high and low tides that are called neap tides. The magnitude of tides is also affected by the actual distances between the sun, moon, and Earth: Gravitational attraction is increased when the Earth is closest to the sun (perihelion) or moon (perigee). For more information on the causes and types of tides, visit <http://www.nos.noaa.gov/education/tides/welcome.html>.

For centuries, people who live and work near seacoasts have understood the importance of being able to predict tides and tidal currents. Low tides may prevent ships from entering harbors, while high tides may make it impossible for ships to pass beneath bridges. Tidal currents may significantly increase the speed of a vessel, or may carry it into dangerous waters. Recreational boaters who anchor near shore may find themselves stranded by a falling tide. Fishermen throughout the world have learned that catches are likely to be much larger during certain portions of the tidal cycle than others.

Many people who live thousands of miles from any ocean also pay close attention to the same lunar cycles that produce tides. Traditional agricultural practices often prescribe planting and harvesting during times when the moon is at a specific location relative to the Earth. Some traditional forestry practices

link lunar cycles with specific properties of wood including strength, resistance to decay, and resonance for musical instruments. Lunar cycles have also been linked with many aspects of human biology, behavior, and folklore including crime, suicide, mental illness, birthrates, fertility, werewolves, and vampirism.

The first part of this lesson is intended to:

- introduce students to tides and tidal currents, and improve their understanding of how these phenomena are measured and predicted; and to
- introduce students to some of the data available from oceanographic monitoring programs that can be used by anyone who wants to study the Earth's oceans.

In the second part of this lesson, students will design and prepare educational materials that can be used to explain the fundamental tidal phenomenon as part of introductory middle school oceanography lessons.

### Learning Procedure

*[Note: This lesson is based on an activity created by Claire Silva, Biology Teacher, Langley High School, McLean, VA]*

#### Part 1: Researching and Exploring Tides

1.

Direct students to the Tides and Water Levels tutorials at: <http://www.nos.noaa.gov/education/tides/welcome.html>. If you choose to have students work in groups, you may want to assign different tutorial sections to each student. Have each student or student group answer questions in Part I of the "Student Worksheet." To save class time, you may want to assign this portion of the lesson as homework.

2.

Review students' answers to questions on the "Student Worksheet." Lead a brief discussion of ways in which knowledge of tides can be useful and important.

3.

Have each student or student group answer questions in Part II of the "Student Worksheet" using data from <http://tidesonline.noaa.gov/geographic.html> or from Appendices A, B, and C.

### Part 2: Explaining Tidal Phenomena

Have students or student groups prepare visual materials that could be used to explain tides and tidal currents to a 5th or 6th grade science class. Appropriate materials may include physical models (e.g., mobiles), visual media (e.g., Powerpoint® presentations; computer animations), theatrical presentations (e.g., drama; music; dance), or publications. Materials produced should support explanations about:

- The influence of the sun and moon
- Spring and neap tides
- Tidal magnitude at perigee, apogee, perihelion, and aphelion

Encourage (and give credit for) creativity! These presentations offer cross-curricular opportunities, particularly with social studies, English language arts, and fine arts. Whatever media students choose to work with, their final presentation should be accompanied by a list of sources for the information they present. A good starting point for this activity is the Roadmap to Resources: Tides & Water Levels ([http://www.nos.noaa.gov/education/tides/supp\\_tides\\_roadmap.html](http://www.nos.noaa.gov/education/tides/supp_tides_roadmap.html)), which provides links to many other sources of data and information about tides.

### The Bridge Connection

[www.vims.edu/bridge/](http://www.vims.edu/bridge/) – Click on “Ocean Science Topics” in the navigation menu to the left, then “Physics,” and then the “Tides” button at the top of the page.

### The “Me” Connection

Have students write a short essay on why knowledge about tides and water levels is (or might be) important in their own lives.

### Extensions

The rise and fall of ocean tides involve huge amounts of energy. Have students or student groups prepare a report on how this energy could be captured in a form that could be used by humans. Reports should include a plausible mechanism for converting tidal motion into useful energy, a strategy for transporting captured energy to potential users, and a rough estimate of the energy that might be available from tidal sources. A keyword search on “tide energy” will produce lots of starting points.

## Resources

- [http://www.nos.noaa.gov/education/tides/supp\\_tides\\_roadmap.html](http://www.nos.noaa.gov/education/tides/supp_tides_roadmap.html)  
– NOAA’s National Ocean Service Web site’s Roadmap to Resources about tides and water levels, with links to many other sources of tide data and background information
- <http://pao.cnmc.navy.mil/Educate/Neptune/quest/wavetide/waves.htm>  
– Naval Meteorology and Oceanography Command Web site with information on waves and tides
- <http://www.edusite.com/sci/tides.htm> – Links to educational resources on ocean science topics
- <http://www.internet4classrooms.com/tide.htm> – Links to internet resources dealing with tides
- <http://school.discovery.com/curriculumcenter/oceans/> – Discovery Channel School resources on ocean science topics

## National Science Education Standards

### Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

### Content Standard B: Physical Science

- Motions and forces

### Content Standard D: Earth and Space Science

- Energy in the earth system

### Content Standard E: Science and Technology

- Understandings about science and technology

### Content Standard F: Science in Personal and Social Perspectives

- Natural resources
- Natural and human-induced hazards



## TIDES LESSON PLAN

# Tides & Water Levels Student Worksheet

### Part I: Background on Tides and Water Levels

Begin your information search by using the text resources provided by your teacher or by accessing the Internet and logging onto: <http://www.nos.noaa.gov/education/tides/welcome.html>

As you read through the Tutorial on Tides and Water Levels, answer the questions below that correspond to each section of the tutorial.

#### What are Tides?

1. What is a basic definition of a tide? Where do tidal waves originate, and where do they end?
2. What is a high tide? What is a low tide?
3. What is tidal range? What is a tidal current?
4. Compare and contrast a flood and ebb current. When are they strong? When are they weak?
5. How do tidal currents perform in the open ocean? How do they perform near the entrances to estuaries?

#### What Causes Tides?

6. Tides are caused by the gravitational attraction of what two celestial bodies?
7. What does Newton's law of universal gravitational state?
8. Which parameter has a greater effect on tidal forces on Earth?
9. Which celestial body has a greater effect on tidal forces on Earth? How is this possible? Compare and contrast the masses and distance of the Earth to the moon and sun.

#### Gravity, Inertia, and the Two Bulges

10. What is inertia?
11. How does the moon create a bulge?
12. What causes a bulge to be created on the opposite side of the Earth or the "far side" from the moon?

#### Changing Angles and Changing Tides

13. Describe how changes in the relative positions of the moon and sun change in relation to the Earth?

14. At what point is the sun at its minimum declination and its maximum declination?

### Frequency of Tides - The Lunar Day

15. Compare and contrast a solar and lunar day. How long is a lunar day?
16. Why do most coastal areas experience two high tides and two low tides?
17. How long does it take for high tide to occur? How long is the time between low and high tide?

### Tidal Variations - The Influence of Position and Distance

18. What is the magnitude of solar tides and how are they expressed?
19. What causes spring tides? What causes neap tides? How many spring and neap tides occur in a lunar month?
20. How are tide-generating forces affected when the moon is closest to the Earth (or perigee)? when the moon is farthest away from the Earth (or apogee)? How does this affect the tides that are produced?
21. How are tide-generating forces affected when the Earth is closest to the sun (or perihelion)? when the Earth is farthest from the sun (or aphelion)? How does this affect the tides that are produced?

### Types and Causes of Tidal Cycles: Diurnal, Semidiurnal, Mixed Semidiurnal; Continental Interference

22. If the Earth were perfect, how many high and low tides would all points on the earth experience in one day? What causes tidal patterns to change? Why is the water unable to move freely?
23. Describe a semidiurnal tide. How do the tidal heights compare in a lunar day? Where might you experience a semidiurnal tide in the continental United States?
24. Describe a mixed semidiurnal tide. How do the tidal heights compare? Where might you experience a mixed semidiurnal tide in the continental United States?
25. Describe a diurnal tide. Where might you experience a diurnal tide?

### What Affects Tides in Addition to the Sun and Moon?

26. How are the magnitudes of tides affected by shorelines? by



- mid-ocean islands?
27. How does a funnel-shaped bay compare to a narrow inlet and shallow water?
  28. What is the affect of strong tidal rivers on tides in estuaries?
  29. What other abiotic factors affect tides? Compare and contrast wind and weather patterns that affect tides.

### The Importance of Monitoring the Tides and Their Currents

30. Explain why commercial fisherman would be interested in tidal shifts. How do tides affect their livelihood?
31. Explain the importance of monitoring tides to maneuver sailing ships. How are today's ships different from old sailing ships?
32. Explain why coastal engineers are required to monitor tides. How do tides affect their planning?
33. Describe why scientists would be interested in monitoring tides? What could an ecologist learn from tides? an oceanographer? an atmospheric scientist?

### How are Tides Measured? - The Old System

34. What United States governmental agency is responsible for monitoring tides in the United States? How long have they been monitoring tides?
35. Describe the function and process of a "stilling" well.
36. Before computers, how was water level data recorded? How was the data processed? (Click on the images in the tutorial for further explanation.)
37. How did processing water level data change in the 1960s?
38. What were the limitations of measuring water level using "stilling" wells, pen and ink strip charts and mechanical punch recorders?

### How are Tides Measured? - The New System

39. How has microprocessor based technologies improved water level monitoring today?
40. How do today's monitoring stations used acoustics and electronics to function?
41. What other oceanographic and meteorological parameters are measured by the new stations?
42. How are geostationary operational environmental satellites used in conjunction with monitoring stations? How often

- are the data recorded? How often are the data transmitted?
43. In the event of storms or foul weather, how can the stations be monitored?

## Part II: Analyzing Real-time Water Level Data from Monitoring Stations

Log onto: <http://tidesonline.noaa.gov/geographic.html>. "Click" on MA (Massachusetts) and select Woods Hole. If at any point there is no data available, please hypothesize on what might have caused this error? Is there unusual or severe weather at the monitoring station?

1. How many high and low tides did Woods Hole, MA experience in the last lunar day? What type of tidal pattern did Woods Hole experience?
2. What are the tidal heights in Woods Hole, MA?
3. How do the observed and predicted data compare? What may have caused any differences between the observed and predicted data for Woods Hole, MA?

Click the Back button twice on your browser or return to <http://tidesonline.noaa.gov/geographic.html>. "Click" on AL (Alabama) and select Dauphin Island, AL.

4. How many high and low tides did Mobile, AL experience in the last lunar day? What type of tidal pattern did Mobile experience?
5. What are the tidal heights in Mobile, AL?
6. How do the observed and predicted data compare? What may have caused any differences between the observed and predicted data for Mobile, AL?

Click the Back button twice on your browser or return to: <http://tidesonline.noaa.gov/geographic.html>. "Click" on WA (Washington) and select Seattle, WA.

7. How many high and low tides did Seattle, WA experience in the last lunar day? What type of tidal pattern did Seattle experience?
8. Are the tidal heights in Seattle, WA?

9. How do the observed and predicted data compare? What may have caused any differences between the observed and predicted data for Seattle, WA?

### Conclusion questions:

1. Summarize what causes tides. Discuss the effects of tidal forces and how bulges are formed.
2. Explain why humans are interested in monitoring tides. What impact do tides have on human life? What impact might tides have on other organisms?
3. Discuss how tides are monitored. Describe the old and new methods of monitoring tides.
4. Compare and contrast the tidal patterns of Cape Cod, MA, Mobile AL, and Seattle, WA. What is the tidal pattern in your area?

### Further Exploration:

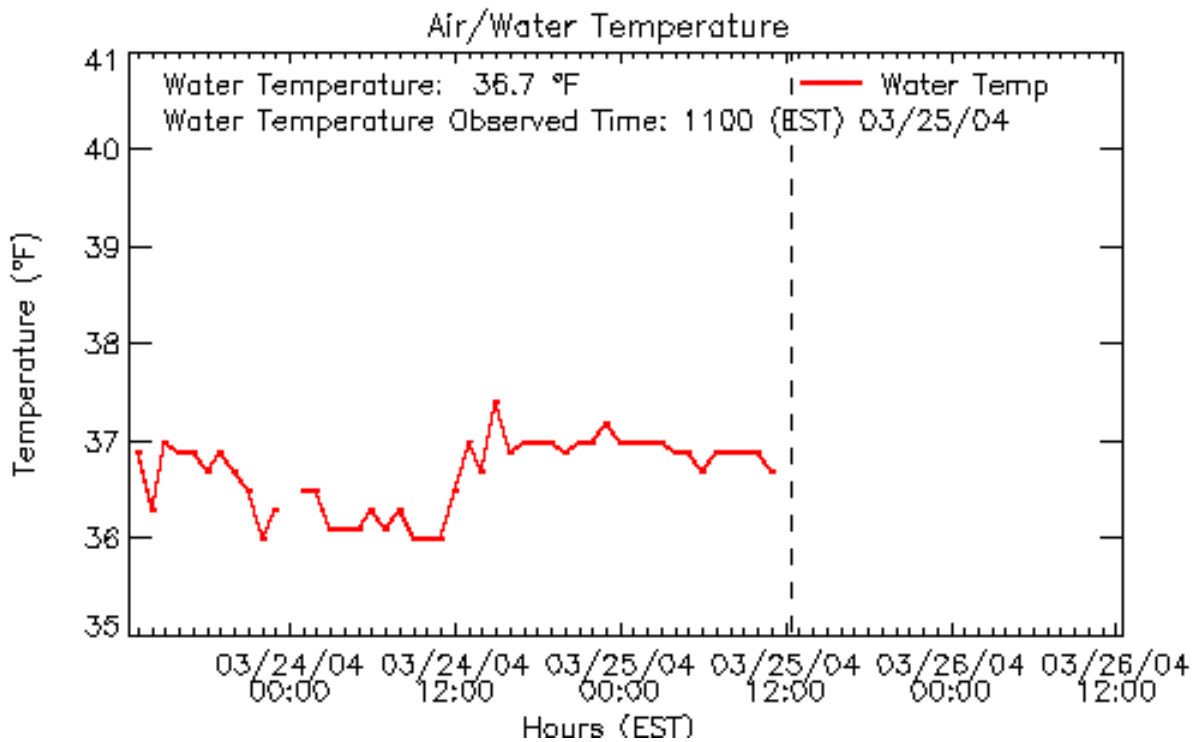
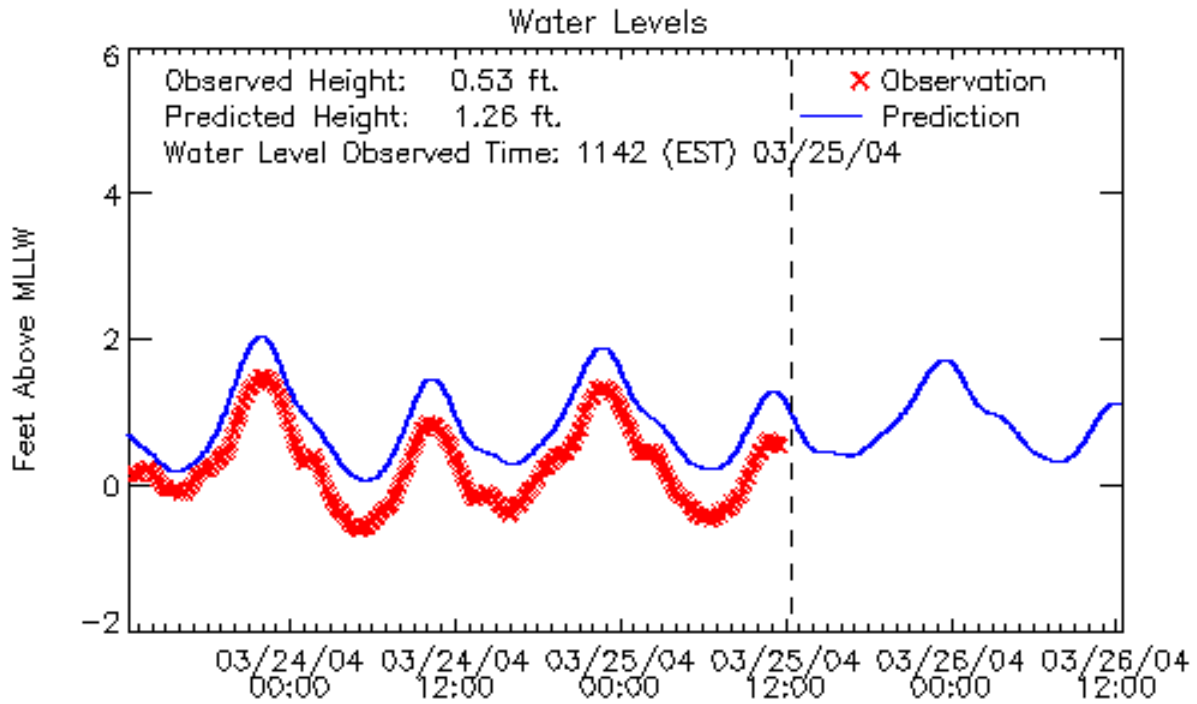
1. Using the NOS Web site at <http://tidesonline.nos.noaa.gov/geographic.html>, select a tidal gauge that is located near your area. Monitor the tidal gauge for one month and record tidal fluctuations. Note any deviation from the predicted and observed tidal levels. What do you think causes this deviation?



# TIDES LESSON PLAN

## Appendix A

### Water Level Data for Monitoring station # 8447930, Woods Hole, MA

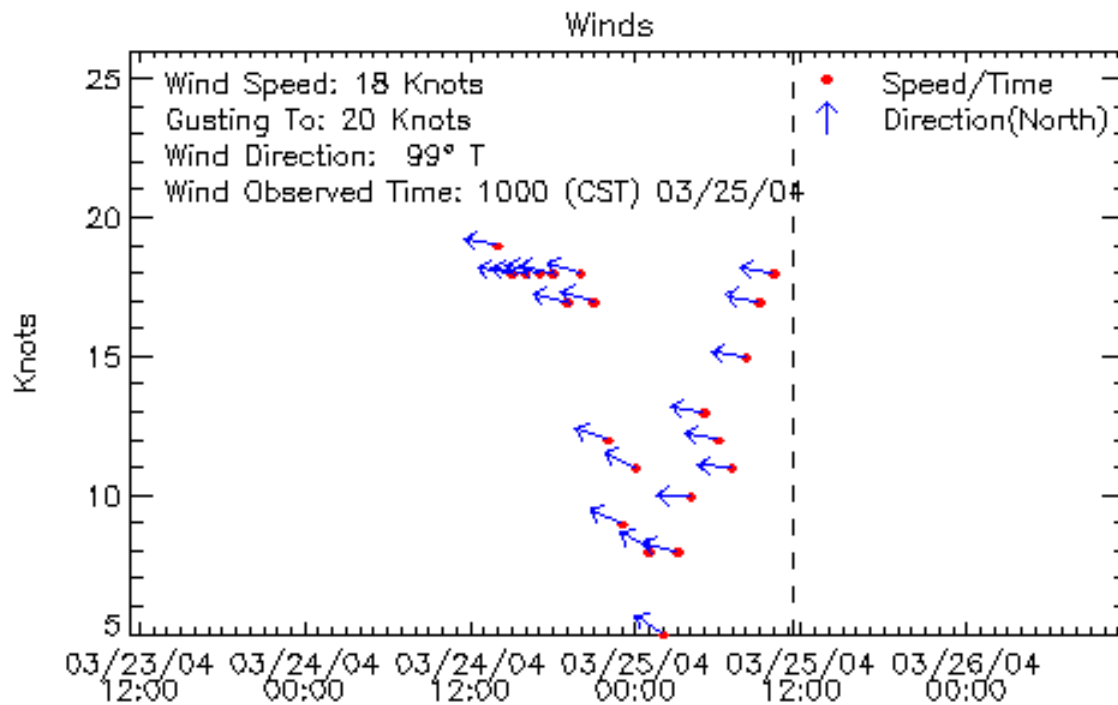
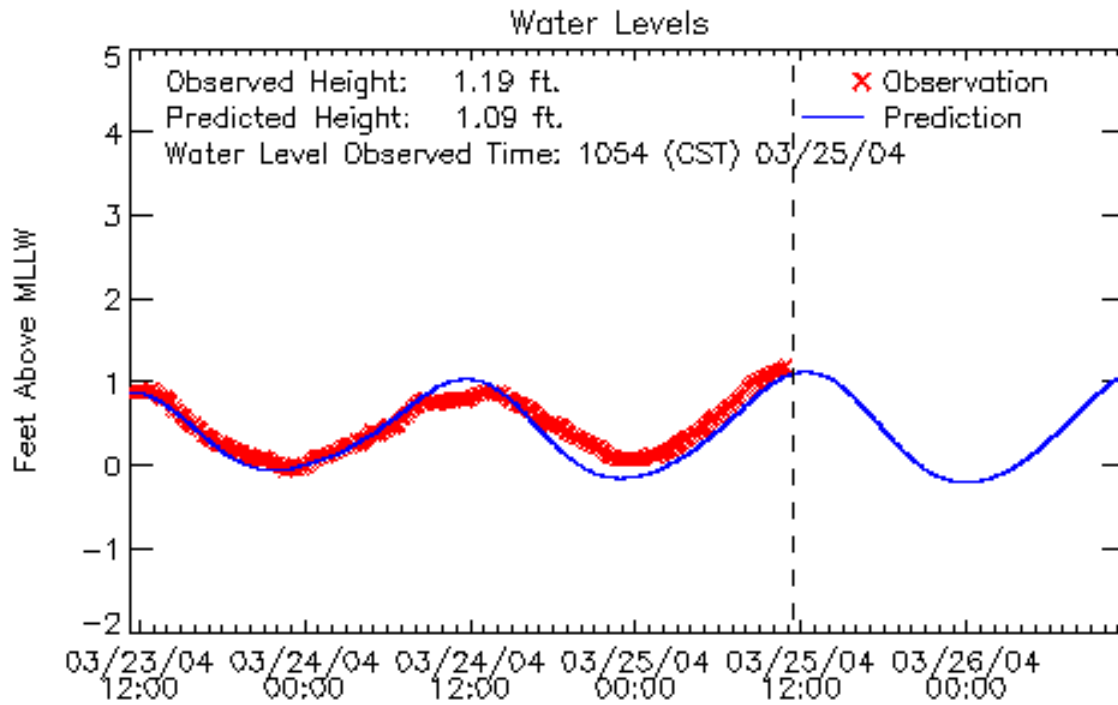




# TIDES LESSON PLAN

## Appendix B

Water Level Data for Monitoring station #8735180  
 Dauphin Island , AL

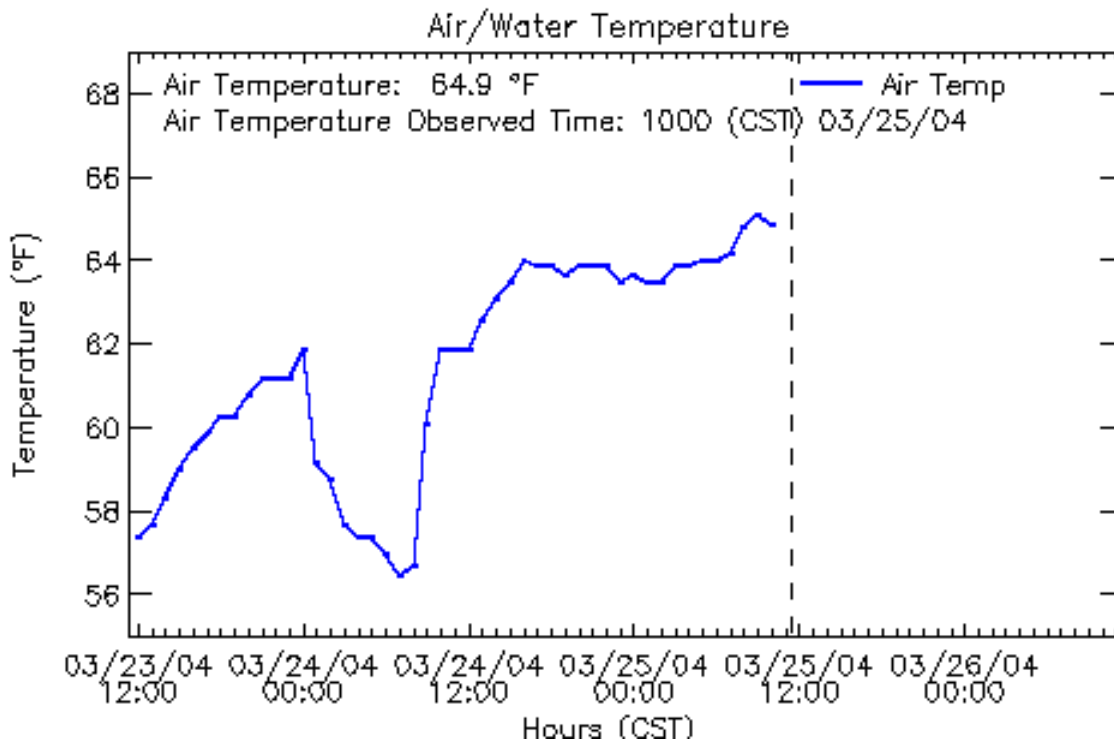
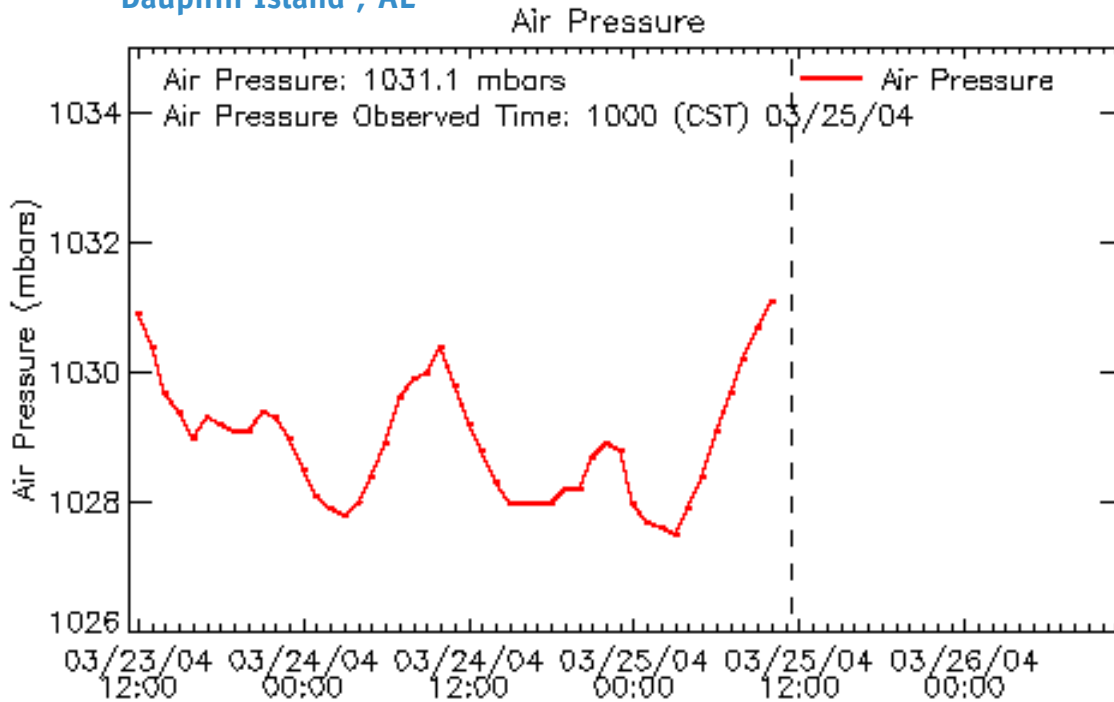




TIDES LESSON PLAN

Appendix B (page 2)

Water Level Data for Monitoring station #8735180  
Dauphin Island , AL

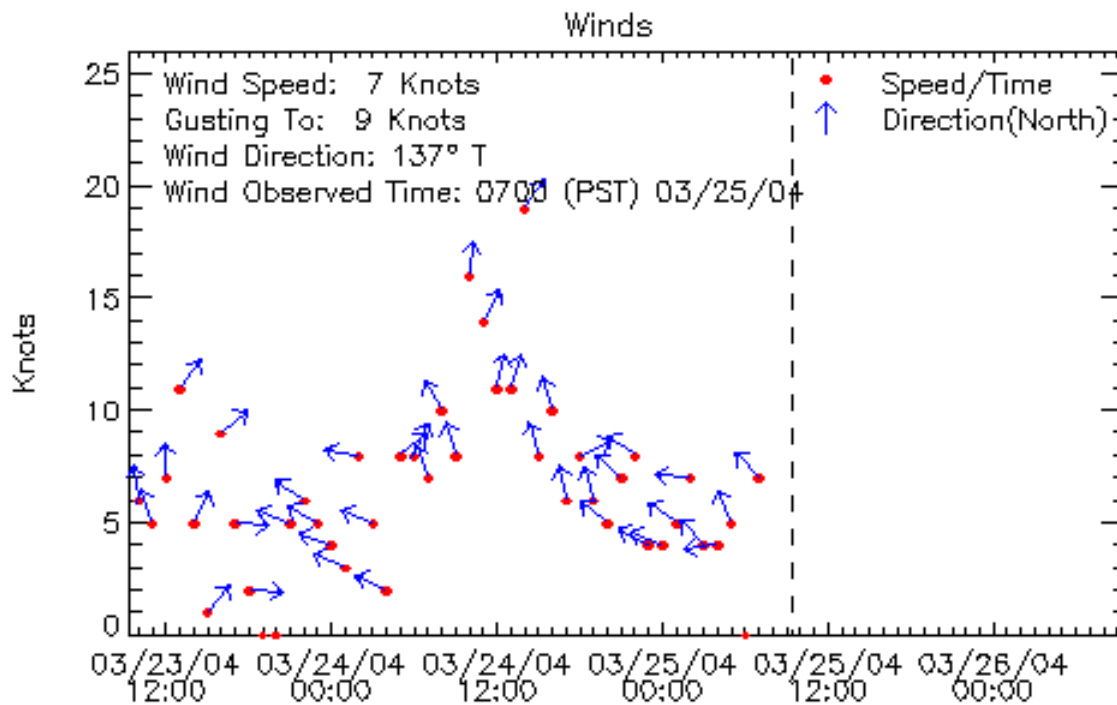
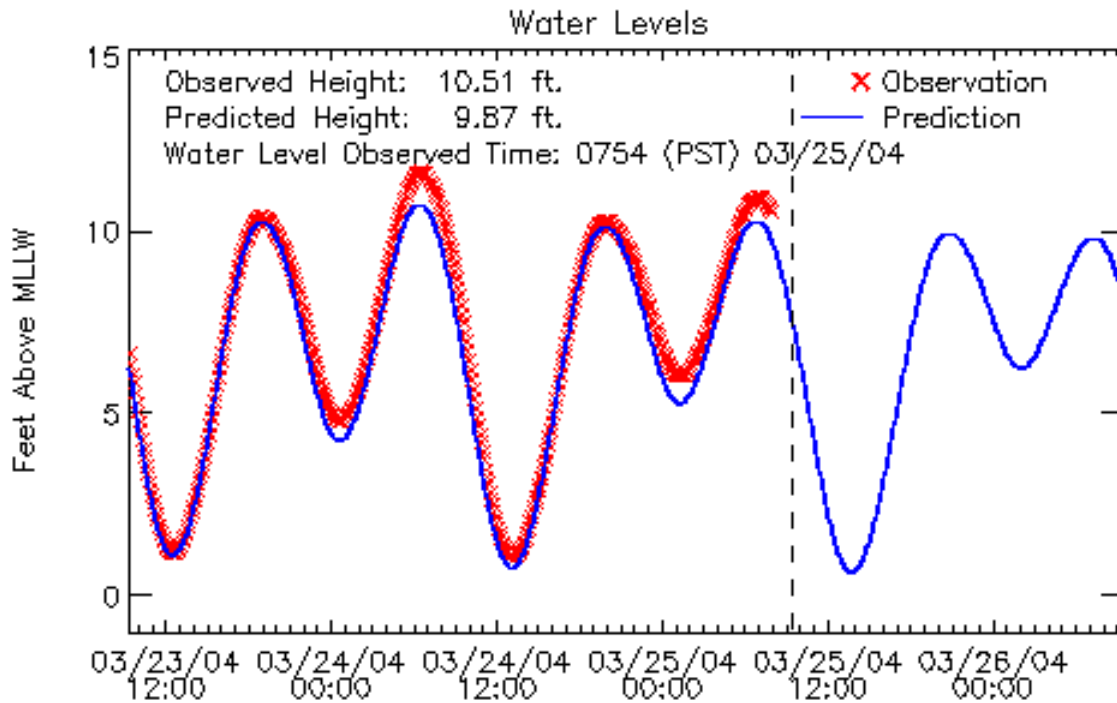




# TIDES LESSON PLAN

## Appendix C

### Water Level Data for Monitoring station # 9447130 Seattle, WA



### Air Pressure



TIDES LESSON PLAN  
**Appendix C** (page 2)

Water Level Data for Monitoring station # 9447130 Seattle, WA

