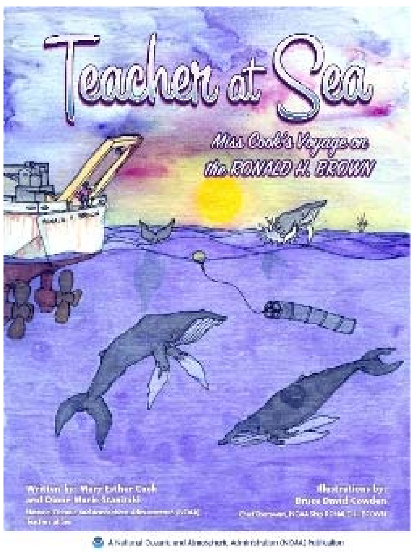
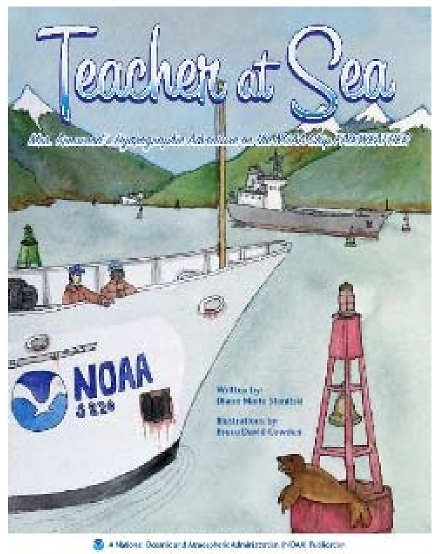
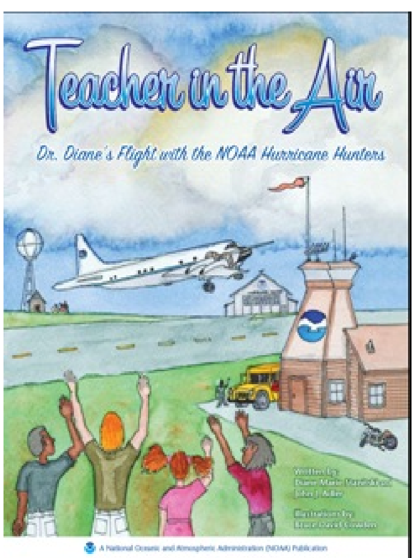
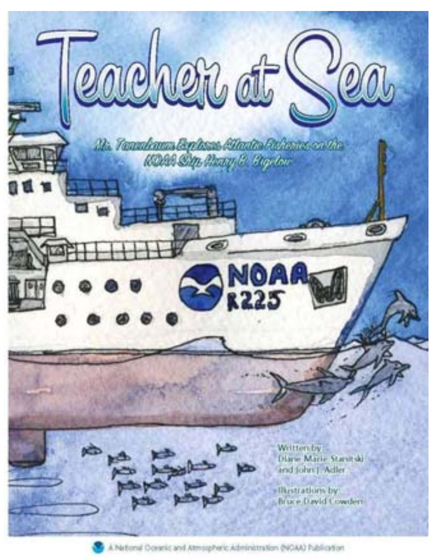
Discovering our Ocean and Atmosphere with the NOAA Teacher at Sea Book Series









Lessons Created By
Diane Stanitski, John Adler, and Jessica Schwarz

This page intentionally left blank

Table of Contents

DISCOVERING OUR OCEAN AND ATMOSPHERE WITH THE NOAA TEACHER AT SEA BOOK SERIES

Dear Teachers:

We are pleased to present this new unit of five lesson plans, *Discovering our Oceans and Atmosphere with the NOAA Teacher at Sea Book Series*, which correspond with the children's science book series published by the National Oceanic and Atmospheric Administration. The books and corresponding lessons can be found at the NOAA Teacher at Sea website, http://teacheratsea.noaa.gov/books/index.html.

The lessons are inquiry-based, and include hands-on activities and concepts that align with the National Science Education Standards, the Ocean Literacy Principles, the Climate Literacy Principles, and the Atmospheric Science Literacy Principles.

The unit theme involves preparing for, and responding to, natural hazards. The unit discusses ways to monitor impacts through ocean/atmosphere sampling, and speed recovery efforts by resurveying coastal waterways, especially in response to hurricanes. The following books (with accompanying lessons) make up the series:

Teacher at Sea: Miss Cook's Voyage on the Ronald H. Brown
Lesson 1: Monitoring Our Ocean and Atmosphere

Teacher in the Air: Dr. Diane's Flight with the NOAA Hurricane Hunters
Lesson 2: Planning and Preparing for a Natural Disaster
Lesson 3: Tracking Hurricanes

Teacher at Sea: Mrs. Armwood's Hydrographic Adventure on the NOAA Ship Fairweather
Lesson 4: Surveying our Coastal Waters

Teacher at Sea: Mr. Tanenbaum Explores Fisheries on the NOAA Ship Henry B. Bigelow
Lesson 5: Living in Coral

Before or after using these lessons, please feel free to forward any questions, comments, suggestions, or edits to: diane.stanitski@noaa.gov. Your feedback is appreciated as we hope to make the lessons as user-friendly and informative as possible. As modifications or updates to the lessons are made, each new version, and ancillary materials, will be made available at the Teacher at Sea website listed above.

DISCOVERING OUR OCEAN AND ATMOSPHERE WITH THE NOAA TEACHER AT SEA

We hope that you enjoy teaching with these lessons, and if you find them useful, please email our sponsor at **teacheratsea.noaa.gov** to ensure support continues for this educational effort.

Sincerely,

Diane M. Stanitski, co-author of TAS books and lessons

John J. Adler, co-author of TAS books and lessons

Jessica K. Schwarz, co-author of TAS lessons

LESSON 1
MONITORING OUR OCEAN AND ATMOSPHERE

Subject (Focus/Topic): Earth Science: Ocean and Atmosphere/CTD and Radiosonde Data

Grade Level: 5th - 9th Grade

Average Learning Time: $2^1/_2$ to 3 hours

Lesson Summary (Overview/Purpose): By participating in small group discussion, analyzing oceanic and atmospheric data, and summarizing/applying their findings, students will determine the characteristics of the oceans and atmosphere with depth and height, respectively.

Overall Concept (Big Idea/Essential Question): What technology is used to monitor the essential physical properties in our oceans and atmosphere, and why is this important to do?

Specific Concepts (Key Concepts):
- Earth's ocean consists of salt water
- Some bodies of water have a greater salinity than others
- Colder, more saline water has a higher density than warmer, fresher water
- Scientists use ocean profiles of temperature, density, and salinity to understand marine habitats, ocean phenomena like El Nino, and the intensification and movement of severe storms, among other applications
- Scientists rely on atmospheric profiles of pressure, temperature, moisture, and wind for weather prediction models and marine and storm forecasts, among other applications

Focus Questions (Specific Questions):
- What do the terms *salinity* and *density* mean, and how do they relate to each other?
- How do scientists measure the salinity and temperature of bodies of water?
- Which is heavier and has a greater density: salt water or fresh water?
- How do scientists monitor the atmosphere above the ground surface?
- How do scientists use atmospheric profiles to determine the location of the tropopause?

Objectives/Learning Goals:
- Students will be able to explain the relationship between temperature, pressure, and density with depth in the ocean and height in the atmosphere.
- Given CTD data, students will be able to calculate density and construct density profiles of a water column, and explain how density differences may affect organisms and movements within the ocean.
- Students will be able to determine the general characteristics of air in the troposphere and the height of the tropopause by graphing and analyzing radiosonde profile data.
- Students will be able to describe the applications of CTD and radiosonde data.

Background Information:

LESSON 1 (CONT)
MONITORING OUR OCEAN AND ATMOSPHERE

Information about CTD Instruments and Casts:
A CTD determines the essential physical properties of ocean water. It gives scientists a precise and comprehensive charting of the distribution and variation of water temperature, salinity, and density that helps to understand how the oceans affect life (Source: Media Relations, Woods Hole Oceanographic Institution). CTD casts have become integral instruments used by scientists to measure conductivity, temperature and depth while conducting research at sea. By measuring conductivity (how easily electrical currents pass through the water sample being tested), scientists can get a measurement of a water sample's salinity (salt content). Basically, the saltier the water, the more conductivity is generated. A *thermistor* (a platinum thermometer) is used to measure temperature and a pressure sensor is used to determine the depth of the water (depth and pressure are directly related). It is a large contraption that is hooked onto a cable and sent down (a vertical cast) into the water. The cast first rests for about 1-2 minutes at the surface of the water to record the salinity. It is then sent down, stops about 5 – 10 meters before reaching the bottom of the ocean floor and is then hauled back to the surface. Recording these data is essential for scientists, especially while conducting surveys of sea scallops or other marine species, because the CTD casts help to associate the water temperature and salinity to sea scallop abundance or the abundance of other types of species that are being studied. The conductivity, temperature and pressure measurements are recorded in digital form. The information collected can either be stored by the actual CTD instrument or transferred to a computer.

For the study in this lesson, data were collected in 2003 from a research vessel where a team of scientists, educators, artists, and oceanographers participated in a cruise on the R/V *Atlantis* to explore seamounts (underwater volcanic mountains). The submersible Alvin was used to visit areas whose depths ranged from 1,100 m to 2,200 m.

Calculations:
The density of seawater depends on temperature, salinity, and pressure. The mathematical relationship between these factors is known as the "equation of state" of seawater. There are several online calculators that compute density of seawater from input values of temperature, salinity, and pressure. The density of seawater is always greater than 1.000 g/cm^3 and less than 2.000 g/cm^3, so oceanographers often express density as sigma, which is

[(Sea water density - 1) x 1000]

By using this equation, oceanographers do not have to write 1 or the decimal places every time they want to record a density measurement. Oceanographers also use a quantity known as sigma-t, which is sigma calculated as described above, for a water sample whose density is adjusted to the density at the ocean's surface (without changing its temperature or salinity) where the absolute pressure is 1.
In this lesson, students will convert CTD data to density measurements, and determine why it is important to collect these data.

LESSON 1 (CONT)
MONITORING OUR OCEAN AND ATMOSPHERE

Facts about CTD Instruments:

- CTD stands for Conductivity-Temperature-Depth recorder.
- Pressure is recorded in decibars and is directly related to depth.
- Scientists can determine the salinity of the water by measuring conductivity.
- Salinity is measured in psu (practical salinity units).

Information about Radiosondes:
A radiosonde is an electronic instrument package that is attached to a hydrogen- or helium-filled weather balloon. Radiosonde instruments are used to measure temperature, air pressure, and relative humidity as they rise to heights of about 19 miles (30.6 kilometers). Radiosondes are attached to radio transmitters, which send upper air readings back to weather stations and forecast offices on the ground. (Source: http://www.enotes.com/science-fact-finder/weather-climate/what-radiosonde).

Using radiosonde data from a weather balloon launch (a sounding), students can determine how rapidly atmospheric temperature, density, humidity, and pressure change with height and should be able to determine the height of the tropopause.

Common Misconceptions/Preconceptions:

- Students often confuse density and thickness, assuming that thick liquid is denser than thinner, less viscous liquids.
- Oceans have the same salinity everywhere.
- Pressure at the ocean's surface does not need to be taken into account when calculating density of ocean water with depth.
- Air temperature changes consistently with height throughout the atmosphere.
- Cold air always relates to high pressure and warm air always relates to low pressure.

Materials:

- Copies of the sheet "CTD Data Collected on Alvin Dive No. 3904"
- Copies of Radiosonde Data collected from the NOAA Ship *Ronald H. Brown*
- Radiosonde data file (RadiosondeData_15Nov08.xls), PowerPoint slides (Radiosonde_History.ppt), and movie (RadiosondeBalloonRelease_Movie.avi) at http://teacheratsea.noaa.gov/books/index.html
- Graph paper

Technical Requirements:

- Computers to access the book *Teacher at Sea: Miss Cook's Voyage on the RONALD H. BROWN*.
- Data analysis using Excel after importing radiosonde data from the NOAA Teacher at Sea website (http://teacheratsea.noaa.gov/books/index.html).

Teacher Preparation:

- Become familiar with the book: *Teacher at Sea: Miss Cook's Voyage on the RONALD H. BROWN*. Prepare guiding questions.

LESSON 1 (CONT)
MONITORING OUR OCEAN AND ATMOSPHERE

- Download spreadsheets of ocean CTD and atmosphere radiosonde data from the Teacher at Sea website: http://teacheratsea.noaa.gov/books/index.html.
- Prepare an explanation of the technology and applications of CTDs and radiosondes.

Keywords:
- CTD – an instrument used to measure conductivity, temperature, and depth within the ocean water (p. 22 of *Teacher at Sea: Miss Cook's Voyage on the RONALD H. BROWN*)
- Radiosonde – an instrument package attached to a weather balloon that measures changes in temperature and other essential variables through the lower atmosphere (p. 6 of *Teacher at Sea: Miss Cook's Voyage on the RONALD H. BROWN*)
- Salinity, Density, Pressure, Dew point
- Atmospheric layers (troposphere, stratosphere, mesosphere, thermosphere)
- Tropopause

Pre-assessment Strategy/Anticipatory Set:
- Ask students how oceanographers learn about changing temperature, pressure, and salinity within our oceans, and why it is important to understand these variables (i.e., link to health and abundance of marine species).
- Ask students what tools are used by meteorologists to help them understand characteristics of the troposphere (the lowest layer of the atmosphere where we live) and why it is important to collect temperature, pressure, wind, and humidity data above the ground surface (i.e., thunderstorm prediction).
- Review the technology available to collect oceanic and atmospheric weather and climate data. Describe how CTDs and radiosondes work.
- Show a CTD launch and describe data collection efforts at the Woods Hole Oceanographic Institution site http://www.whoi.edu/instruments/viewInstrument.do?id=1003
- Show the brief movie (RadioBalloonRelease_Movie.avi) of a balloon release in windy conditions. Describe the history of radiosondes by showing the PPT slides in file Radiosonde_History.ppt. Also, review the website http://www.erh.noaa.gov/gyx/weather_balloons.htm where students can read a fact sheet about National Weather Service radiosonde observations, learn about applications of the data, and watch a 4.5 minute video about radiosondes and the release of a weather balloon.
- Ask students if they know how key variables (i.e., pressure and temperature) change with height in the atmosphere and depth in the ocean. Review the atmospheric layers with students.

Lesson Procedure:
CTD exercise:
1. Review the meaning of density, and be sure students understand how the density of seawater varies with an increase or decrease of temperature, salinity, and pressure.
2. Provide students or student groups with copies of "CTD Data Collected on Alvin Dive No. 3904." Tell students that their assignment is to:

LESSON 1 (CONT)
MONITORING OUR OCEAN AND ATMOSPHERE

a. Graph salinity as a function of depth (salinity on the y-axis)
b. Graph temperature as a function of depth (temperature on the y-axis)
c. Find the density at each depth using seawater density calculators found at http://www.es.flinders.edu.au/~mattom/Utilities/density.html or http://freespace.virgin.net/mark.davidson3/OSC272/density.html

These calculators require users to input values of pressure, temperature, and salinity. Tell students that pressure in the ocean (in bars) is nearly equal to the depth in meters divided by 10 (therefore, for every 1 m increase in depth, pressure increases 0.1 bar). Remind students that pressure at the ocean surface (depth = 0 m) is equal to 1 bar, so pressure underwater is equal to

[(depth in meters) ÷ 10] + 1.0

d. To determine if students understand the pressure/depth relationship, have them complete the sample exercise on p. 22 of the book *Teacher at Sea: Miss Cook's Voyage on the RONALD H. BROWN*
e. Calculate sigma for each depth by subtracting 1.0 using the formula

[(Sea water density in g/cm3) - 1] x 1000

f. Graph sigma as a function of depth (sigma on the y-axis)

3. Discuss students' results. The following points should emerge during this discussion:
   a. Where did density change most rapidly? *<near the surface>*
   b. In general, what happens to density as depth increases? *<density increases>*
   c. How do changes in density with increasing depth differ from changes in temperature and salinity with increasing depth? *<temperature and salinity tend to level out, while density continues to increase because pressure continues to increase with increasing depth>*

   Note: While you are talking about fresher water versus more saline water, talk about the different types of marine life (vegetation and species) that live within these two types of water. Talk about their differences and similarities. Some marine species can dwell in both and some can only inhabit fresh water versus salt water.

Radiosonde exercise:

1. Review the atmospheric layers and be sure students understand how temperature, density, pressure, and humidity of air changes with height through each layer.
2. Provide students or student groups with copies of the radiosonde data. Tell students that their assignment is to:
   a. Graph temperature as a function of height (temperature on the y-axis)
   b. Graph pressure as a function of height (pressure on the y-axis)
   c. Graph dew point as a function of height (dew point on the y-axis)
   d. Graph wind speed as a function of height (wind speed on the y-axis)

(Bonus: have students plot latitude, longitude coordinates on a map to determine how the weather balloon moves downwind as it ascends)

3. Discuss students' results. The following points should emerge during this discussion:
   a. Where did temperatures seem to change its trend (a switch to increasing or decreasing temperature with height)? *<inversion near surface and when moving into the stratosphere>*
   b. How do pressure, dew point, and wind speed change with height? *<decreases, decreases, increases>*
   c. On average, what is the diameter of a weather balloon when it bursts? *<~24 ft when it bursts>* What can you compare this to, with regard to size, in your classroom? *<various answers>*
   d. What happens to a weather balloon when it bursts? *<a parachute opens and it drifts to the ground; only ~20% are recovered>*

Assessment and Evaluation:

Have students write an essay describing how pressure and density of fluids (liquid and gas) on Earth affect their lives and the lives of plants and/or animals. Students may need a few examples to trigger their thoughts in terms of atmospheric fluids (air) and issues concerning the density of these fluids (rise and fall of barometric pressure affecting weather patterns, storms, etc.).

Standards:

National Science Education Standards Addressed (Grades 5-8):

- NSES A: Science as Inquiry
  - Sub-categories Abilities necessary to do scientific inquiry, Understandings about scientific inquiry
- NSES B: Physical Science
  - Sub-categories Properties and changes of properties in matter, Motions and forces, Transfer of energy
- NSES C: Life Science
  - Sub-category Populations and ecosystems
- NSES E: Science and Technology
  - Sub-categories Abilities of technological design, Understandings about science and technology
- NSES F: Science in Personal and Social Perspectives
  - Sub-category Science and technology in society
- NSES G: History and Nature of Science
  - Sub-categories Science as a human endeavor, Nature of science, History of science

Ocean Literacy Principles Addressed:

- Principle 1: The Earth has one big ocean with many features.
  - Fundamental Concepts: B.3., B.4., B.5., C.4., C.5.
- Principle 3: The ocean is a major influence on weather and climate.

LESSON 1 (CONT)
MONITORING OUR OCEAN AND ATMOSPHERE

- Fundamental Concepts: A.8., A.10., B.2., B.5., B.7., B.9.
- Principle 5: The ocean supports a great diversity of life and ecosystems.
  - Fundamental Concepts: A.2., A.4.
- Principle 7: The ocean is largely unexplored.
  - Fundamental Concepts: A.1., A.2., A.3., A.6., B.2., B.3., B.4., B.5., B.6., B.7., B.8., B.9., B.10., C.1., C.2., C.6., D.1.

Atmospheric Science Literacy Principles Addressed:
- Essential Principle 3: Atmospheric circulations transport matter and energy
  - Fundamental Concept: 3.4
- Essential Principle 6: We seek to understand the past, present, and future behavior of Earth's atmosphere through scientific observation and reasoning
  - Fundamental Concept: 6.1, 6.2, 6.3, 6.4, 6.5
- Essential Principle 7: Earth's atmosphere and humans are inextricably linked
  - Fundamental Concepts: 7.4

Climate Literacy Principles Addressed:
- Essential Principle 2: We increase our understanding of the climate system through observation and modeling
  - Fundamental Concepts: A, B, C, D, E
- Essential Principle 3: The sun is the primary source of energy for the climate system
  - Fundamental Concepts: A
- Essential Principle 4: Earth's weather and climate systems are the result of complex interactions
  - Fundamental Concepts: B
- Essential Principle 5: Earth's weather and climate vary over time and space
  - Fundamental Concepts: A

State Science Standard(s) Addressed:
- Will differ depending on your state

Additional Resources:
Websites:
- http://www.es.flinders.edu.au/~mattom/Utilities/density.html — seawater density calculator
- http://freespace.virgin.net/mark.davidson3/OSC272/density.html — another on-line calculator that computes density and many other things

Book:
- *Teacher at Sea: Miss Cook's Voyage on the RONALD H. BROWN* by Mary E. Cook and Diane M. Stanitski (http://teacheratsea.noaa.gov/books/index.html)

Author: Diane M. Stanitski
Assistance provided by John Adler and Jessica Schwarz

LESSON 1 (CONT)
MONITORING OUR OCEAN AND ATMOSPHERE

The CTD component of this lesson plan is adapted from a lesson by Kimberly Papa and the NOAA Ocean Explorer activity identified below. An original CTD lesson plan was produced by Mel Goodwin, PhD, The Harmony Project, Charleston, SC for the National Oceanic and Atmospheric Administration. For the original lesson, see: http://oceanexplorer.noaa.gov

The original radiosonde data, History of Radiosondes PowerPoint slides, and brief radiosonde launch video were provided by Daniel Wolfe, NOAA Earth System Research Laboratory, Boulder

Creation Date: March 3, 2009

CTD DATA

STUDENT WORKSHEET				
CTD Data Collected on Alvin Dive No. 3904				
Depth	**Temp**	**Salinity**	**Density**	**Sigma**
(m)	**(°C)**	**(ppt)**	**(g/cm^3)**	**(g/cm^3)**
0	26.88	35.28		
25	21.17	34.80		
50	17.07	36.06		
100	16.43	35.79		
200	13.27	35.59		
300	11.59	35.43		
400	9.26	35.15		
500	7.80	35.05		
600	6.40	35.01		
700	5.38	34.97		
800	5.05	34.98		
900	4.69	34.98		
1000	4.53	34.97		
1100	4.40	34.98		
1200	4.25	34.97		
1300	4.08	34.97		
1400	3.95	34.95		
1500	3.76	34.94		
1600	3.65	34.93		
1700	3.59	34.94		
1800	3.58	34.94		
1900	3.58	34.95		
2000	3.46	34.94		
2100	3.35	34.94		
2200	3.40	34.94		

RADIOSONDE DATA

Radiosonde Serial Number: C4854707
Station Name: WTEC
Launch Time: 0815 Zulu
Launch Date: 15 November 2008

Positive Lat Values = North of the Equator
Positive Long Values = East of the Prime Meridian
Negative Lat Values = South of the Equtor
Negative Long Values = West of the Prime Meridian

Data courtesy: Daniel Wolfe, NOAA

Time	Height	Pressure	Temp	Dew Pnt Temp	Rel Humid	Wind Speed	Wind Dir	Latitude	Longitude
sec	mtrs	hPa	deg C	deg C	Percent	m/s	Azimuth	Decimal ø	Decimal ø
3.31	13.9	1013.1	18.12	12.2	68	3.2	163.9	-19.86	-75.77
58.31	200.9	991.2	15.95	10.8	71	4	155	-19.86	-75.77
122.31	394.9	968.7	14.13	10.2	77	4.5	155.8	-19.86	-75.77
182.31	641.4	940.8	11.83	9.6	86	4.9	128	-19.86	-75.77
243.31	936.2	908.2	8.98	8.8	98	4.2	121.7	-19.86	-75.77
303.32	1203.3	879.3	7.15	7.2	100	4.3	120	-19.86	-75.78
363.32	1362.3	862.7	16.75	-21.5	6	0.5	63.7	-19.86	-75.78
423.32	1505.3	848.4	17.35	-25	4	1.1	65.7	-19.86	-75.78
483.32	1652.3	833.8	17.25	-26.8	3	0.7	152.3	-19.86	-75.78
544.32	1800.8	819.3	16.55	-28.2	3	1	195.3	-19.85	-75.78
604.32	1944.8	805.5	15.67	-28.1	3	1.5	282.8	-19.85	-75.78
664.32	2084.8	792.3	15.55	-26.2	4	1.2	221	-19.85	-75.78
724.32	2228.6	778.9	15.35	-29.5	3	0.7	232.4	-19.85	-75.78
784.32	2368.8	766	14.65	-30.4	3	1.1	208.2	-19.85	-75.78
844.32	2518.8	752.5	13.55	-27.1	4	1.7	262	-19.85	-75.78
904.32	2670.8	739	12.55	-25.9	5	1.7	308.2	-19.85	-75.78
965.33	2824.3	725.6	11.55	-26.9	5	1.8	285.7	-19.85	-75.77
1026.33	2973.7	712.7	10.53	-25.1	6	3.8	274	-19.85	-75.77
1087.33	3124.3	699.8	9.25	-22.5	9	5	263.3	-19.85	-75.77
1150.33	3285.8	686.2	8.35	-22.3	9	6.4	278.2	-19.85	-75.77
1214.33	3458.8	672	7.55	-24.1	8	7.1	296	-19.86	-75.76
1275.33	3619.3	659	6.35	-26	8	7.1	305	-19.86	-75.76
1337.33	3774.3	646.6	5.08	-26.7	8	7.1	317	-19.86	-75.76
1399.33	3922.3	634.9	4.68	-32.4	5	6.5	293.3	-19.86	-75.75
1459.33	4066.3	623.8	4.08	-33.9	4	8.3	275	-19.86	-75.75
1520.33	4213.8	612.6	2.95	-31.4	6	9.5	275	-19.86	-75.74
1581.33	4362.3	601.4	1.75	-29.9	7	10.6	273.3	-19.86	-75.74
1641.34	4512.3	590.2	0.85	-28.6	9	12.2	270	-19.86	-75.73
1703.34	4667.3	578.9	-0.55	-28.8	10	12.3	272	-19.86	-75.72
1763.34	4816.7	568.2	-1.45	-31.8	8	10	280.7	-19.86	-75.72
1825.34	4963.7	557.8	-2.75	-26.6	14	11.2	284	-19.87	-75.71
1885.34	5099.7	548.2	-4.12	-27	15	11.1	286	-19.87	-75.71
1946.34	5245.8	538.1	-5.47	-27.2	16	10.7	285.8	-19.87	-75.7
2006.34	5391.8	528.1	-5.85	-41.1	4	9.2	277	-19.87	-75.69
2069.34	5547	517.8	-6.45	-41.4	4	7.6	272	-19.87	-75.69

RADIOSONDE DATA

Time	Height	Pres-sure	Temp	Dew Pnt Temp	Rel Humid	Wind Speed	Wind Dir	Latitude	Longitude
sec	mtrs	hPa	deg C	deg C	Percent	m/s	Azimuth	Decimal ø	Decimal ø
2129.34	5699.3	507.8	-7.02	-43.7	4	8.6	266	-19.87	-75.69
2189.34	5854	497.8	-8.15	-44.1	4	9.5	260	-19.87	-75.68
2249.34	6007.3	488	-9.15	-43.7	4	9.3	269	-19.87	-75.67
2310.35	6164.7	478.1	-9.77	-44.4	4	8.4	268	-19.87	-75.67
2372.35	6322.9	468.4	-11.17	-45.3	4	8.2	268	-19.87	-75.66
2432.35	6478.9	458.9	-12.15	-46.1	4	7.5	286	-19.87	-75.66
2494.35	6648	448.9	-13.55	-45.7	5	10.3	292	-19.87	-75.66
2554.35	6816.9	439	-14.15	-48.7	4	8.9	286.8	-19.87	-75.65
2614.35	6974.9	429.9	-14.85	-51.2	3	7.9	292	-19.87	-75.65
2675.35	7129.4	421.2	-15.85	-50.8	3	8.7	295	-19.88	-75.64
2736.35	7281.9	412.8	-16.45	-51.6	3	9.7	290	-19.88	-75.64
2797.35	7434.7	404.5	-17.25	-51.7	3	11.5	281	-19.88	-75.63
2857.35	7582.4	396.6	-18.12	-53	3	12	275	-19.88	-75.62
2918.36	7735.9	388.4	-19.45	-51.1	4	13.1	270	-19.88	-75.62
2978.36	7886.9	380.6	-20.75	-51.8	4	14.8	275	-19.88	-75.61
3039.36	8045.1	372.6	-21.72	-51.9	5	16.6	285	-19.88	-75.6
3099.36	8212.1	364.2	-22.35	-53.7	4	17	288	-19.89	-75.59
3159.36	8386.1	355.6	-23.95	-53.9	5	17.5	282	-19.89	-75.58
3220.36	8555.1	347.4	-25.17	-54.6	5	19.7	278	-19.89	-75.57
3280.36	8720.1	339.6	-26.35	-55.9	4	20.1	281	-19.89	-75.56
3340.36	8884.9	332	-27.65	-57.4	4	20.9	285	-19.89	-75.55
3400.36	9044.9	324.6	-28.25	-60.3	3	24	283	-19.9	-75.53
3461.36	9220.1	316.8	-29.05	-59.6	4	26.6	287	-19.9	-75.52
3521.36	9402.1	308.8	-30.22	-60.9	3	26.9	294	-19.91	-75.51
3581.37	9567.1	301.7	-31.42	-60.5	4	27	300	-19.91	-75.49
3642.37	9728.9	294.9	-32.85	-61	4	27	302	-19.92	-75.48
3702.37	9889.9	288.2	-34.35	-61.3	5	27.1	302	-19.93	-75.47
3762.37	10055.9	281.4	-35.87	-61.9	5	27.5	302	-19.94	-75.45
3823.37	10220.1	274.8	-37.25	-62.1	6	28.4	299	-19.94	-75.44
3883.37	10385.1	268.3	-38.25	-63	6	29.5	303	-19.95	-75.42
3943.37	10551.4	261.9	-39.25	-63.4	6	31.8	301	-19.96	-75.41
4003.37	10718.4	255.6	-40.45	-65	6	31.7	302	-19.97	-75.39
4066.37	10898.1	248.9	-42.07	-65.9	6	32.3	300.8	-19.98	-75.38
4126.37	11070.1	242.6	-42.65	-68.9	4	32.5	305	-19.99	-75.36
4186.38	11245.1	236.4	-43.95	-68	5	33.6	306	-20	-75.35
4246.38	11419.1	230.4	-45.35	-68.5	6	35.2	307	-20.01	-75.33
4307.38	11596.1	224.3	-46.82	-64.3	12	36.7	309	-20.02	-75.31
4368.38	11765.1	218.6	-48.25	-57	36	37.6	311	-20.04	-75.3
4429.38	11941.1	212.8	-49.95	-55.6	52	38	311	-20.05	-75.28
4489.38	12117.8	207.1	-51.38	-56.1	58	37.9	311	-20.06	-75.27
4549.38	12307.1	201.2	-52.65	-60.4	39	39.1	305.3	-20.08	-75.25
4610.38	12490.1	195.5	-53.75	-66.1	21	36.4	301	-20.09	-75.23
4672.38	12697.1	189.3	-54.75	-73.4	9	31.1	297.8	-20.1	-75.21
4733.38	12892.4	183.6	-55.62	-76	6	27.6	289.3	-20.1	-75.2

RADIOSONDE DATA

Time	Height	Pres-sure	Temp	Dew Pnt Temp	Rel Humid	Wind Speed	Wind Dir	Latitude	Longitude
sec	mtrs	hPa	deg C	deg C	Percent	m/s	Azimuth	Decimal ø	Decimal ø
4793.39	13071.2	178.5	-56.75	-77.4	6	26	289	-20.11	-75.18
4853.39	13249.2	173.5	-58.12	-78.5	6	25.9	286	-20.11	-75.17
4914.39	13432.2	168.6	-59.55	-79.2	7	25.3	283	-20.12	-75.15
4975.39	13621.2	163.5	-59.98	-79.7	6	21.3	286	-20.12	-75.14
5035.39	13809.2	158.6	-60.65	-80.2	6	19.3	298	-20.12	-75.13
5095.39	13989.2	154.1	-61.05	-81.3	6	18.2	311	-20.13	-75.12
5155.39	14171.2	149.7	-62.25	-82.9	5	19.3	321	-20.14	-75.11
5215.39	14360.2	145.1	-64.02	-84	5	21.4	325.7	-20.14	-75.11
5278.39	14553.4	140.6	-65.55	-84.9	6	21.4	327	-20.16	-75.1
5338.39	14737.2	136.4	-66.57	-84.9	7	19.1	326.2	-20.16	-75.09
5398.39	14919.4	132.4	-67.47	-85.1	7	15.5	327	-20.17	-75.09
5459.4	15105.9	128.3	-68.72	-85.4	8	16.1	319	-20.18	-75.08
5519.4	15293.2	124.3	-68.95	-85.3	9	14	309.3	-20.18	-75.08
5581.4	15487.2	120.3	-69.65	-85.7	9	10.6	292	-20.19	-75.07
5641.4	15675.2	116.6	-71.02	-86.7	9	10	283	-20.19	-75.06
5701.4	15865.2	112.9	-72.52	-87.5	10	9.6	275	-20.19	-75.06
5762.4	16054.2	109.4	-73.25	-87.6	11	8	268	-20.19	-75.05
5822.4	16234.2	106	-74.75	-88.4	12	6.2	275	-20.19	-75.05
5884.4	16411.2	102.8	-75.47	-88.5	13	4.2	335.4	-20.19	-75.05
5944.4	16590.2	99.7	-75.85	-88.4	13	6.9	351	-20.19	-75.05
6007.4	16783.2	96.4	-76.55	-88.7	14	5.9	10.7	-20.2	-75.05
6067.41	16971.9	93.3	-77.25	-89	15	4.1	33.4	-20.2	-75.05
6128.41	17164.2	90.2	-78.55	-89.8	16	6.2	64	-20.2	-75.05
6191.41	17354.2	87.2	-79.35	-90	17	5.3	87	-20.2	-75.05
6259.41	17555.2	84.2	-79.55	-89.7	19	7	86.7	-20.2	-75.06
6348.41	17828.2	80.3	-79.15	-88.9	20	8.7	118.2	-20.2	-75.06
6414.41	18028.2	77.5	-79.25	-88.8	21	11	125	-20.2	-75.07
6485.41	18246.2	74.5	-79.75	-89	22	10.3	132	-20.2	-75.08
6547.41	18439.9	72	-80.05	-89.1	23	11.7	124.3	-20.19	-75.08
6608.41	18628.2	69.7	-78.25	-87.6	22	6.7	99	-20.19	-75.09
6669.42	18816.3	67.4	-78.35	-88.1	21	5.4	125.7	-20.19	-75.09
6729.42	19000.3	65.3	-77.28	-87.7	19	6.6	119.7	-20.19	-75.09
6790.42	19180.3	63.3	-74.63	-86.4	16	7.7	154	-20.18	-75.09
6851.42	19371.3	61.2	-71.48	-85.5	12	11.3	119	-20.18	-75.1
6912.42	19576.5	59.2	-69.35	-86.1	8	10.5	97	-20.18	-75.1
6996.42	19837.3	56.7	-68.05	-87.7	5	8.5	119.2	-20.18	-75.11
7063.42	20049	54.7	-67.82	-88.9	4	14.6	105.3	-20.17	-75.12
7125.42	20263	52.8	-67.22	-89.2	3	12.2	113.7	-20.17	-75.13
7188.42	20471.3	51	-65.15	-88.5	3	17.1	125.8	-20.17	-75.13
7251.42	20667.3	49.4	-62.55	-87.4	3	18.4	114.7	-20.16	-75.14
7312.43	20873.3	47.8	-62.23	-87.6	2	18.4	107	-20.16	-75.15
7387.43	21135	45.8	-63.05	-88.1	2	16.8	88		
7447.43	21343	44.2	-64.32	-88.9	2	15.1	75.3		
7519.43	21586	42.5	-64.05	-88.8	2	10.6	82.4	-20.16	-75.18

RADIOSONDE DATA

Time	Height	Pres-sure	Temp	Dew Pnt Temp	Rel Humid	Wind Speed	Wind Dir	Latitude	Longitude
sec	**mtrs**	**hPa**	**deg C**	**deg C**	**Percent**	**m/s**	**Azimuth**	**Decimal ø**	**Decimal ø**
7586.43	21811.5	41	-63.55	-88.4	2	9.4	90	-20.16	-75.19
7665.43	22073	39.3	-62.65	-87.8	2	12.1	123	-20.16	-75.2
7742.43	22320.1	37.7	-62.45	-87.8	2	16.5	105	-20.16	-75.2
7826.43	22593.5	36.1	-62.23	-87.8	2	20.9	92	-20.15	-75.22
7893.43	22813	34.8	-59.88	-86.3	2	14.6	87	-20.15	-75.23
7956.44	23012.3	33.8	-58.15	-85.2	2	20.9	75.8	-20.16	-75.24
8017.44	23203	32.7	-55.98	-83.8	2	19.9	65.3	-20.16	-75.25
8080.44	23403.5	31.8	-55.15	-83.2	2	20.4	57.8	-20.16	-75.26
8149.44	23624	30.7	-55.35	-83.1	2	13.2	47	-20.17	-75.27
8215.44	23834.3	29.7	-55.65	-83.3	2	10.5	65.7	-20.18	-75.28
8293.44	24077.3	28.6	-54.35	-82.6	2	7.9	60.4	-20.18	-75.28
8368.44	24305.3	27.6	-54.05	-82.3	2	5.5	94.2		
8441.44	24518.3	26.7	-54.35	-82.5	2	11.7	115		
8534.44	24798.3	25.5	-55.07	-83	2	8.5	97	-20.17	-75.3
8595.45	24976.6	24.8	-54.65	-82.8	2	15.1	112	-20.17	-75.31

The following are only a few of the radiosondes used around the world. The NWS at one time used only one manufacturer, but now there are several different brands. Comparing radiosondes is an ongoing effort to maintain quality.

- **1970s - NWS type sonde, data collected manually via strip chart, heavy, winds via radio-theodolite**
- **1980s - Research spinning sonde normally attached to tethered balloon, air temperature and wet bulb temperature sensors at end of wings**
- **1980s - Research sonde, winds only if tracked manually with theodolite**
- **Mid 1980s - mid 1990s - NWS type sonde, paper tape calibration information, winds via Loran C**
- **Mid 1980s - mid 1990s - NWS type sonde, paper tape calibration information, no winds**

Radio-theodolite

Theodolite

Tethered balloon

LESSON 2
PLANNING AND PREPARING FOR A NATURAL DISASTER

Subject (Focus/Topic): Ocean and Atmospheric Science: Planning for Natural Disasters

Grade Level: 5th – 9th grade

Average Learning Time: 2 50-minute classes

Lesson Summary (Overview/Purpose): Students will participate in a group activity to discuss natural disasters and emergency planning. A sample family emergency kit will be created in the classroom. Students will determine which items are appropriate to add to their emergency kit. This exercise extends to family emergency planning.

Overall Concept (Big Idea/Essential Question): How should you and your family prepare for emergencies? What items are essential to place in a family emergency kit?

Specific Concepts (Key Concepts):
- Natural disasters can result in the need for emergency planning
- Hurricanes are a type of natural disaster
- Hurricanes primarily hit the southeastern and eastern United States
- If you live in a coastal area, there may be a loss of electricity and the need for emergency materials
- Preparation is key to survival

Focus Questions (Specific Questions):
- What are some of the natural disasters that strike the United States?
- What are the primary natural disasters that strike the southeastern and eastern United States?
- What is the difference between a severe weather watch and a warning?
- How would you prepare for a power outage and/or disaster in your community?
- Do you have a family emergency plan?
- What items should you place in your family emergency kit in case of a disaster?

Objectives/Learning Goals:
- Students will be able to describe the natural disasters that impact the United States, specifically the southeastern United States.
- Students will be able to define the problems associated with severe weather in their area.
- Students will be able to make appropriate plans for a family meeting place in their home and plan of action in times of emergency.
- Students will be able to choose the appropriate items to place in a family emergency kit.

LESSON 2 (CONT)
PLANNING AND PREPARING FOR A NATURAL DISASTER

Background Information:
http://www.nws.noaa.gov/om/brochures.shtml - NOAA's Office of Climate, Water, and Weather Services (The Office of Services) produces outreach materials to increase the public's awareness of weather safety and emergency preparedness. Many publications are only available online with no printed copies available. These publications say DOWNLOAD. You can order printed copies of some of the publications from your Local National Weather Service Office, the NOAA Outreach Unit, or the American Red Cross. There is no charge for any of the publications. You need a free copy of Abobe Reader to view PDF files.

- http://nutmeg.easternct.edu/%7Epocock/disasters.htm - This site offers information about Disasters in the United States, 1650-2005.

- http://www.harborinsurance.com/guides/disasterprofile.htm - This site provides a Natural Disaster Risk Profile and Natural Disaster Tips.

- http://www.sciencedaily.com/articles/l/list_of_major_natural_diasters_in_the_united_states.htm - A list of major natural disasters in the United States is presented.

- http://www.agu.org/sci_soc/articles/eisvink.html - This article explains "Why the United States Is Becoming More Vulnerable to Natural Disasters."

- http://www.aoml.noaa.gov/hrd/Landsea/USdmg/ - This article describes "Normalized Hurricane Damages in the United States: 1925-1995."

Common Misconceptions/Preconceptions:
- You can easily ride out a hurricane at home, as long as you can move to an upper level room.
- There is no need to evacuate or seek shelter when an emergency occurs as long as you are inside your home.
- It will be easy to find one another after a natural disaster or major storm passes.

Materials:
Hurricane poster
Sealable bucket
NOAA weather radio
Flashlight
Batteries
Tool kit
Candle
Canned soup and other non-perishable food items
Can opener
Water
Whistle
Warm clothing

LESSON 2 (CONT)
PLANNING AND PREPARING FOR A NATURAL DISASTER

Banana
Milk
Chocolate bar
Bread
Ice cream wrappers (to represent ice cream)
Xbox games
Letter for parents indicating that they have completed an emergency plan and created an emergency disaster supply kit with their child

Technical Requirements:
Computer and projector to show video of hurricanes (http://jrscience.wcp.muohio.edu/coriolis/hurricanearchives.html) or other severe weather

Teacher Preparation:
- Mix all perishable items with non-perishable and other safety items on table

Keywords:
- Hurricane awareness and safety
- Natural disaster
- Emergency family disaster plan
- Emergency disaster supply kit
- Hurricane watch
- Hurricane warning

Pre-assessment Strategy/Anticipatory Set:
- Ask students to define "natural disaster." Have students list the types of natural disasters that affect them in their state and town. Place a compiled list in the "K" column of a KWL chart.
- Ask students if they have a family disaster plan in place.
- Ask students what they would place in an emergency disaster supply kit.
- Have students turn-and-talk with each other about what they would like to learn about natural disasters. Record students' questions in the "W" column of a KWL chart.

Lesson Procedure:
- Present a map of the United States. Discuss the natural disasters that are found in various places across our country and show one or two brief videos of natural disasters.

  Read: *Teacher in the Air: Dr. Diane's Flight with the NOAA Hurricane Hunters*, found at http://teacheratsea.noaa.gov/books/index.html. Focus on page 40 after reading the book.
  - Discuss the TIA book in detail, asking questions about the content along the way.
  - Show students a NOAA weather radio and describe the benefits of having one in their home.
  - Ask students to write down the items that they would place in a family emergency kit.

LESSON 2 (CONT)
PLANNING AND PREPARING FOR A NATURAL DISASTER

- Have one or two students come up to the front of class (one at a time) to choose what they would place in an emergency kit from the items that are displayed on a table in the classroom.
- Ask everyone to write down the key items that they would add to their emergency disaster supply kit.
- Discuss the difference between a severe weather watch and a severe weather warning.
- Have students sketch out a family plan including where to meet outside of the house, which number(s) to call, and whom to contact if separated from their immediate family.
- Have students move on to the Track a Hurricane exercise (Lesson 3 in this Unit) to learn how a hurricane moves and responds to ocean temperature.

Assessment and Evaluation:

- Assess each student's choices regarding what to include in a family disaster supply kit. Have students compare checklists and discuss why they may have made different choices.
- Ask students to share their emergency family plan out loud. This should help inspire ideas and enable comparison of appropriate plans.
- Ask students to have their parents sign a letter when they have discussed their emergency plan and created their own emergency disaster supply kit.

Standards:

National Science Education Standards Addressed (Grades 5-8):

- NSES F: Science in Personal and Social Perspectives
    - Sub-categories Personal health, Natural hazards, Risks and benefits, Science and technology in society

Ocean Literacy Principles Addressed (Grades 6-8):

- Principle 6: The ocean and humans are inextricably interconnected
    - Fundamental Concepts: A.8, C.9, C.10

Atmospheric Science Literacy Principles Addressed:

- Essential Principle 3: Atmospheric circulations transport matter and energy
    - Fundamental Concept: 3.4
- Essential Principle 4: Earth's atmosphere changes over time and space, giving rise to weather and climate
    - Fundamental Concept: 4.4
- Essential Principle 7: Earth's atmosphere and humans are inextricably linked
    - Fundamental Concepts: 7.3, 7.4, 7.5

Climate Literacy Principles Addressed:

- Essential Principle 6: Evidence indicates human activities are impacting the climate system
    - Fundamental Concepts: B, C
- Essential Principle 7: Earth's climate system is influenced by complex human decisions involving economic costs and social values
    - Fundamental Concepts: B, C

LESSON 2 (CONT)
PLANNING AND PREPARING FOR A NATURAL DISASTER

State Science Standard(s) Addressed:
- Will differ depending on your state

Additional Resources:

Websites:
- Ocean Literacy Principles - http://www.coexploration.org/oceanliteracy/scopeandsequence/publicreview/index.html#cfds
- Climate Literacy Principles – http://www.climate.noaa.gov/index.jsp?pg+/education/edu_index.jsp&edu=literacy
- Atmospheric Science Literacy Principles – http://eo.ucar.edu/asl/

Book:
- *Teacher in the Air: Dr. Diane's Flight with the NOAA Hurricane Hunters* by Diane M. Stanitski and John J. Adler

Video:
- *Hurricane Montage* - http://video.nationalgeographic.com/video/player/environment/environment-natural-disasters/hurricanes/hurricane-montage.html by *National Geographic*
- *Spectacular Hurricane Movies and Images--Past and Present*
- http://jrscience.wcp.muohio.edu/coriolis/hurricanearchives.html by R. Hays Cummins, Miami University

Author: Diane M. Stanitski
Assisted by John Adler and Jessica Schwarz

Creation date: March 3, 2009

LESSON 3
TRACKING HURRICANES

Subject (Focus/Topic): Ocean and Atmospheric Science: Tracking Hurricanes

Grade Level: 5^{th} – 8^{th} grade

Average Learning Time: 2 50-minute classes

Lesson Summary (Overview/Purpose): Students will participate in an individual activity and group discussion focusing on hurricane formation and historical hurricane tracks. Tracking charts will be used to show that tropical storms and hurricanes follow a fairly consistent pattern across the Atlantic Ocean.

Overall Concept (Big Idea/Essential Question): What is the primary track of tropical storms and hurricanes in the Atlantic Ocean, and what factors contribute to this pattern?

Specific Concepts (Key Concepts):
- Tropical disturbances form in the tropical eastern Atlantic Ocean and, driven by the trade winds, track toward the west
- Hurricanes in the Northern Hemisphere always rotate counter-clockwise
- The ingredients necessary for a hurricane to form include a pre-existing weather disturbance, warm tropical oceans, moisture, and relatively light winds aloft
- Hurricanes gain their energy by traveling over warm ocean water
- Hurricanes that form in the Atlantic basin primarily hit the southeastern and eastern United States

Focus Questions (Specific Questions):
- What factors determine the movement of a hurricane across the ocean?
- After plotting and tracking a series of hurricanes, what pattern(s) can you identify in their movement?
- How are tropical cyclones (a generic term) categorized as they develop and intensify?

Objectives/Learning Goals:
- Students will know the difference between a tropical storm or hurricane watch and warning.
- Students will become familiar with the categories of tropical cyclone formation, including the categories associated with the Saffir-Simpson scale.
- Students will be able to graph the paths of tropical storms and identify the storm's stages of development based on wind speed. Students will also be able to plot the symbol for a tropical storm or hurricane.

Background Information:
http://www.nhc.noaa.gov/ - The National Hurricane Center's website with individual tropical storm information, forecasts, and hurricane awareness and safety information.

http://www.nhc.noaa.gov/HAW2/english/basics.shtml - This website describes hurricane basics.

LESSON 3 (CONT)
TRACKING HURRICANES

http://serc.carleton.edu/research_education/katrina/index.html - Teaching with Hurricane Katrina

This module is designed to provide scientific information and resources to help students understand the science behind the storm. This collection contains an assortment of digital resources and teaching ideas relevant to the many components of the Hurricane Katrina disaster.

http://www.aoml.noaa.gov/hrd/Landsea/USdmg/ - This article describes "Normalized Hurricane Damages in the United States: 1925-1995."

Common Misconceptions/Preconceptions:
- Hurricanes can rotate in any direction.
- Hurricanes are found at the equator.
- Hurricanes can pass from the Northern to the Southern Hemisphere.
- Hurricanes form in all areas of the ocean.
- Hurricanes are similar to tornadoes.
- Tornadoes are never found in the same environment as a hurricane.

Materials:
- Copies of a Western Atlantic Hurricane Tracking chart
- Colored pencils

Technical Requirements:
- Access to computer and projector to show students tracks of past tropical cyclones.

Teacher Preparation:
- Read: *Teacher in the Air: Dr. Diane's Flight with the NOAA Hurricane Hunters*, found at http://teacheratsea.noaa.gov/books/index.html.
- Prepare a presentation where students can watch historical hurricane tracks using the http://www.nhc.noaa.gov/pastall.shtml website.

Keywords:
- Hurricane watch
- Hurricane warning
- Tropical depression
- Tropical storm
- Saffir-Simpson scale

Pre-assessment Strategy/Anticipatory Set:
- Present a map of the United States and the Atlantic Ocean. Ask a student to come to the board or computer and draw or sketch with their finger the general movement of a hurricane across the Atlantic Ocean. Have students come up one by one until someone draws a probable track.

LESSON 3 (CONT)
TRACKING HURRICANES

- Ask students what factors play a role in directing a hurricane in this general path. Discuss global wind and ocean circulation patterns.
- Introduce the ingredients necessary for a hurricane to form.
- Describe the spawning grounds (Africa and eastern Atlantic) for tropical disturbances and explain how a disturbance can strengthen to form a tropical cyclone and hurricane.
- Define the difference between a tropical storm/hurricane watch and warning.
- Ask students if they ever experienced a hurricane. If so, ask them to describe the experience.
- Show students the presentation of historical hurricane tracks based on the http://www.nhc.noaa.gov/pastall.shtml website.
- Explain to the students that they will complete a tracking exercise where they will plot the coordinates of four famous past storms using different colors for each track.

Tracking Procedure:
- You can access the inserted lesson, *Follow That Hurricane!*, at the NOAA 200th celebration site: http://celebrating200years.noaa.gov/edufun/book/welcome.html
- This lesson was assembled, along with 42 other activities, in the Discover Your World With NOAA Activity Book designed for NOAA's 200th celebration!

Wrap-up:
- Once students plot their storms, they will conduct research to learn more about the factors that caused these storms to intensify and become famous storms.
- Students will then write a summary of their findings. Ask them to describe at least three factors that led to the intensification of each hurricane and to describe the overall movement of each cyclone.
- If there is time, read *Teacher in the Air: Dr. Diane's Flight with the NOAA Hurricane Hunters*, found at http://teacheratsea.noaa.gov/books/index.html. Discuss what it is like to be a hurricane hunter and the types of data collected by scientists on board the NOAA WP-3D Orion planes.

Assessment and Evaluation:
Collect each student's tracking charts and grade them based on their accuracy and use of the correct tropical storm and hurricane symbols. Assess each student's research paper ensuring that they included at least three intensification factors for each hurricane. Include each student's contribution to group discussion in the grade as well.

Standards:

National Science Education Standards Addressed (Grades 5-8):
- NSES B: Physical Science
  - Sub-categories Motion and forces; Transfer of energy
- NSES F: Science in Personal and Social Perspectives
  - Sub-categories Population, resources, and environments; Natural hazards; Risks and benefits; Science and technology in society

Ocean Literacy Principles Addressed (Grades 6-8):
- Principle 2: The ocean and life in the ocean shape the features of Earth

    - Fundamental Concepts: A.5., A.6., A.11.
- Principle 3: The ocean is a major influence on weather & climate
    - Fundamental Concepts: A.1., A.5., A.7., A.8., A.9., A.10., B.1., B.2., B.8., B.10.
- Principle 6: The ocean and humans are inextricably interconnected
    - Fundamental Concepts: A.4., A.7., A.8., B.4.

Atmospheric Science Literacy Principles Addressed:

- Essential Principle 4: Earth's atmosphere changes over time and space, giving rise to weather and climate
    - Fundamental Concept: 4.4
- Essential Principle 7: Earth's atmosphere and humans are inextricably linked
    - Fundamental Concepts: 7.3, 7.4, 7.5

Climate Literacy Principles Addressed:

- Essential Principle 3: The sun is the primary source of energy for the climate system
    - Fundamental Concepts: B
- Essential Principle 4: Earth's weather and climate systems are the result of complex interactions
    - Fundamental Concepts: A, E

State Science Standard(s) Addressed:

- Will differ depending on your state

Additional Resources:

Websites:

- Atlantic Tropical Storm Tracking by Year - http://weather.unisys.com/hurricane/atlantic/ - This is a list of Atlantic hurricanes since 1851. Provided are charts on the track of the storm plus a text based table of tracking information. The table includes position in latitude and longitude, maximum sustained winds in knots, and central pressure in millibars. Data courtesy of the Tropical Prediction Center.

Book:

- *Teacher in the Air: Dr. Diane's Flight with the NOAA Hurricane Hunters* by Diane M. Stanitski and John J. Adler

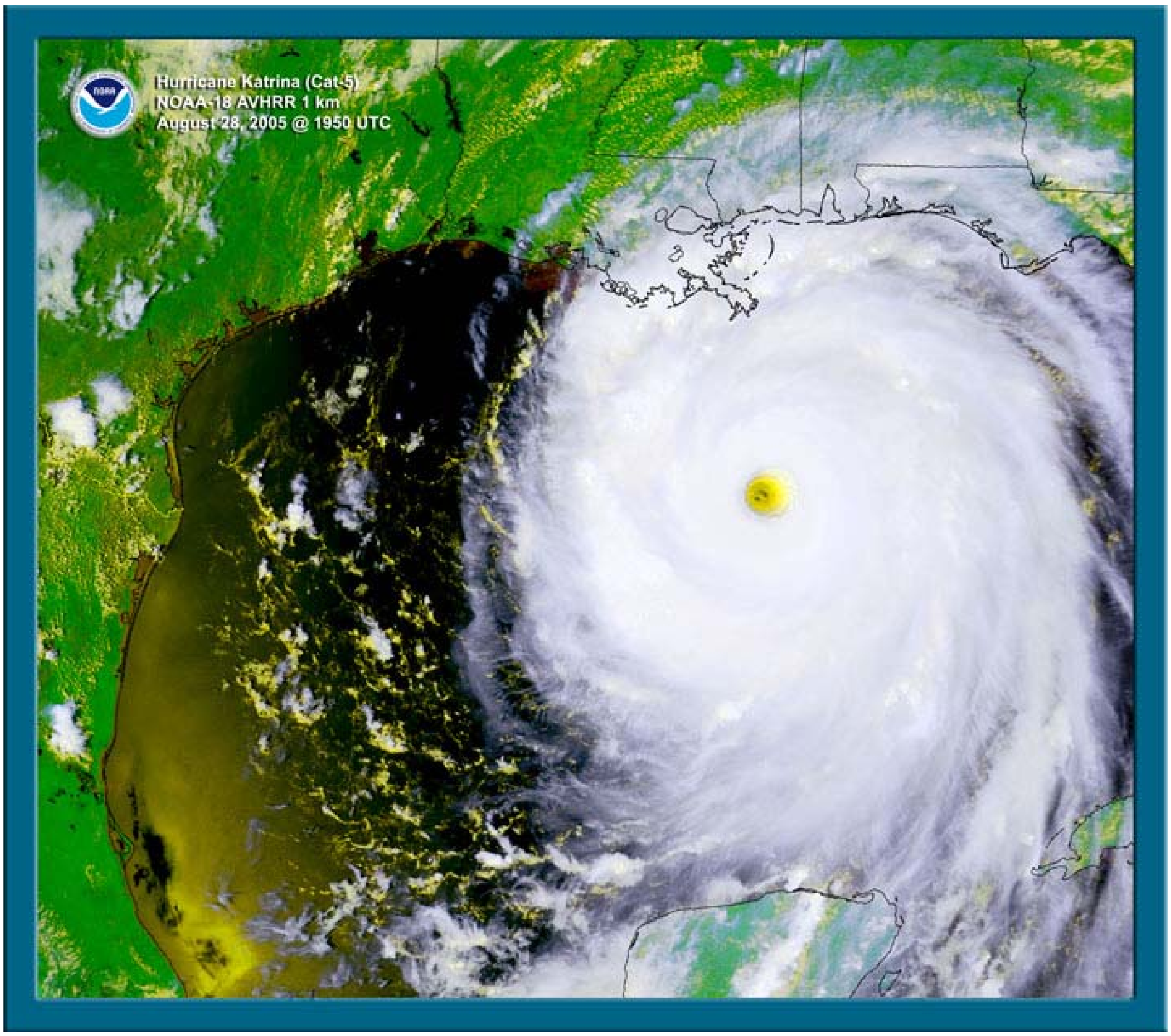
Video:

- *Hurricane Montage* - http://video.nationalgeographic.com/video/player/environment/environment-natural-disasters/hurricanes/hurricane-montage.html by *National Geographic*

Author: Diane M. Stanitski
Assisted by John Adler and Jessica Schwarz

Creation date: March 3, 2009

LESSON 3 (CONT)
TRACKING HURRICANES



Follow That Hurricane!

What You Will Do

Track a hurricane on the same type of chart used at the National Hurricane Center

"Devastating damage expected... A most powerful hurricane with unprecedented strength... Most of the area will be uninhabitable for weeks, perhaps longer... At least one half of well constructed homes will have roof and wall failure... all wood framed low rising apartment buildings will be destroyed... High rise office and apartment buildings will sway dangerously, a few to the point of total collapse... airborne debris will be widespread... persons, pets, and livestock exposed to the winds will face certain death if struck..."

~ from Urgent Weather Statement issued by Robert Ricks, Meteorologist, National Weather Service, New Orleans/Baton Rouge Office, August 28, 2005

This weather statement, warning of Hurricane Katrina's approach, probably saved many lives. Providing weather forecasts and warnings is one of the ways the National Weather Service carries out its mission to protect life and property and enhance the national economy. The National Hurricane Center (part of the National Weather Service) tracks tropical storms and hurricanes, and issues hurricane watches and warnings when the storms get close to the U.S. Here's how you can track the approach of tropical storms and hurricanes.

Startled man ready to run after a hurricane driven wave smashes into seawall
Historic NWS Collection. Courtesy NOAA.

What You Will Need

- ❒ Copy of the "Western Atlantic Hurricane Tracking Chart." To download one yourself, go to *http://www.nhc.noaa.gov*, scroll down the page to the blank tracking charts and click on the Western Atlantic one.
- ❒ Pencil and eraser
- ❒ A record of hurricane locations from the National Hurricane Center, or from historical hurricane records; records from four famous hurricanes are found on the following pages.

How to Do It

1. The location of a hurricane on a particular date and time is described by the latitude and longitude of the storm's center, called the "eye." Latitude measures how far north or south a location is from the equator, and longitude measures how far east or west a location is from a line that goes from the North Pole to the South Pole, passing through Greenwich, England. On the "Atlantic Basin Hurricane Tracking Chart," latitude is shown by horizontal lines and longitude is shown by vertical lines. Latitude and longitude are measured in degrees. Hurricane coordinates are given in pairs, with latitude written before longitude. So, the location of Bermuda would be written as: 32.3°N, 64.7°W. The "N" means that the location is north of the equator, and the "W" means that the location is west of Greenwich, England.

2. To plot the location of a storm:
   (a) Find the latitude of the storm (the first coordinate in the pair), and locate the horizontal line on the map that matches this latitude.
   (b) Find the longitude (the second coordinate in the pair, usually followed by a W or E), and locate the vertical line on the map that matches this longitude.
   (c) Find the place on the map where the two lines intersect. This is the location of the storm eye. Draw the symbol for a hurricane or a tropical storm (depending upon the kind of storm you are tracking) at this spot, and write the date and time next to the symbol. (See above right).

3. Try plotting the track of one or more famous hurricanes. You are now ready to plot real storms during the next hurricane season! You can get coordinates from NOAA WeatherRadio-All Hazards, newspapers, or from *http://www.nhc.noaa.gov*.

Hurricane Katrina Satelite View. Courtesy NOAA

Hurricane Symbol: 

Tropical Storm Symbol: 

Is It a Tropical Depression, Tropical Storm, or Hurricane?

Tropical Depressions, Tropical Storms, and Hurricanes are all cyclones, which are areas of low pressure in the atmosphere that have a spiralling inward pattern of air movement. In the Northern Hemisphere, the spiral turns counterclockwise, while cyclones in the Southern Hemisphere have spirals that turn clockwise.

A Tropical Depression is a tropical cyclone in which the maximum sustained wind speed is 38 mph or less.

A Tropical Storm is a tropical cyclone in which the maximum sustained wind speed ranges from 39 mph to 73 mph.

Hurricanes are tropical cyclones with maximum sustained wind speeds of 74 mph or greater. Hurricanes are classified into five categories:

- Category One: Winds 74-95 miles per hour
- Category Two: Winds 96-110 miles per hour
- Category Three: Winds 111-130 miles per hour
- Category Four: Winds 131-155 miles per hour
- Category Five: Winds greater than 155 miles per hour

Is Your Family Disaster-Ready?

Visit *http://www.fema.gov/kids/dizkit.htm* for information about how to make a Disaster Supply Kit.

Courtesy FEMA

Want to Do More?

Check out these Web sites:

- *http://www.nhc.noaa.gov/HAW2/english/intro.shtml* – Hurricane Awareness from the National Hurricane Center
- *www.nhc.noaa.gov/aboutnames.shtml* – The list of World-Wide Tropical Cyclone Names
- *www.nhc.noaa.gov/aboutsshs.shtml* – Information about the Saffir-Simpson Hurricane Scale
- *http://www.weather.gov/os/hurricane/pdfs/Hurricane_unleashing06.pdf* – "Hurricanes, Unleashing Nature's Fury," a booklet about hurricanes and why they happen
- *http://www.nhc.noaa.gov/pastall.shtml* – Historical Hurricane Tracks Web site, with information about dozens of hurricanes in the Atlantic and East-Central Pacific Ocean Basins

Track Coordinates of Some Famous Storms

Hurricane Hugo

Location and Windspeed at 0000 GMT

Date	Latitude (North)	Longitude (West)	Wind Speed (knots)
9/11/1989	13.2	23.7	30
9/12/1989	12.5	31.0	40
9/13/1989	12.6	38.2	55
9/14/1989	12.9	44.9	70
9/15/1989	13.8	50.5	100
9/16/1989	14.8	56.1	135
9/17/1989	16.1	60.4	120
9/18/1989	17.2	64.1	130
9/19/1989	19.7	66.8	100
9/20/1989	23.5	69.3	90
9/21/1989	27.2	73.4	100
9/22/1989	31.7	78.8	120
9/23/1989	42.2	80.2	35
9/24/1989	52.0	62.0	40
9/25/1989	54.0	57.0	40

Courtesy NOAA

Three views of Hurricane Andrew on 23, 24, and 25 August 1992 as the hurricane moves East to West. Time lapse satellite image courtesy NASA.

Hurricane Andrew
Location and Windspeed at 0000 GMT

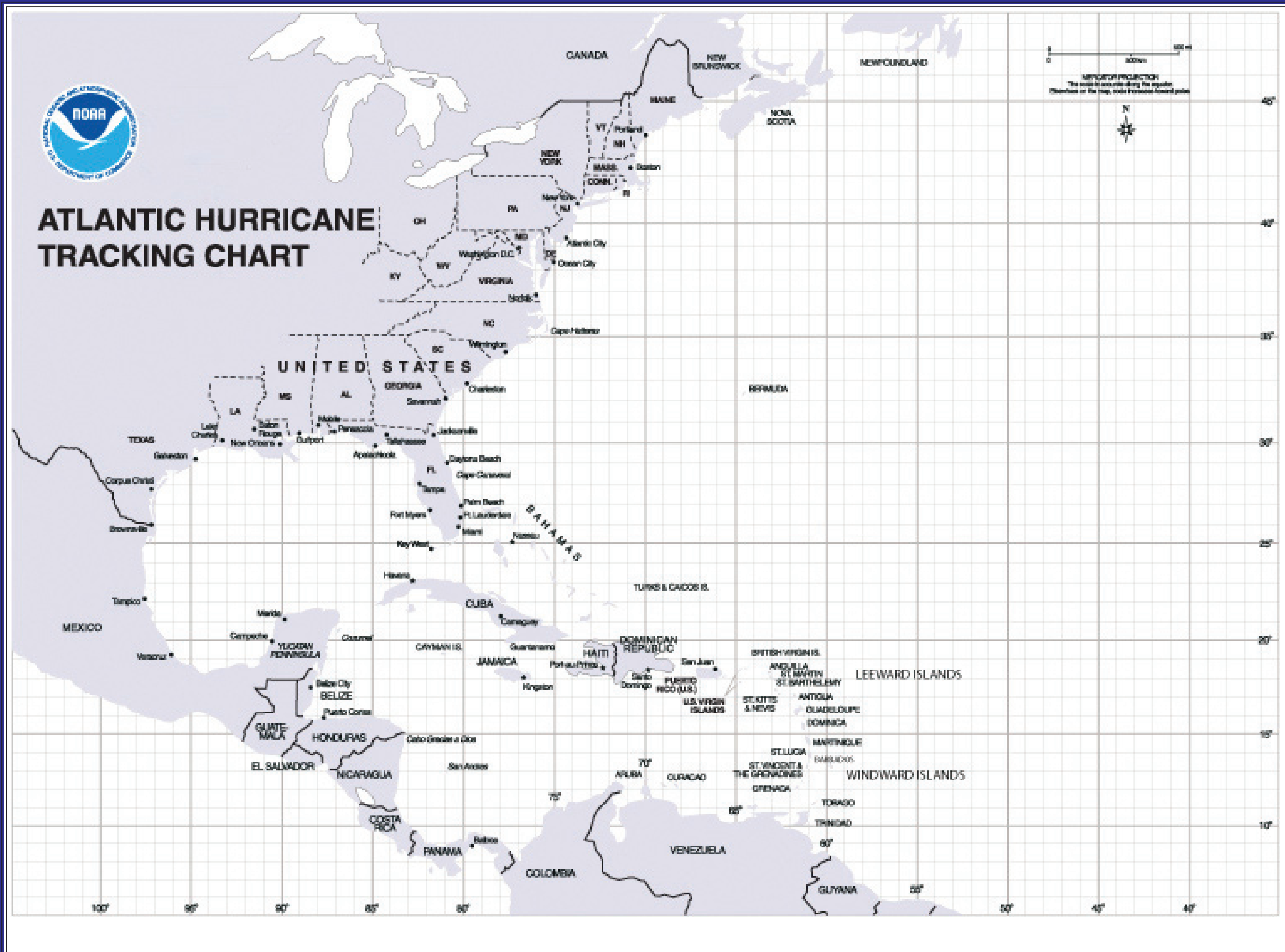
Date	Latitude (North)	Longitude (West)	Wind Speed (knots)
17/8/1992	11.2	37.4	30
18/8/1992	13.6	46.2	40
19/8/1992	16.3	53.5	45
20/8/1992	19.8	59.3	40
21/8/1992	23.2	62.4	45
22/8/1992	25.3	65.9	55
23/8/1992	25.6	71.1	110
24/8/1992	25.4	77.5	125
25/8/1992	26.2	85.0	115
26/8/1992	28.5	90.5	125
27/8/1992	31.5	91.1	35
28/8/1992	34.4	86.7	20

Hurricane Floyd
Location and Windspeed at 0000 GMT

Date	Latitude (North)	Longitude (West)	Wind Speed (knots)
8/9/1999	15.0	46.9	30
9/9/1999	16.7	52.6	45
10/9/1999	18.3	57.2	60
11/9/1999	20.8	60.4	80
12/9/1999	22.7	64.1	85
13/9/1999	23.4	68.7	125
14/9/1999	24.5	74.0	115
15/9/1999	27.1	77.7	115
16/9/1999	32.1	78.7	90
17/9/1999	40.6	73.5	50
18/9/1999	44.8	67.3	40
19/9/1999	48.0	56.3	35

Hurricane Katrina
Location and Windspeed at 0000 GMT

Date	Latitude (North)	Longitude (West)	Wind Speed (knots)
24/8/2005	23.4	75.7	30
25/8/2005	26.0	77.7	45
26/8/2005	25.9	80.3	70
27/8/2005	24.6	83.3	90
28/8/2005	24.8	85.9	100
29/8/2005	27.2	89.2	140
30/8/2005	32.6	89.1	50
31/8/2005	38.6	85.3	30


ATLANTIC HURRICANE TRACKING CHART
NOAA
CANADA
NEW BRUNSWICK
NEWFOUNDLAND
NOVA SCOTIA
MAINE
VT
NH
Portland
NEW YORK
MASS.
Boston
CONN.
RI
PA
NJ
OH
MD
DE
Atlantic City
Ocean City
Washington D.C.
WV
KY
VIRGINIA
Norfolk
NC
Cape Hatteras
SC
Wilmington
UNITED STATES
GEORGIA
Charleston
Savannah
AL
MS
LA
TEXAS
Mobile
Pensacola
Jacksonville
Tallahassee
Gulfport
New Orleans
Baton Rouge
Lake Charles
Galveston
Apalachicola
Daytona Beach
FL
Cape Canaveral
Tampa
Corpus Christi
Palm Beach
Ft. Lauderdale
Fort Myers
Miami
Brownsville
Key West
Nassau
BAHAMAS
BERMUDA
Havana
TURKS & CAICOS IS.
CUBA
Tampico
Camaguey
MEXICO
Merida
Campeche
YUCATAN PENINSULA
Cozumel
CAYMAN IS.
Guantanamo
HAITI
DOMINICAN REPUBLIC
Veracruz
JAMAICA
Port-au-Prince
San Juan
Santo Domingo
PUERTO RICO (U.S.)
Kingston
Belize City
BELIZE
BRITISH VIRGIN IS.
ANGUILLA
ST. MARTIN
ST. BARTHELEMY
LEEWARD ISLANDS
U.S. VIRGIN ISLANDS
ST. KITTS & NEVIS
ANTIGUA
GUADELOUPE
DOMINICA
MARTINIQUE
Puerto Cortes
GUATEMALA
HONDURAS
Cabo Gracias a Dios
ST. LUCIA
BARBADOS
EL SALVADOR
NICARAGUA
San Andres
ARUBA
CURACAO
ST. VINCENT & THE GRENADINES
WINDWARD ISLANDS
GRENADA
TOBAGO
TRINIDAD
COSTA RICA
PANAMA
Balboa
COLOMBIA
VENEZUELA
GUYANA
MERCATOR PROJECTION
N
45°
40°
35°
30°
25°
20°
15°
10°
100°
95°
90°
85°
80°
75°
70°
65°
60°
55°
50°
45°
40°

LESSON 4
SURVEYING OUR COASTAL WATERS

Subject (Focus/Topic): Ocean Science: Coastal Surveying

Grade Level: 5th – 9th grade

Average Learning Time: 2 50-minute classes

Lesson Summary (Overview/Purpose): Students will learn about the history of coastal surveying through video, books, and construction of their own hydrography box. Hydrography and the construction of charts enable safe navigation of coastal waterways and help ships avoid hazards, especially after major storm events where the bathymetry of the coast has been modified.

Overall Concept (Big Idea/Essential Question): How do hydrographers create accurate coastal surveys for safe passage of ships, especially after natural hazards like hurricanes?

Specific Concepts (Key Concepts):
- The bathymetry along a coast constantly changes due to natural processes such as erosion, deposition of river silt, and storm impacts.
- Much of the nation's food, raw materials, and finished products arrive in the U.S. via our nation's busy ports.
- Without adequate charting, major catastrophes, such as ship groundings, would occur.
- Modern technology, such as sidescan sonar and multibeam sonar, enables hydrographers to rechart our nation's coastal areas more efficiently than in the past.
- Construction of a hydrography box shows students the early leadline method for determining water depth.

Focus Questions (Specific Questions):
- What is the difference between a foot, a fathom, and a meter?
- What instruments are used to measure depths of coastal waterways?
- Why is it important to survey and resurvey harbors and coastal waterways?

Objectives/Learning Goals:
- Students will be able to describe the technology that is available to measure the depths of coastal waterways.
- Students will understand the significance of conducting coastal surveys.
- Students will build a hydrography box and understand its similarity to the method for detecting obstructions and measuring water depth.

Background Information:
The following background information can be found at the Office of Coast Survey's site: http://www.nauticalcharts.noaa.gov/staff/headline3-hurricanes.htm.

LESSON 4 (CONT)
SURVEYING OUR COASTAL WATERS

The Office of Coast Survey is instrumental in responding to each year's Atlantic Hurricane Season. “Critical to a coastal community's rebound after a major coastal storm hit is the work of NOAA's Office of Coast Survey's Navigation Response Teams (NRTs). When hurricanes and strong storms make landfall they often bring with them stronger than normal ocean currents that can shift navigational channels and bring debris that can threaten the ability of vessels to navigate safely in these channels.

NRTs utilize small boats that can quickly survey ports and channels to update nautical charts allowing marine transportation to resume immediately following a hurricane or other disaster. Each of the six regional NRTs teams around the country consist of a three-person crew that uses some of the latest technology to quickly assess storm damage, identify submerged hazards or obstructions, and work with their federal, state and local community partners to restore safe navigational access.

Most recently, OCS was instrumental in planning and responding to Hurricanes Gustav and Ike in the Gulf of Mexico. NRT personnel and OCS' regional navigation managers worked with federal and state agencies, including the U.S. Coast Guard and U.S. Army Corps of Engineers, to provide rapid response.

Coastal areas hit hard by hurricanes require this rapid investigation to keep maritime vessel traffic navigating safely. The nation’s economic welfare depends upon the Marine Transportation System with ports and commercial vessel traffic contributing more than $1 trillion annually to the nation’s economy.”

Interesting trivia:
The famous American author, Samuel Clemens, gave himself the nickname “Mark Twain” which was the call of a hydrographer as they charted the Mississippi and other waterways. “Mark Twain” meant that the lead line showed 2 fathoms (12 feet) of depth and indicated safe water.

A website for NOAA’s Office of the Coast Survey: The Nation’s Chartmaker - http://www.nauticalcharts.noaa.gov/

A website showing shipwrecks and obstructions - http://www.nauticalcharts.noaa.gov/hsd/awois.html

A website showing historical nautical charts of the New York Harbor - http://celebrating200years.noaa.gov/new_york_charts/welcome.html

Common Misconceptions/Preconceptions:

- A chart and a map are the same thing.
- The nation’s ports used to be very important to our country, but with rail and air transport they are no longer as important.
- Once you’ve charted the sea floor, it never changes.
- It is very difficult to detect sunken ships and other objects on the seafloor.

LESSON 4 (CONT)
SURVEYING OUR COASTAL WATERS

Materials:
- 1 shoe box per student
- Sea floor items - rocks, gravel, dirt, and sand
- Items to sink - Legos, toy planes, and small boats
- "Pretend" water - Blue Air Filter or aluminum foil to represent the water surface. Label each side of the filter or aluminum foil with a grid to match the attached plotting chart
- Long, skinny stick like a bamboo skewer, long pencil, knitting needle, or a dowel
- 2 copies of the “Depth Chart” grid
- 1 copy of a “Color Coded Depth Scale”
- Pencil, colored pencils, or crayons

Technical Requirements:
- Access to computer and projector to show students video of the history of coastal surveying.

Teacher Preparation:
Read: *Teacher at Sea: Mrs. Armwood’s Hydrographic Adventure on the NOAA Ship FAIRWEATHER*, found at http://teacheratsea.noaa.gov/books/index.html.
Watch the video on the history of coastal surveying to learn about changing survey technology.

Keywords:
- Fathom
- Hydrography
- Hydrographer
- Lead line
- Coastal survey
- Nautical chart
- Sonar
- Sidescan sonar
- Multibeam sonar
- Bathymetry

Pre-assessment Strategy/Anticipatory Set:
1. Ask students to look at the label on their shirt to determine where the shirt was made.
2. Ask them how they think their shirt was transported from where it was made to the U.S.
3. After indicating that most of our goods are transported by ship in huge containers, explain the significance of keeping our coastal waterways free of obstacles.
4. In order to explain the history of coastal surveying from use of the lead line to sidescan and multibeam sonar, show the 27-minute streaming video of the history of America’s Surveyors, called “The Surveyors: Charting America’s Course” at http://celebrating200years.noaa.gov/surveyors.html.

LESSON 4 (CONT)
SURVEYING OUR COASTAL WATERS

5. To help students understand how scientists collect hydrographic data, read *Teacher at Sea: Mrs. Armwood's Hydrographic Adventure on the NOAA Ship FAIRWEATHER*, found at http://teacheratsea.noaa.gov/books/index.html. Discuss what it is like to be on a ship taking measurements of changing water depth.
6. Explain to the students that they will construct a hydrography box, thus completing an exercise similar to what surveyors did when charting the bathymetry of a water body with a lead line. Ask students to bring in a shoebox and items representing obstructions that could be found at the bottom of the ocean (e.g., rocks, tiny ships, miniature planes, coral).

Hydrography Box Activity:
You can access the following Sounding Box Activity at the NOAA Ocean Service Education site: http://www.oceanservice.noaa.gov/education/seafloor-mapping/sounding_box_make1.html

Sounding Box Activity

OCS Hydrography Kids' Kit
Revised January 29, 2007

Best for Ages 8 -12

Introduction

Now that you know a little about some of the methods used to chart ocean depths, it's time to put one of these sampling techniques to the test. This activity is modeled after the lead line sampling method, the method scientists used before the introduction of sonar. You will play the part of a hydrographer and survey an imaginary ocean. You will chart the water depths so that ships can safely navigate through your "ocean". You will need to be careful with the survey and not miss any parts on your seafloor. Accurate maps are needed to find shallow points of a busy port or objects sticking up from the sea bottom!

How Do I Make a Sounding Box?

Your sounding box can be made out of a small box like a shoe box. You can use rocks, gravel, dirt, and sand with different shaped objects to represent different landforms on the bottom or various surprises found during surveying. Pieces of building sets, toy planes, and small boats are all good ways to represent airplanes and ships that sometimes sink and come to rest on the ocean floor. Aluminum foil to cover the box is the best way to represent the water surface.

If you're interested in making your sounding box an irresistible snack, you can use graham crackers, candy, and Jell-O to make an edible version of your sounding box.

Design the seafloor of your box and place all of the items in the box. Cover your box with aluminum foil so you can't see below the surface of the "water." You can either make your own sounding box, or you can work in pairs or in a group to make separate boxes and then trade with each other to explore your own personal oceans!

LESSON 4 (CONT)
SURVEYING OUR COASTAL WATERS

Example of Handmade Sounding Box without the aluminum foil

Materials for Taking Depth Measurements

Sounding box covered with aluminum foil

Long, skinny stick: bamboo skewer, long pencil, knitting needle or a dowel

2 copies of "Depth Chart" grid (last page of this document)

1 copy of a "Color Coded Depth Scale"

Pencil

Crayons, Pencils or Markers

What to Do

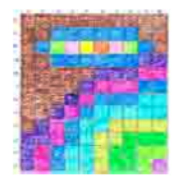
1. Have your "Color Coded Depth Scale" ready: color each grid that is next to a number in a different color of your choice. Example: #1 – Red, #2 – Orange, etc.
2. Get a copy of the "Depth Chart" and a small sharp object. Poke a small hole in each square of the "Depth Chart" so that you can easily push through your bamboo skewer through each square of the grid. Tape the "Depth Chart" on top of the aluminum foil that covers the box.
3. Position the stick carefully into the first spot you want to sample. (grid 1,1)

4. **Measure "depths" by gently pushing the long and skinny stick through the Depth Chart and cover of the sounding box until it hits something on the bottom.**
5. **Pinch your fingers around the stick where it is even with the cover.**

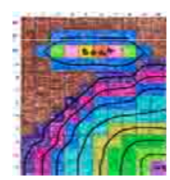
6. **Measure the distance from the end of the stick to your fingers using the Color Coded scale. What is the color that corresponds to that distance?**

7. **On your second copy of the "Depth Chart" color the first grid (1,1) with the color that corresponds to the distance that you measured.**

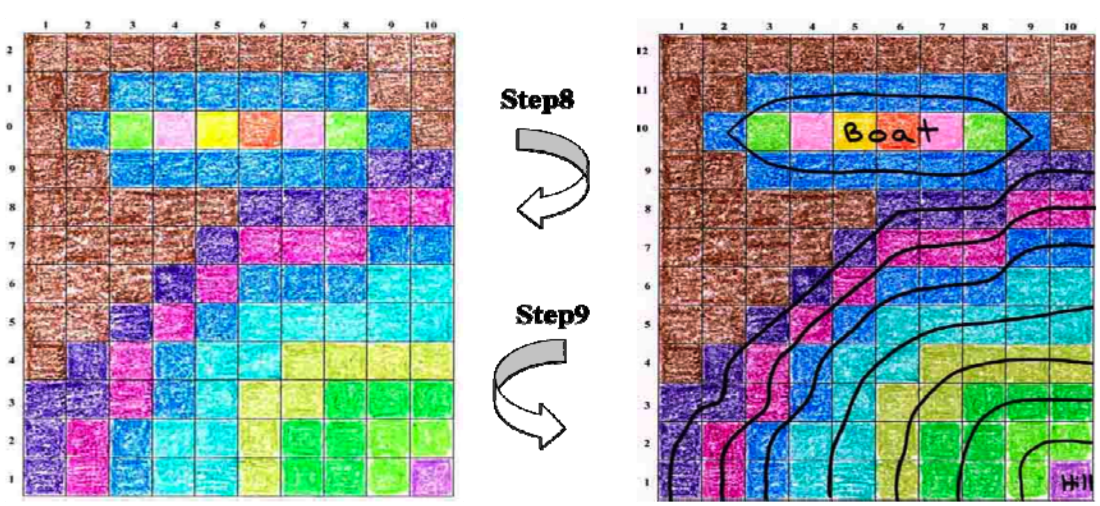
8. **Repeat steps 4-7 at each point marked on the grid on the box. Record each measurement in the proper place on the depth chart. When you have finished, each square on the Depth chart should be colored. (see the example here and below)**



9. **Draw lines that connect grid boxes that have the same colors to show what objects or landforms are on the bottom of your seafloor. (see example here and below)**



10. **Carefully take the aluminum foil off and compare your plotting sheet to the bottom of the box. Did you find all of the objects or landforms on the bottom of your seafloor? Why or why not?**



LESSON 4 (CONT)
SURVEYING OUR COASTAL WATERS

Color Coded Depth Scale
Print and Color in Your Favorite Colors

15	
14	
13	
12	
11	
10	
9	
8	
7	
6	
5	
4	
3	
2	
1	

LESSON 4 (CONT)
SURVEYING OUR COASTAL WATERS

Depth Chart

Print and make 2 copies of this chart:

- **Paste one copy on top of the box**
- **Use second copy to color in your measurement results**

	1	2	3	4	5	6	7	8	9	10
12										
11										
10										
9										
8										
7										
6										
5										
4										
3										
2										
1										

LESSON 4 (CONT)
SURVEYING OUR COASTAL WATERS

Wrap-up:
Once students create their hydrography box, the following questions should be discussed as a group and students should individually write their own opinion on a separate sheet of paper.

- What type of old hydrographic surveying method is most like the sounding box activity?
- Do you think we still have charts that use information from lead line surveying?
- What could happen if the depth information we have from old surveys is out of date?
- Look at the different depths you marked on your plotting chart. What was the most shallow depth you found?
- If you were on a small imaginary boat do you think your chart would have safely helped you across your ocean? Why or why not?
- How would you change your measurement method to find smaller objects, or to find more detail in the large objects on the bottom of your ocean?

Assessment and Evaluation:
Check each student's depth chart to ensure that it aligns with their hydrography box. Collect the answers to the wrap-up questions and grade them based on their accuracy, use of correct hydrographic language, and creativity.

Standards:

National Science Education Standards Addressed (Grades 5-8):

- NSES D: Earth and Space Science
  - Sub-category Structure of the earth system
- NSES F: Science in Personal and Social Perspectives
  - Sub-category Science and technology in society

Ocean Literacy Principles Addressed (Grades 6-8):

- Principle 1: Earth has one big ocean with many features.
  - Fundamental Concepts: A.8.
- Principle 2: The ocean and life in the ocean shape the features of Earth
  - Fundamental Concepts: A.1., A.2., A.5., A.6., A.9., A.10., A.11., A.15., B.1.
- Principle 6: The ocean and humans are inextricably interconnected
  - Fundamental Concepts: A.2., B.3., B.11.

Climate Literacy Principles Addressed:

- Essential Principle 1: Life on earth has been shaped by, depends on, and affects climate
  - Fundamental Concepts: D

State Science Standard(s) Addressed:

- Will differ depending on your state

LESSON 4 (CONT)
SURVEYING OUR COASTAL WATERS

Additional Resources:

Websites:

- http://celebrating200years.noaa.gov/edufun/book/NauticalChartChallenge.pdf - Nautical Chart Challenge – an activity linked with NOAA's 200th celebration where students can discover some of the ways a nautical chart can help a mariner safely navigate in unfamiliar coastal waters.

Book:

- *Teacher at Sea: Mrs. Armwood's Hydrographic Adventure on the NOAA Ship FAIRWEATHER* by Diane M. Stanitski

Video:

- "The Surveyors: Charting America's Course" at NOAA's 200th celebration website: http://celebrating200years.noaa.gov/surveyors.html

Author: Diane M. Stanitski
Assisted by John Adler and Jessica Schwarz

The Hydrography Box exercise (pp. 4-8) was taken directly from the Education site of the National Ocean Service.

Creation date: March 3, 2009

LESSON 5
LIVING IN CORAL

Activity Title: Living in Coral

Subject (Focus/Topic): Life science: marine ecology

Grade Level: 5^{th} – 7^{th} Grade

Average Learning Time: 2 hours

Lesson Summary (Overview/Purpose): Students will construct and present an edible coral reef habitat and identify organisms and their adaptations and functions within the system to gain an understanding of a reef ecosystem and the characteristics of organisms that live there. In addition, students will explore what happens to a coral reef and its marine life in the event of a hurricane.

Overall Concept (Big Idea/Essential Question): This activity is designed to acquaint students with the coral reef ecosystem and the physical characteristics of organisms adapted to make the reef their home.

Specific Concepts (Key Concepts):
- Coral reefs are structures made of deposited limestone built mostly by species of coral (although not all coral species build reefs).
- Hermatypic, or reef building corals, are the hard, stony corals that build reef structures.
- Coral reefs are generally divided into four categories: fringing reefs, barrier reefs, atolls, and patch reefs.
- Coral reefs support 25% of all marine species - 700 species of coral and 4,000 species of fish.
- The different types of reefs support different species of marine life that are adapted to survive and function within each specific niche.
- Coral reefs are vulnerable to damage associated with natural disasters such as hurricanes with certain species more susceptible to damage than others.
- Marine populations are impacted by coral reef damage after a natural disaster such as a hurricane.

Focus Questions (Specific Questions):
- What is a coral reef and how is it made?
- What are the various marine organisms that make the reef its home?
- What are the different categories scientists use to classify coral reefs?
- What are the organisms that live within each category of reef?
- In what ways are marine species physically adapted to survive within the reef ecosystem?
- What behaviors make living within a reef ecosystem appropriate for marine species to dwell there?
- What functions do marine organisms perform for the reef system?

LESSON 5 (CONT)
LIVING IN CORAL

Objectives/Learning Goals:

- Students will be able to distinguish between four categories of coral reef
- Students will be able to identify the physical and behavioral characteristics of marine organisms adapted to live within each category of coral reef.
- Students will be able to identify functions of marine organisms within a coral reef system.
- Students will be able to present their coral reef habitat and describe the adaptations of at least 5 marine organisms within that system.
- Students will be able to describe what happens to a coral reef and associated marine life in the event of a hurricane.

Background information:
Although coral is often mistaken for a rock or a plant, it is actually composed of tiny, fragile animals called coral polyps. When people say *coral*, they are referring to these little animals and the skeletons they leave behind after they die.

Although there are hundreds of different species of corals, they are generally classified as either hard coral or soft coral.

Hard corals grow in colonies and are the architects of coral reefs. Including such species as *brain* coral and *elkhorn* coral, hard coral skeletons are made out of calcium carbonate (also known as *limestone*), a hard substance that eventually becomes rock. Hard corals are *hermatypes,* or reef-building corals, and need tiny algae called *zooxanthellae* (pronounced zo-zan-THEL-ee) to survive. Generally, when we talk about coral, we are referring to hard corals.

Soft corals, such as sea fingers and sea whips, are soft and bendable and often resemble plants or trees. These corals do not have stony skeletons, but instead grow woodlike cores for support and fleshy rinds for protection. They are referred to as *ahermatypes*, or non–reef building corals, and they do not always have zooxanthellae. Soft corals are found in both tropical seas and in cool, dark regions.

Coral reefs are found in more than 100 countries around the world. Most reefs are located between the Tropics of Cancer and Capricorn, in the Pacific Ocean, the Indian Ocean, the Caribbean Sea, the Red Sea, and the Arabian Gulf. Corals are also found farther from the equator in places where warm currents flow out of the tropics, such as in Florida and southern Japan. Worldwide, coral reefs cover an estimated 110,000 square miles (284,300 square kilometers).

Coral reefs grow best in warm water (70–85°F or 21–29°C). It is possible for soft corals to grow in places with warmer or colder water, but growth rates in these types of conditions are very slow. Corals prefer clear and shallow water, where lots of sunlight filters through to their symbiotic algae. It is possible to find corals at depths of up to 300 feet (91 meters), but reef-building corals grow poorly below 60–90 feet (18–27 meters). Corals need salt water to survive, so they also grow poorly near river openings or coastal areas with excessive

LESSON 5 (CONT)
LIVING IN CORAL

runoff.

Scientists generally divide coral reefs into four classes: fringing reefs, barrier reefs, atolls, and patch reefs.

Fringing reefs grow near the coastline around islands and continents. They are separated from the shore by narrow, shallow lagoons. Fringing reefs are the most common type of reef that we see.

Barrier reefs also parallel the coastline but are separated by deeper, wider lagoons. At their shallowest point they can reach the water's surface forming a "barrier" to navigation. The Great Barrier Reef in Australia is the largest and most famous barrier reef in the world.

Atolls are rings of coral that create protected lagoons and are usually located in the middle of the sea. Atolls usually form when islands surrounded by fringing reefs sink into the sea or the sea level rises around them (these islands are often the tops of underwater volcanoes). The fringing reefs continue to grow and eventually form circles with lagoons inside.

Patch reefs are small, isolated reefs that grow up from the open bottom of the island platform or continental shelf. They usually occur between fringing reefs and barrier reefs. They vary greatly in size, and they rarely reach the surface of the water.

Despite their importance, many of Earth's coral reefs are in trouble. Severe storms, water pollution, overfishing, disease, global climate change, and ships running aground are some of the things that have destroyed or badly damaged many reefs. Because of these threats, coral reefs and all of the creatures that call them home may be in danger of disappearing if something isn't done to protect them. NOAA is one of many organizations participating in the U.S. Coral Reef Task Force, which was established in 1998 to protect and conserve coral reefs. Satellites are being used to map shallow U.S. coral reefs, as well as to watch for high sea surface temperacan smother reefs. NOAA's National Undersea Research Program completes research projects to learn more about coral reefs, and restores damaged reefs in marine reserves and among deep sea coral banks.

Coral reefs need your help, too! More people need to understand why coral reefs are important and what needs to be done to protect them. Here's a tasty way to start a conversation about coral reefs.

Background information taken from NOAA Discover Your World: Make an Edible Coral Reef Lesson and the Coral Reef Alliance Website: http://oceanservice.noaa.gov/education/for_fun/Makeanediblecoralreef.pdf
tures that can damage corals and to detect harmful algae that

Web Resources:
http://www.coralreef.noaa.gov/outreach/welcome.html. NOAA Coral Reef Conservation Program.

LESSON 5 (CONT)
LIVING IN CORAL

- http://www.coris.noaa.gov/about/hazards/. Information regarding hazards to coral reefs.
- http://www.floridamarine.org/features/view_article.asp?id=2020. Assessment of coral loss after Hurricane Georges, April 1999, Fish and Wildlife Research Institute.
- http://coastal.er.usgs.gov/publications/ofr/01-133/. Coral Reefs in Honduras: Status after Hurricane Mitch, United States Geological Survey (USGS).
- http://www.coral.org/resources/about_coral_reefs/coral_overview#types. The Coral Reef Alliance website.
- http://www.vims.edu/bridge/reef.html. Links to various resources on coral reefs.
- http://www.mbgnet.net. Missouri Botanical Garden.

In the News:
- http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/ORGANIZATION/EXTSDNETWORK/0,,contentMDK:21623191~menuPK:3981802~pagePK:64159605~piPK:64157667~theSitePK:3167628,00.html – Sustainable Development Network: International Year of the Reef.
- http://www.ens-newswire.com/ens/dec2008/2008-12-02-093.asp - Environment News Service - Article on Florida's reef economy.
- http://www.enn.com/top_stories/article/22197 - Environmental News Network: Hurricane Dean.
- http://www.enn.com/top_stories/article/2998 - Environmental News Network: Hurricane Wilma.

Common Misconceptions/Preconceptions:
- Only organisms that live in the coral reef system are affected by the survival and success of the reef.
- Top predators such as sharks do not utilize the coral reef ecosystem for any reason.
- It's okay to step on coral because it looks just like a rock.
- Coral is non-living.
- Coral are plants.
- Hurricanes only affect plants and animals (including humans) on land.

Materials:
Web-based or library resources on coral reefs and marine life
Large paper plate or large shoe box
Toothpicks
One sheet white cake
Icing in various colors
Food coloring
Marshmallows
Licorice whips
Small round cookies
Candy sprinkles
Candiquick mix

LESSON 5 (CONT)
LIVING IN CORAL

Technical Requirements:
Access to the internet for student research on coral reefs
Google Ocean: http://earth.google.com/ocean/

Teacher Preparation:

- Read *Teacher at Sea: Mr. Tanenbaum Explores Fisheries on the NOAA Ship Henry B. Bigelow* to learn more about how fisheries research is conducted, with particular attention paid to p. 24.
- Create an exemplar model of a coral reef habitat utilizing the materials listed above and do your best not to eat it before showing it to your students.
- Print (and laminate if possible) coral reef photos from the NOAA photo library: http://www.photolib.noaa.gov/reef/
- Print copies of the KWL (Know, Want to know, Learned) chart to assess student's prior knowledge: http://www.eduplace.com/graphicorganizer/pdf/kwl.pdf

Keywords: coral, reef, adaptation, habitat, niche, hurricane, endosymbionts

Pre-assessment Strategy/Anticipatory Set (Optional):
Start by reviewing the terms ***adaptation, habitat, and niche.*** Introduce students to the four categories of reef (**fringing reef, barrier reef, atoll, patch reef**). Have students brainstorm prior to conducting research what types of adaptations (among fish species) might be best suited for each of the four categories of reef.

Utilizing photos of the four categories of coral reef as a visual aid, explain to students that they are going to explore coral reefs by first, conducting their own research on one of the four categories of reef; second, by building a coral reef habitat of their own; and third, by exploring what threats a natural disaster such as a hurricane may pose to coral reefs. While photos are being passed around the class, hand out the KWL chart to each student. Ask students to share what they already know about coral reefs and hurricane impact on marine life. Make a list of what is 'known' on the board for the class to see. Then ask students to share a few things they would like to know about coral reefs. Did students know there were different categories of reef? After students have shared a few things they would like to know with the class, have them individually write at least 5 things they would like to learn about coral reefs, the organisms that live there, and hurricane impact on marine life. Once students have completed the first two portions of the chart, have students put the sheet aside to be returned to at the end of the activity to reflect on what has been learned from the lesson.

After the photos have been passed among the class, hang them up where students can easily see and reference them while building their habitat.

Lesson Procedure:
Student research

1. Allow students to choose a category of coral reef they would like to research. Make it clear that students are to conduct research on their category of coral reef only.

LESSON 5 (CONT)
LIVING IN CORAL

2. Have students gather information on the types of coral that comprise their reef system and at least 5 fish species that live within that reef system.
3. Have students research at least 3 adaptations and 3 functions of their reef fish that make them suited for that reef habitat. Remind students they will be presenting these adaptations and functions to the class along with their reef habitat.
4. Ask students to write a one-page summary of their reef habitat, 5 fish species, and 3 adaptations/3 functions of those species. If there is time at the end of class, on a separate sheet of paper students can brainstorm what edible materials will be used for the different parts of their reef system. List on the board the list of materials provided above and encourage students to be creative and think of other edible things they can use in constructing their habitat. Have students bring in those additional materials to the next class.
5. If there is additional time (and class resources), students can explore coral reefs using Google Ocean.

Construction and presentation of edible coral reef

1. Place students into groups (of no more than 4) based on what category of coral reef they chose to research.
2. Allow students 5-10 minutes to meet and discuss their individual ideas on what materials they would like to utilize to construct their coral reef habitat. Students will then make a collective list of fish adapted to survive within that niche.
3. Have all edible materials on one table in the classroom. One student from each group will go to the materials table to collect all the things they will need to construct their habitat. Each group will need a large shoebox or paper plate to construct their reef habitat on.
   Examples of how students might utilize materials are:
   Marshmallows might represent the polyp body of the coral and licorice whips might be the tentacles. Marshmallows can be soaked in hard candy coating to be molded and stuck together to represent a colony. Sprinkles can be used to represent the endosymbionts. Allow students to get creative in how they use their materials, but remind them they will need to justify their decision in their final presentation based on what they've learned about corals.
4. Give students 30 minutes to construct their coral reef habitat including their fish species (fish do not need to be edible, students can draw fish and associated adaptations on paper and incorporate that into their edible model). Students can then use the white sheet cake as the base for the entire coral colony.
5. Each group will give a 5-minute (time will be dependent on the number of groups) presentation on their reef habitat including an explanation of the fish species that live in their reef system and the adaptations that make them suited for that niche. Students will also need to present the 3 functions of each fish species within their coral reef habitat.

LESSON 5 (CONT)
LIVING IN CORAL

Here comes the hurricane!

1. As a class, ask students what they imagine would happen to their reef habitat in the event of a hurricane. Once the students have brainstormed as a class, allow students 20 minutes of class time to individually (or in small groups) conduct web-based research on the impact of hurricanes to coral reefs. Ask students to add their hurricane research summary (at least one page) to their one-page write up from the beginning of the lesson. The following focus questions should be answered within the one page write up. Please remind students to provide citations from the web (or library) resources they utilized to come up with their answers.

   Focus questions:
   - Is your reef habitat, based on where it is found (geographically), more or less likely to be impacted by a hurricane event?
   - Can hurricanes reduce the risk of coral bleaching to corals?
   - Will global warming affect sea surface temperatures, hurricane intensity and coral bleaching?
   - What damage to the reef might occur during or after a hurricane?
   - Does this impact the fish species that live in the reef? If so, how?
   - Are coral reefs able to revive from the impact of a hurricane?
   - What happens to a coral reef in the event of a hurricane?
   - What types of changes might be expected to occur to a reef ecosystem as a result of a hurricane?

2. Ask students to hand in the entire written summary (one page on fish species, adaptations, and functions and one page on the impact of hurricanes) to you for assessment.
3. Last, ask students to return to their KWL chart. Have them list at least 10 things they've learned based on their research and classmates' presentations.

Assessment and Evaluation:
For the purpose of this lesson, evaluate students based on their KWL charts, one-page write up, edible habitat model, and their presentation. KWL charts can be evaluated based on writing a list of thoughts for all three categories, including at least 10 lessons learned. The one-page write up should be graded based on the inclusion of a description of their reef system, 5 fish species, 3 adaptations, and 3 functions within that reef ecosystem. The habitat model can be assessed during the student presentations. Assess student knowledge of their reef system through their description of their model. Students need to include in their presentations the 5 fish species, 3 adaptations of each fish species, and 3 functions they perform within the reef. Assess student's one-page hurricane write-up along with the one-page summary they wrote in the beginning of the lesson. Check to see if students addressed each one of the focus questions listed above. Students may also assess how well they worked within the group. A peer evaluation at the end of the activity could be used to assess how well students participated within the group.

LESSON 5 (CONT)
LIVING IN CORAL

Standards:

National Science Education Standard(s) Addressed:

- NSES A: Unifying Concepts and Processes
    - Sub-categories 1, 3, 4 and 5
- NSES B: Earth and Space
    - Sub-category 1
- NSES C: Life Science
    - Sub-categories 1, 2 and 3
- NSES E: History of Nature and Science
    - Sub-categories 1 and 2
- NSES F: Personal and Social Perspectives
    - Sub-categories 2 and 4

Ocean Literacy Principles Addressed:

- Principle 1: The Earth has one big ocean with many features.
    - Fundamental Concepts: a, b, f and h
- Principle 4: The ocean makes Earth habitable.
    - Fundamental Concepts: a and b
- Principle 5: The ocean supports a great diversity of life and ecosystems.
    - Fundamental Concepts: a, b, c, d, e, f, g and h
- Principle 7: The ocean is largely unexplored.
    - Fundamental Concept: f

Additional Resources:

Movie:

- Discovery Channel movie-*Blue Planet: Open Ocean*

Websites:

- http://www.usc.edu/org/cosee-west/FebMar07Resources/19ResourcesCoral.pdf - Comprehensive list of coral reef resources (videos, websites, powerpoint presentations)
- http://www.coris.noaa.gov/about/ – Information about coral reefs from NOAA's Coral Reef Information System
- http://www.coralreef.noaa.gov/outreach/thingsyoucando.html – Things You Can Do to Protect Coral Reefs from NOAA's Coral Reef Conservation Program
- http://www.coralreef.noaa.gov/news/welcome.html – NOAA's Coral Reef Newsletter
- http://www.coralreef.noaa.gov/outreach/welcome.html – NOAA Coral Reef Conservation Program, Education and Outreach
- http://oceanservice.noaa.gov/education/kits/corals/welcome.html – Coral Reef Discovery Kit from NOAA's National Ocean Service
- http://www.latimes.com/news/local/oceans/la-oceans-series,0,7842752.special – A five-part series from the Los Angeles Times about what is happening to Earth's oceans
- http://www.coris.noaa.gov/glossary/ - Glossary of terms
- http://www.iyor.org - International Year of the Reef website

Books:

- *Teacher at Sea: Mr. Tanenbaum Explores Fisheries on the NOAA Ship Henry B. Bigelow* by Diane M. Stanitski and John J. Adler.
- Barnes, R. and R. Hughes. 1999. *An Introduction to Marine Ecology.* Oxford, UK: Blackwell Science Ltd. pp. 131-133.
- Bryant, D., L. Burke, J. McManus, and M. Spalding. 1998. *Reefs at Risk: A Map-based Indicator of Threats to the World's Coral Reefs.* World Resources Institute. pp. 11-15.

Author: Jessica Schwarz
Assisted by: Diane Stanitski and John Adler

Adapted from: NOAA Discover Your World, Make an Edible Coral Reef http://oceanservice.noaa.gov/education/for_fun/Makeanediblecoralreef.pdf

Creation date: March 3, 2009

NOTES

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NOAA

U.S. DEPARTMENT OF COMMERCE