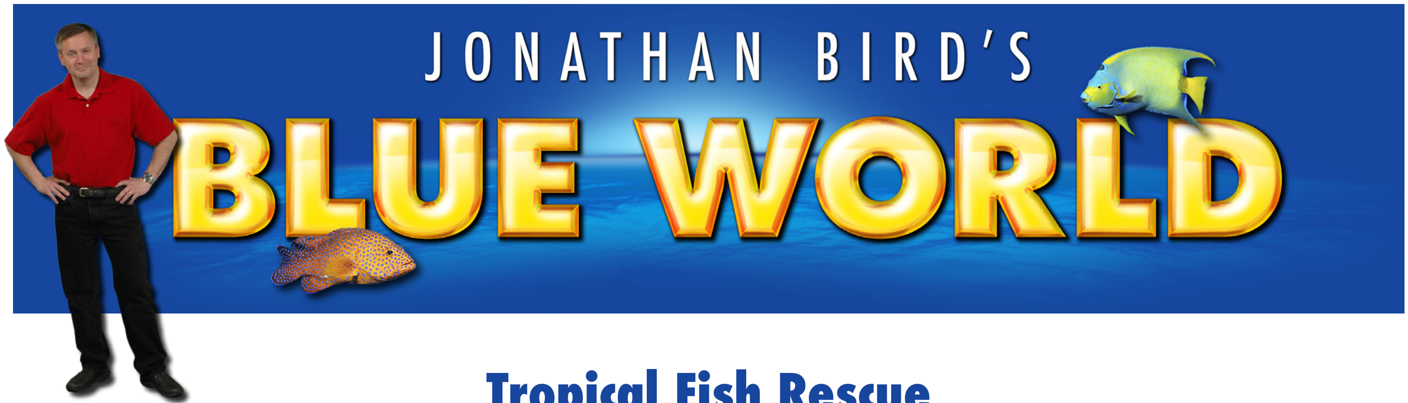

Tropical Fish Rescue

Rivers in the Sea: The Surface Currents of Our Oceans

by Bill Andrake

Science Lesson: Rivers in the Sea: The Surface Currents of Our Oceans - Based on Webisode 21
Grade Level: 6-8
Time: 4 Activities; Each ranges from 1 to 4 (45-50 min) class periods for up to 9 classes total

Introduction

In the late summer or early fall, tropical and sub-tropical fish species are often found in waters along Southern New England and Mid-Atlantic states. They are transported northward by a powerful river in the sea known as the Gulf Stream. Swirling currents that spin-off of the Gulf Stream send these warm water species into unfamiliar shores where they face a certain death as winter approaches.

In this episode Jonathan works with volunteers from the New England Aquarium Dive Club to capture and rescue these displaced fish that had found their way to the waters of Rhode Island. After their capture these fish will get new homes in the tropical exhibits of the New England Aquarium.

This lesson discusses the cause of currents and how they impact weather and life in the oceans.

Science Standards

National Science Education Standards

Earth and Space Science:
- Structure of the Earth System

Physical Science
- Motion and Forces
- Transfer of Energy

Ocean Literacy Principles
- Principle #1: The Earth has one big ocean with many features. Topic: Ocean Circulation
- Principle #3: The ocean is a major influence on weather and climate. Topic: Weather and Climate

Objectives

- To understand the cause of major surface currents in our oceans and the forces that determine their motion and direction.
- To learn how the circulation of surface currents affect the weather and climate of our planet.
- To learn the impact that these currents can have on the life in our oceans.

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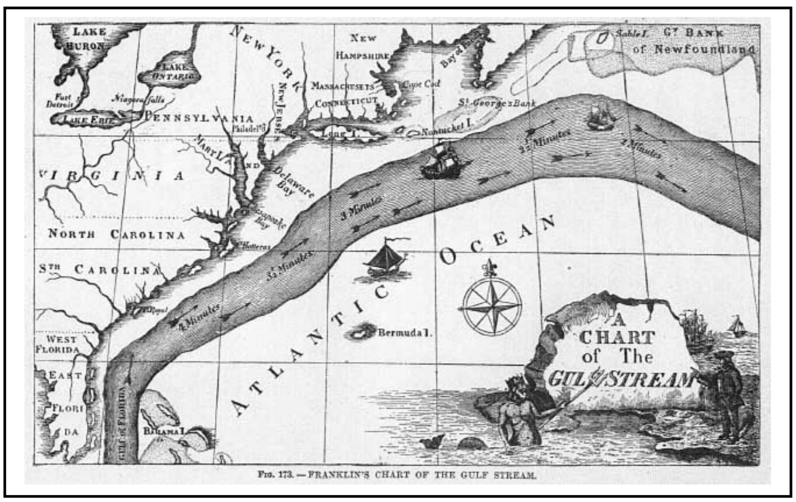
Background

For centuries sailors knew of mysterious forces in the sea that could push them backwards despite having the wind in their sails. If their ships were pointed in the right direction, these forces could also aide their travel, pushing them toward their destination faster than expected. In 1513, sailing off the coast of Florida, the Spanish explorer Juan Ponce de Leon reported in his ship's log a current more powerful than the wind that pushed his ships backward. This was probably the first written record of one of the most powerful surface currents in the sea, the Gulf Stream. Ponce de Leon's chief pilot, Anton de Alaminos established the path of the stream along the coast of North America and its eastern turn toward Europe giving the Spanish ships a tremendous advantage on their return voyage. Ship's captains were reluctant to share their knowledge of the Gulf Stream as it gave them a competitive edge over other vessels as they crossed the Atlantic.

From 1764 to 1775 Benjamin Franklin was the Postmaster General for the American colonies. Franklin observed that the mail ships leaving England took two weeks longer to reach the colonies than heavier merchant ships. While in London, Franklin presented this problem to his cousin Timothy Folger, the captain of a whaling ship. Like all whalers Folger had a vast knowledge the Gulf Stream, because whales were often found feeding along its edges where colder waters met the warm water of the stream and food was abundant. Folger explained to Franklin that the merchant ships knew to avoid the current as they sailed to America whereas the mail ships ignored this knowledge and sailed against it.

In 1769, Franklin with the help of his cousin created a chart of the Gulf Stream (below).



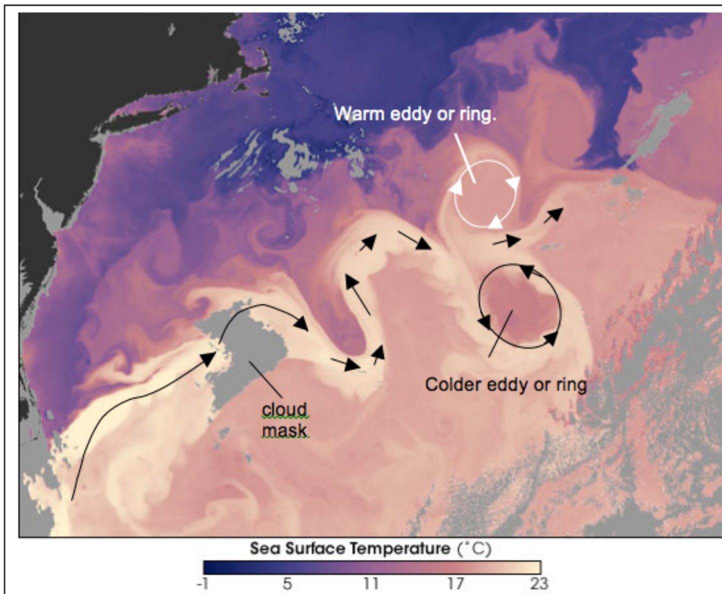
1769 Folger-Franklin Chart of the Gulfstream. From NOAA Celebrating 200 years of Science, Service, and Stewardship.
http://celebrating200years.noaa.gov/magazine/charleston_bump/franklin_mapgulfstream642.jpg

Perhaps it was an arrogant refusal to take the advice of a whaler or an American, but the captains of British mail ships continued to ignore this information, unnecessarily delaying mail and packages from England.

As a true scientist Benjamin Franklin, and had an insatiable curiosity about the Gulf Stream and how it worked. He published two more charts using temperature data that he painstakingly collected as sailed across the Atlantic. After Franklin's death in 1790, his grand nephew Jonathan Williams and great grandson Alexander Bache continued to study the Gulf Stream, collecting detailed temperature data on trans-Atlantic voyages which updated charts and led to even more information about this current. Williams discovered **eddies** or **rings** that spun off of the stream. Bache even discovered colder currents running in an opposite direction under the stream. Their work painted a picture of the Gulf Stream that was much more complex than Franklin or Folger had ever imagined.

Background (continued)

Satellite data such as this false color Sea Surface Temperature Satellite image of the Gulf Stream confirm Williams' findings and show a complex current, where cold and warm eddies (or rings) spin off the stream as it meanders along its path.

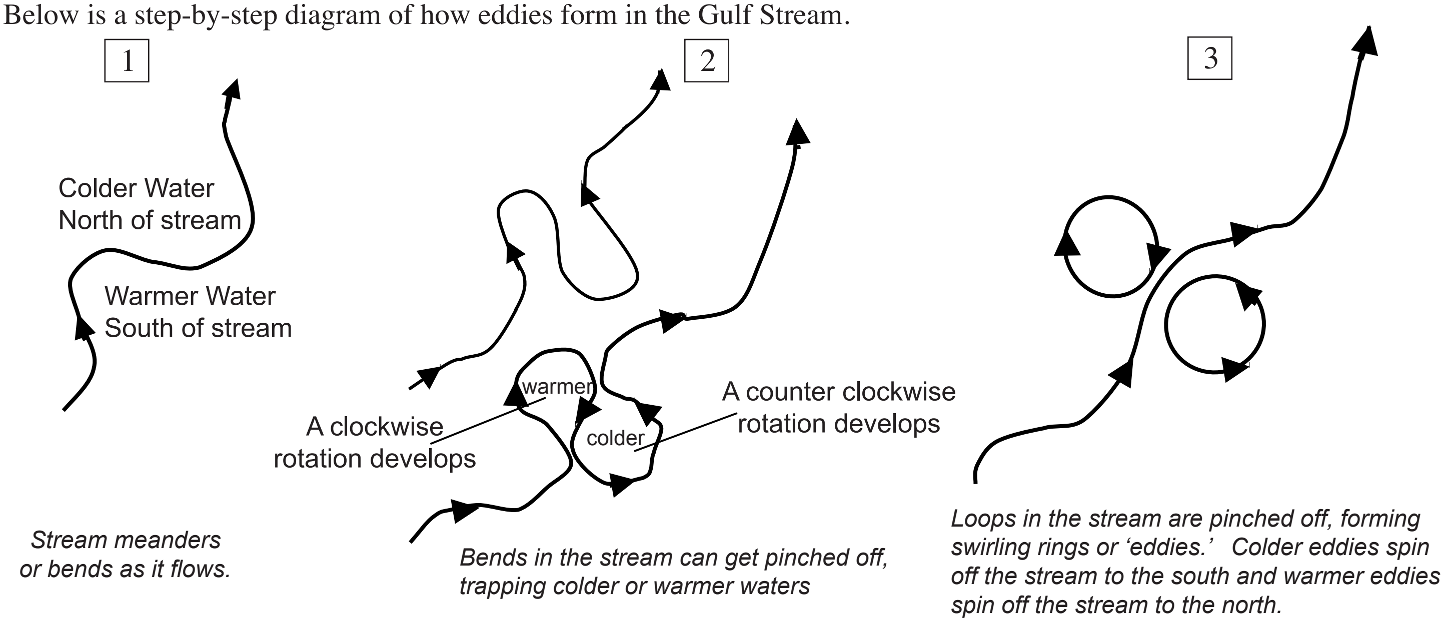


"The Gulf Stream," Image of the Day. NASA Earth Observatory

"The Gulf Stream," Image of the Day. NASA Earth Observatory
http://earthobservatory.nasa.gov/IOTD/view.php?id=5432

These rings or eddies distribute warmer waters to regions north of the stream whereas cold rings take cooler waters from north of the stream and bring them further south. Eddies can be hundreds of miles in diameter and spin off huge amounts of water north and south of the Gulf Stream. It's in this manner that warm water species can be transported to the waters of Southern New England, as was probably the case for the fish rescued in this episode of *Jonathan Bird's Blue World*.

Below is a step-by-step diagram of how eddies form in the Gulf Stream.



Background (continued)

Today we know that the Gulf Stream is just one of many powerful surface currents that control the circulation in our oceans. Traveling at speeds around 4 miles per hour, these currents can transport marine species and debris over thousands of miles, they are an important factor in shipping and navigation, and are a major influence on our planet's climate. So, what causes these currents? What forces are responsible for their motion and direction? How do they affect the climate of this planet and the life in the sea? To be sure Benjamin Franklin had some of these same questions.

Activity #1: What Causes the Surface Currents in Our Oceans?

Time: 2-3 class periods

Materials: Markers, paperplates. Optional: a manual turntable or lazy susan.

Resources:

Maps of ocean surface currents. The map in this document is from Britanica Online Encyclopedia
http://www.britannica.com/EBchecked/topic/424354/ocean-current

Maps of the Earth's prevailing winds. The sample map in this document is from How Stuff Works.com
http://maps.howstuffworks.com/world-prevailing-winds-map.htm

Also helpful: You'll need internet access and a projector to view one or more of these online resources:

1.) From Teacher's Domain.org:

a.)"Examine Global Surface Currents". This visualization from McDougal Littell/TERC illustrates the patterns of ocean currents and the global wind patterns that drive them.
http://www.teachersdomain.org/ext/ess05_int_globalsurf/index.html

b.)"What Causes the Gulf Stream?" This 2 minute video segment adapted from NOVA episode, "Adrift on the Gulf Stream", uses satellite imagery to illustrate the Gulf Stream's path. Animations show how atmospheric phenomena initiate the motion of the Gulf Stream.
http://www.teachersdomain.org/resource/ess05.sci.ess.watcyc.gulfstream/

2.)From NOAA's Ocean Explorer: Lesson 8 "Ocean Currents" This presentation explains the factors that create currents in the ocean. http://oceanexplorer.noaa.gov/edu/learning/player/lesson08.html

3.)From NASA Visualization: http://svs.gsfc.nasa.gov/vis/a010000/a010800/a010841/index.html

"Perpetual Ocean"

4.)From "Science on a Sphere": http://www.sos.noaa.gov/videos/gfdl_sst_black_400.mov

http://www.sos.noaa.gov/Datasets/dataset.php?id=133

Helpful Vocabulary:

Coriolis Effect: The apparent deflection of a body in motion with respect to the Earth due to the Earth's rotation. This deflection is to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. This results in ocean and wind currents rotating counter clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

Currents: A mass of fluid, such as air or water, moving in a given direction

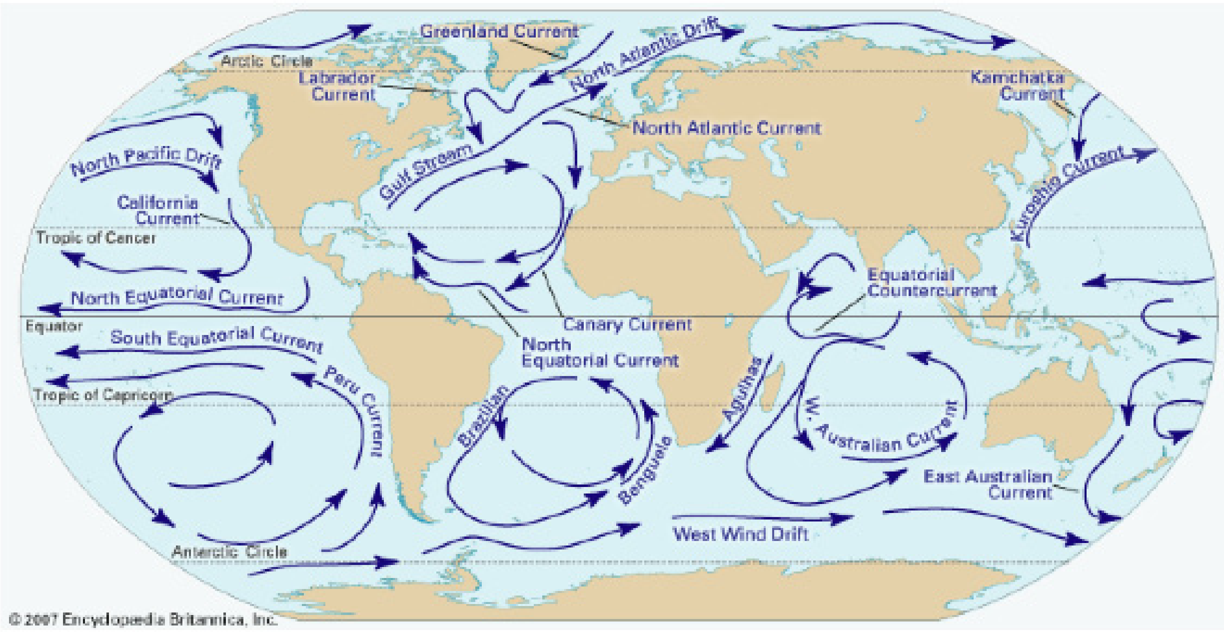
Eddy: A rotating flow or ring of water spinning off a main current

Gyre: A large system of ocean currents rotating clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere

Meander: a winding or turning path of a current

Ring: a circular current of water spinning off a main current also known as an eddy

Activity #1: What Causes the Surface Currents in Our Oceans? (continued)



Developing a Hypothesis and Eliciting Prior Knowledge:

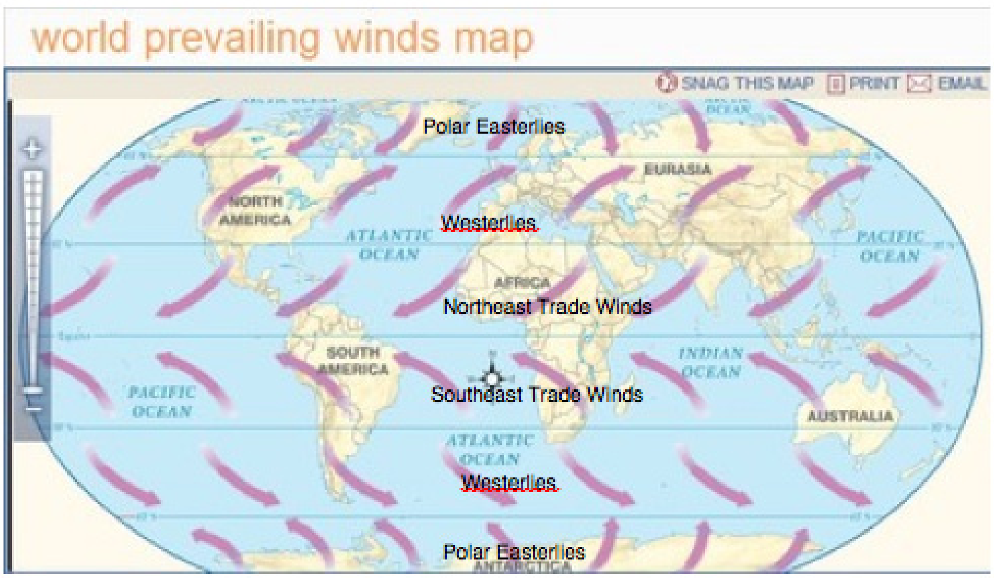
Study the map of ocean surface circulation and answer the following questions:

1. Make a list of forces or factors that could move large masses of water along the surface of the ocean to create the currents such as the Gulf Stream and the others in this map?
2. Describe the circulation pattern in the currents for each ocean ?
3. Compare the circulation in the Northern Hemisphere with that in the Southern Hemisphere. Describe what you see.
4. Other observations or ideas for discussion? In what way are these currents important?

Follow-up discussion.

1. Make a list of forces or factors that could move large masses of water along the surface of the ocean to create the currents such as the Gulf Stream and the others in this map? *Possible answers: wind, tides, Earth's rotation, gravitational pull, temperature*
2. Describe the circulation pattern in the currents for each ocean ? *Students should notice that the currents move in a circular pattern in each ocean. This circulation is like giant whirlpools.*
3. Compare the circulation in the Northern Hemisphere with that in the Southern Hemisphere. Describe what you see. *The currents circulate in a clockwise pattern in the Northern Hemisphere whereas the circulation is counter clockwise in the Southern Hemisphere.*
4. Other observations or discussion? In what way are these currents important? *Students may begin to see how these currents affect climate on the Earth. Currents moving from the tropics toward the poles would carry warmer water toward the poles and currents moving from colder latitudes toward the tropics might deliver cooler water to those areas.*

Activity #1: What Causes the Surface Currents in Our Oceans? (continued)



What gets the water moving?
From the class discussion on possible causes for surface currents, students can test their idea that winds drive the ocean circulation. Compare a map of the prevailing wind patterns on Earth with the circulation of the oceans. Students should see a connection between ocean circulation and the prevailing wind patterns. For example the Westerlies would drive currents such as the Gulf Stream and Kuroshio. The Westerlies in the Southern Hemisphere would drive the circulation of the Brazilian and East Australian Currents. The Trade Winds would push the Equatorial Currents.

View the visualization titled: "Examine Global Surface Currents."from McDougal Littell/TERC which shows how global wind patterns drive ocean circulation at: http://www.teachersdomain.org/ext/ess05_int_globalsurf/index.html

What is responsible for the circular pattern of the ocean currents in each ocean? *(Refer to maps of ocean circulation)*
In the major oceans of the planet we can see in the maps giant whirlpools formed from the circulation of the ocean currents. These giant whirlpools are called **gyres**. There are five major gyres in our oceans: the North Atlantic, South Atlantic, North Pacific, South Pacific, and Indian Ocean. What causes these gyres? Once the winds set the ocean in motion one can see in the maps that the continents block the flow of the currents, diverting them toward the North or South. *However, there is another force at work.*

Notice that the gyres in the Northern Hemisphere rotate clockwise whereas those in the Southern Hemisphere rotate counterclockwise. This has to do with the Earth's rotation and a phenomenon known as the **Coriolis Effect**.

If one were to observe the Earth from above the South Pole we would see that the Earth rotates in a clockwise direction… it is West to East. However, the view above the North Pole shows the Earth spinning counterclockwise… still West to East. (see below)

Activity #1: What Causes the Surface Currents in Our Oceans? (continued)

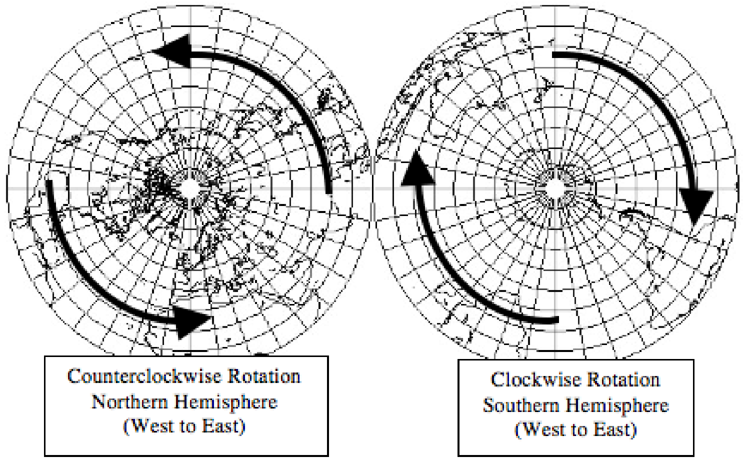


Image from: http://novaonline.nvcc.edu

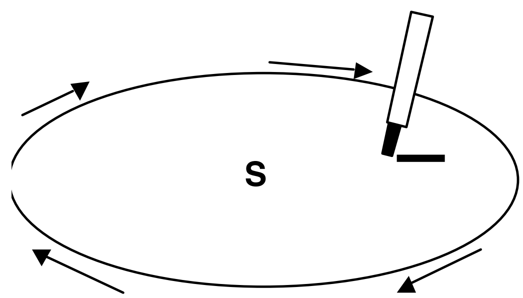
*** This opposing rotation can be demonstrated with a spinning globe when viewed from different hemispheres.*

With the **Coriolis Effect,** wind or ocean currents that travel across the rotating surface of the Earth are deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. This contributes to the clockwise rotation that we see in the ocean gyres of the Northern Hemisphere and the counter clockwise rotation of the gyres in the Southern Hemisphere.

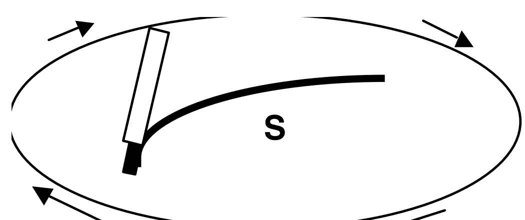
Activity #1: Demonstration of Coriolis Effect - Procedure

- Have the students work in pairs.
- One student will rotate the plate while the other will trace the path of a current with the marker.
- Label one paper plate with an "N" for Northern Hemisphere and label the other with an "S" for Southern Hemisphere.
- Lie the paper plate marked "S" flat on a table.

Using both hands one student turns the paper plate clockwise while the other student traces a path with the marker moving it in A STRAIGHT LINE across the plate. *(This may take some practice… try doing this a few times with the cap on the marker)*.



The result will be a line that has curved to the left. The marker moved in a straight line but the path it traced was deflected to the left.

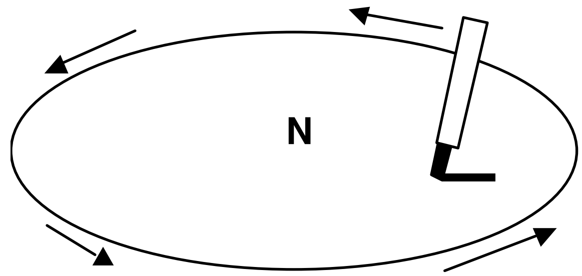


This demonstrates how the clockwise rotation of the Earth in the Southern Hemisphere results in ocean currents being deflected to the left, helping to cause counterclockwise motion of the gyres in the Southern Oceans.

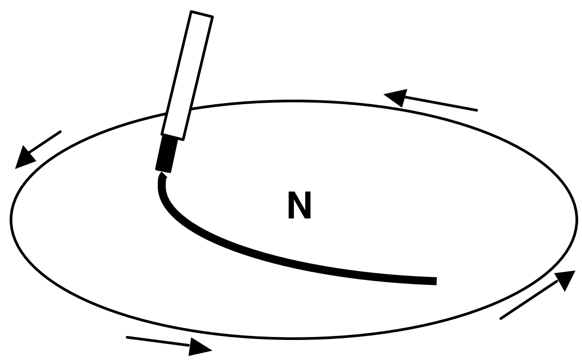
Activity #1: Demonstration of Coriolis Effect - Procedure (continued)

- Next, repeat this procedure with the plate labeled "N"

  EXCEPT THIS TIME rotate the plate in a COUNTERCLOCKWISE direction while your partner traces a path, moving the marker in a straight direction across the plate.



  The result will be a line that has been deflected to the right.



  This demonstrates how the counterclockwise rotation of the Earth in the Northern Hemisphere results in ocean currents being deflected to the right, helping to cause clockwise motion of gyres in the Northern Oceans

***An alternative method for this demonstration is to tape paper to a manual turntable or lazy susan. Then, slowly rotate the turntable clockwise or counterclockwise, tracing a path on the paper with the marker in the same manner as with the paper plates.*

Conclusion: What causes the Surface Currents in our Oceans ?

The major surface currents of the ocean are driven by the force from the prevailing winds patterns on the Earth. Continents deflect the path of the currents along with the Coriolis Effect to form giant circular whirlpools or gyres in each of the major oceans.

The following online resources summarize the cause of the major surface currents in the oceans.

- Ocean Explorer from NOAA Lesson 8.Ocean Currents
  http://oceanexplorer.noaa.gov/edu/learning/player/lesson08.html

- What causes the Gulf Stream? from on Teachers Domain PBS Series NOVA "Adrift on the Gulf Stream"
  http://www.teachersdomain.org/resource/ess05.sci.ess.watcyc.gulfstream/

- Animations of Ocean Circulation:

  From NASA Visualization Explorer : "Perpetual Ocean"
  http://svs.gsfc.nasa.gov/vis/a010000/a010800/a010841/index.html

  From NOAA's Science on a Sphere.
  http://www.sos.noaa.gov/Datasets/dataset.php?id=133

Activity #2: How Do Surface Currents Affect Weather and Climate?

Time: One Class Period

Materials: Maps of Ocean Surface Currents, World Map, Atlas, or Globe.

Introduction:

The Earth's oceans help keep the temperature of the entire planet from getting extremely hot during days by absorbing so much of the Sun's energy and this tremendous amount of stored heat each day keeps the planet from getting extremely cold each night. Without the ocean's ability to absorb this solar energy the Earth would be uninhabitable.

Ocean circulation can bring warmer water to colder regions of the world and colder waters to warmer regions, thus moderating the climate worldwide. These currents also have a major impact on the climate in those areas.

Large bodies of water keep the air near them from extreme temperature change. The ocean can keep the air along the coast cooler in the summer as they absorb a lot of heat from the air. The ocean can keep the air along the coast little warmer in the winter from the heat stored in the ocean over the summer.

Let's look at some weather and climate data that illustrates how the ocean can influence climate. Using a map, atlas, or globe find and record the latitudes for the following locations:

- Boston, Massachusetts ___________
- London, England ___________
- Reykjavik, Iceland ___________

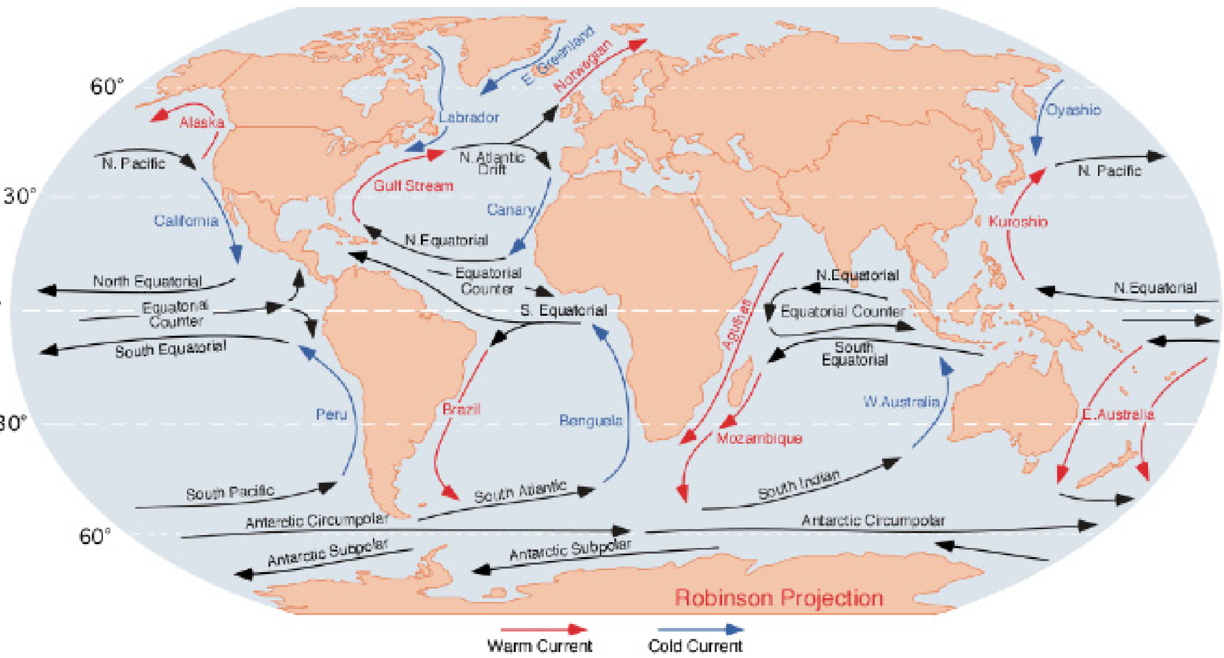
From their latitudes ... which location(s) should have the coldest climate? ___________________________________

The average winter monthly temperatures for Boston, Massachusetts....Rekyavik, Iceland... and London, England are listed in the table below. *(ClimateData from City Rating.com and The Weather Underground:wunderground.com)*

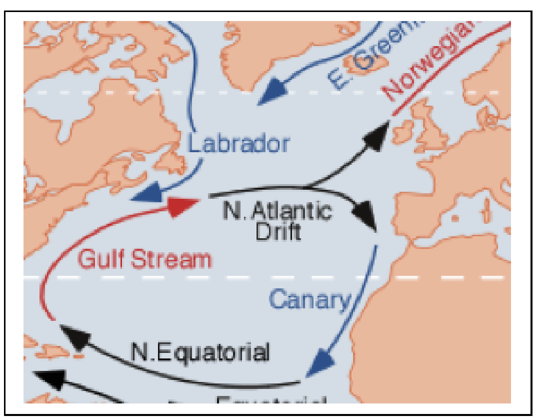
Month	Boston, Mass.	Reykjavik, Iceland	London, England
December	29 °F	33 °F	41 °F
January	30 °F	30 °F	40 °F
February	33 ° F	30 °F	41 °F

Activity #2: How Do Surface Currents Affect Weather and Climate? (continued)

Next, examine a map of ocean surface currents. *(Map from PhysicalGeography.net)*.



How can we explain the milder winter climates of Iceland and England when they are so much farther north than Boston?

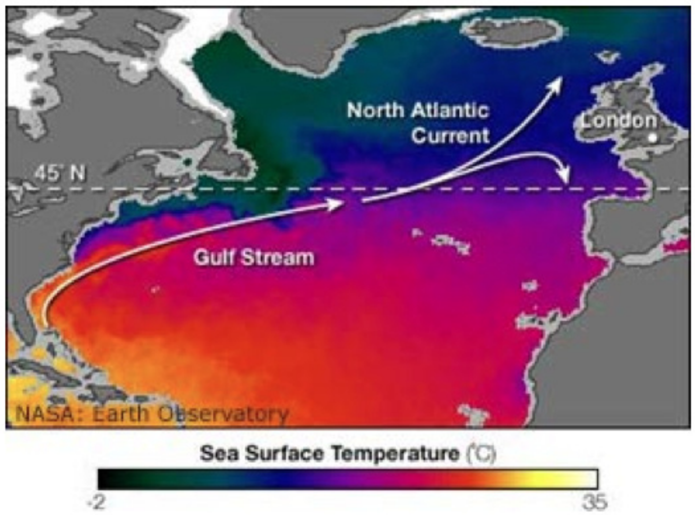


Discussion:

We can see that the Gulf Stream becomes the North Atlantic Drift , which brings warmer waters to areas such as the United kingdom and Iceland. In addition, the Westerly winds are warmed as they travel across the Gulf Stream and bring milder air to these regions. Boston, Massachusetts and the Gulf of Maine are influenced by the colder waters of the Labrador Current, which winds its way south from the Arctic.

Activity #2: How Do Surface Currents Affect Weather and Climate? (continued)

We can see the temperature influence from these currents in the North Atlantic in this false color satellite image of sea surface temperature from NASA: Earth Observatory.



Watch this 4 minute video which summarizes the affect of ocean surface currents on climate.
"The Role of Oceans in Climate" http://www.teachersdomain.org/resource/ttv10.sci.ess.watcyc.currents/

Follow-up Questions: *(All climate data from Weather Underground: wunderground.com)*

1) The latitude of the British Isles is the same latitude as NewFoundland and Labrador in Canada. The coastal town of Cartwright, Labrador has an average temperature of 5 to 7 ºF in the month of January whereas in the British Isles the January temperature is normally in the low 40's. Explain this drastic difference in climate between these locations.

2) Mark Twain once said that the coldest winter he'd ever spent was a summer in San Francisco. San Francisco's latitude is roughly that of Virginia Beach, VA on the Atlantic coast. In San Francisco, the average temperature in July is in the lower 60's whereas the temperature is in the upper 80's in Virgina Beach.

Using a map of ocean surface currents, identify the currents that influence these areas and explain how they create this difference in summer temperatures between these two locations.

Investigating Further:

What would happen to climate if there was a shift in the direction, motion, or volume of these currents?

The Earth has changed drastically over its 4.5 billion year history. What types of changes to the Earth would result in a change in ocean surface circulation?

Think about this: What might the ocean currents have been like when the continents were together in the giant landmass of Pangea?

More reading on the Gulf Stream, especially the history of its study:

Heiligman, Deborah. *The Mysterious Ocean Highway: Benjamin Franklin and the Gulf Stream*. Turnstone Publishing Group Inc., 2000.

Activity #3: The Heat Capacity of Water

Time: Three to four class periods

Materials: small paper bathroom cups, candle or busen burner, metal stand and screen to hold cup over a flame, matches, water, timer or clock, and safety glasses

Introduction:

We have learned that Gulf Stream absorbs its energy in the Gulf of Mexico and Tropics then heads north along the Atlantic Coast and still has enough heat stored to deliver mild climates to areas at high latitudes such as Iceland and the British Isles. How is it that water can store this heat AND carry it for thousands of miles. The answer is that among water's special properties, it has a very high heat capacity.

Heat Capacity is the amount of heat energy required to raise the temperature of a substance.

Water is very good at soaking up heat. Water can absorb a lot of heat without raising its temperature. Since water absorbs so much heat to raise its temperature... it can take a long time to lose this heat and lower the temperature of water. Once it's warm, water stays warm. It's difficult to change the temperature of water.

Water is great at cooling things down... water puts out fires, water cools automobile engines, and machinery... water cools us down. The ocean keeps the air near the coast cool during the summer. The world's oceans keep our planet Earth from overheating each day.

As stated above… **once its warm ...water stays warm.** We see this as air near the coast is warmer during the winter than it is further inland at the same latitude. In Massachusetts, we do not see the coldest ocean temperatures usually until early March as it takes the nearly the entire winter for the coastal waters to lose the heat that they absorbed during warmer months.

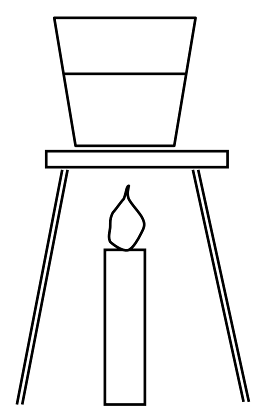
Background: ***Heat always travels from high to low temperature.***

- *Something that feels cold to your touch is absorbing heat from your hand.*
- *Something cools down because heat is leaving it and heats up because its taking heat from its surroundings.*

Activity #3: Demonstration: Heating or Boiling Water in a Paper Cup

Procedure:

- Fill a small paper bathroom cup about half –way with water and place it on a metal stand with metal screen. Put on your safety glasses when working with flame.
- Place cup over a flame from a candle or bunsen burner and record the starting time.
- Observe the heating of the water.
- How long did it take to boil the water? __________
- Did it take longer than you thought it would? __________
- What would have happened to an empty cup over the flame? ______________________
- In terms of water's high heat capacity explain why this cup with water doesn't burn over a flame?



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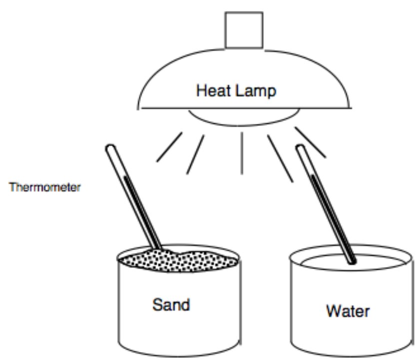
Activity #3: Demonstration: Heat Capacity of Sand vs. Water

In this activity the heat capacity of water will be compared to that of sand. A material with a high heat capacity can absorb a lot of energy without having its temperature increase. In addition since a substance that can hold a lot of heat will take a longer time to lose its heat, because it has so much more heat to lose.

Materials: Two small metal pans or shallow metal cans, sand, water, heat lamp or desk lamp with an incandescent bulb, two thermometers, access to a refrigerator.

Procedure:

- Fill one of the containers with sand and the other with an equal volume of water.
- Record the starting temperature of the sand and water in the table on the next page.
- Place the containers of sand and water under a heat lamp for about five minutes then record the temperatures of the sand and water.



Place Cups with equal volumes of Sand and Water under a heat lamp

STARTING TEMPERATURE	TEMP. AFTER HEATING	TEMPERATURE CHANGE
Sand ________° C	Sand _______ºC	Sand _______ºC
Water________ºC	Water _______ºC	Water _______ºC

- Next place the containers together in a cool location (a space in a refrigerator or cooler with ice is best).
- Leave the containers in this spot for several minutes.
- Record the temperature of the sand and water as you begin to cool them.
- Record the temperature after the cooling period.

STARTING TEMP. BEFORE COOLING	TEMP. AFTER COOLING	TEMPERATURE CHANGE
Sand ________° C	Sand _______ºC	Sand _______ºC
Water________ºC	Water _______ºC	Water _______ºC

Activity #3: Demonstration: Heat Capacity of Sand vs. Water

Results and Discussion:

1. Which material experienced the greatest change in temperature when heated? ______________________________
2. Which of the following is true: ______________________________

   a) The sand received more energy from the lamp than the water.
   b) The water received more energy from the lamp than the sand.
   c) The water and sand were exposed to the same amount of energy.

3. Which material soaked up more of this energy from the heat lamp? ______________________________

4. Review the definition of **heat capacity....then** give an explanation for the difference in the temperature change between that of the sand and that of the water.

____

____

____

5. Which material cooled quicker.... the sand or the water ? ______________________________

   Review your answer to question 3 (above), then explain why the _________ took longer to lower its temperature.

____

____

____

6. At the beach, why is it that the sand feels so hot on your feet whereas the water feels so cool… even though they are getting equal exposure to the Sun.

____

____

____

7. During the summer, locations along the coast experience cooler temperatures than places inland. How does the ocean's high heat capacity help explain these temperature differences.

____

____

____

JONATHAN BIRD'S BLUE WORLD

Activity #4: Other Effects of Ocean Currents

Relevant Connections: Tsunami Debris Washes Up on U.S. and Canadian Shores
Opportunities for extending this activity

Time: One class period

Helpful Vocabulary:

Ecosystem: A habitat and the living things that are found in a particular area

Gyre: A large system of ocean currents rotating clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere

Invasive species: Non-native or alien organisms found in a particular ecosystem.

Nuisance Species: Organisms, introduced into new habitats that can have harmful impacts on those **ecosystems**.

Tsunami: pronounced (soo- nah- mee). A large ocean wave produced by an earthquake or volcanic eruption

Resources:

• NOAA Marine Debris Program: http://marinedebris.noaa.gov/welcome.html

• Aquatic Nuisance Species Task Force: http://anstaskforce.gov/

Background:

Japanese soccer ball found in Alaska. *NOAA Marine Debris Program*.

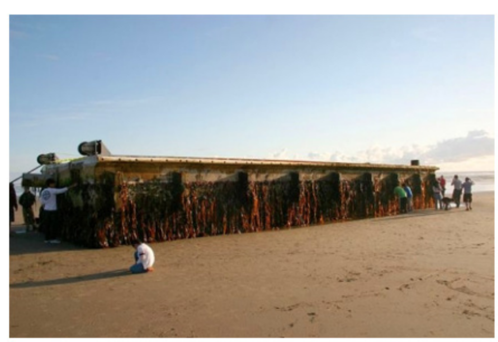
The **tsunamis** following the March 11, 2011 9.0 earthquake in Northern Japan devastated coastal areas, claiming close to 16,000 lives and leaving nearly 6000 injured. Along with the unimaginable destruction, the Japan Ministry of the Environment estimated that the tsunamis carried 5 million tons of debris into the sea. Most of this material sank offshore, but an estimated 30% or 1.5 million tons of the material floated away. Soccer balls and even abandoned ships have traveled across the Pacific on ocean curents from Japan and reached the shores of the Northwestern United States, Canada and Alaska.

Cause for concern.

Biologists are concerned that tsunami debris can harbor unwanted species of marine life from the waters of Japan that could take hold in coastal ecosystems of the Pacific Northwest and Alaska and become **nuisance species**.

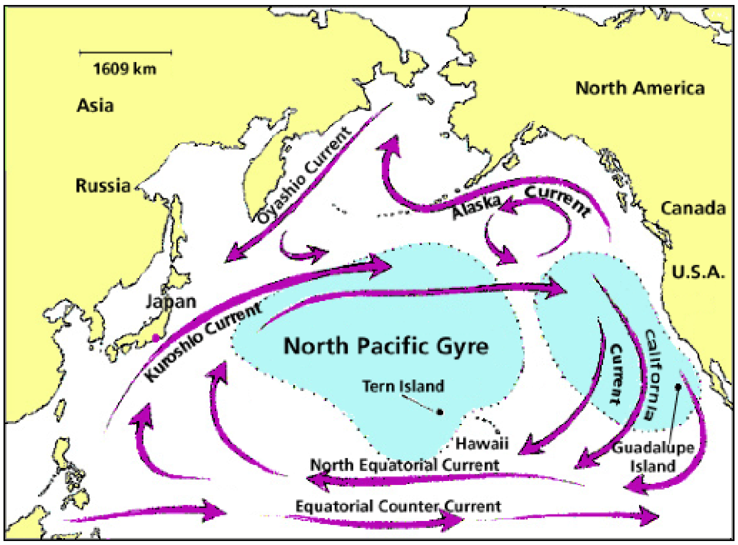
Nuisance Species or **bioinvaders** are organisms, introduced into new habitats that can have harmful impacts on those **ecosystems**. They can often out compete local species for food and space as they do not have any natural predators or grazers to keep their populations in check. On June 5, 2012, a 165 ton floating dock washed ashore on the Oregon Coast. (see photo below from from Aquatic Nuisance Species Task Force @ http://anstaskforce.gov/Tsunami.html).

The **Aquatic Nuisance Species Task Force** reported that on this dock alone, there were more than 90 non-native species, including the Asian brown seaweed (*Undaria pinnatifida*—on Oregon's 100 Worst List of Invasive Species) and the Asian shore crab (*Hemigrapsus sanguineus*—an aggressive invader of the East Coast). About **1.5 tons** of marine organisms were removed form this dock and later destroyed.



Activity #5: Other Effects of Ocean Currents (continued)

Discussion and Follow-up Questions:



Map of the North Pacific Gyre : Canadian Museum of Nature at http://nature.ca/explore/di-ef/wdgc_e.cfm

- From a map of North Pacific Ocean describe how debris from Japan could eventually reach the shores of the United States, Canada, and Alaska. Which currents would be involved in the journey of this debris?
- *Math Connection*. The dock that washed up on the Oregon Coast took about 14 months to reach the U.S. from Japan. What was its average speed as it crossed the Pacific?.. miles per day? ... miles per hour?
  Answer: Students should get an answer of about 12 miles per day… roughly 0.5 miles per hour.
- Discuss ways that non-native species can become a problem in the habitats that they invade.

Going further.

- *Students can research examples of invasive species and learn ways in which they've become a problem in ecosystems.*
- *Research other examples where ocean currents may have brought new species to distant shores. (For example.. how did coconuts end up on so many tropical islands?)*
- *It's not rare for abandoned ships to drift on ocean currents and turn up on distant shores. Perhaps they harbored invasive species that are now common in our coastal ecosystems. These vessels may have carried cargo and tools which found their way into the hands of native populations influencing their culture and methods.*

Check out "Abandoned Vessels: Drifting Across the Pacific Ocean Since 1617."
NOAA's Response and Restoration Blog:

http://usresponserestoration.wordpress.com/2012/04/05/abandoned-vessels-drifting-across-pacific-ocean-since-1617/

Activity #3: The Heat Capacity of Water: Expected Results and Answer Key

From: Boiling Water in a Paper Cup…

Question: "In terms of water's high heat capacity explain why this cup with water doesn't burn over a flame?"

Answer: The water's high heat capacity allows it to absorb so much of the heat from the flame that the paper cup cannot get hot enough to ignite and burn. Parts of the cup above the water line might burn because there isn't water there to take away the heat.

** Another dramatic demonstration of this is to take a balloon filled with air and a water balloon and hold them over a flame. The balloon with air will pop instantly whereas the water balloon can remain over the flame.

From: Heat Capacity of Sand vs. Water…

What students should expect to see:

- Heating the sand and water: *The temperature of the sand will rise several degrees whereas the temperature of the water will only increase one or two degrees at most.*
- Cooling the sand and water: *The temperature of the water will barely change whereas the sand's temperature will drop significantly.*

Results and Discussion Questions

1. Which material experienced the greatest change in temperature when heated? *Sand*

2. Which of the following is true: *(c) is the correct choice*

   a) The sand received more energy from the lamp than the water.
   b) The water received more energy from the lamp than the sand.
   c) The water and sand were exposed to the same amount of energy.

3. Which material soaked up more of this energy from the heat lamp? *Water*

4. Review the definition of **heat capacity....then** give an explanation for the difference in the temperature change between that of the sand and that of the water.

   Answer: *The heat capacity of water is much higher than that of the sand. Although both materials were exposed to roughly the same amount of energy, the water was able to absorb large amounts of this heat without raising its temperature. The sand could only absorb a small amount of this heat before releasing the excess, resulting in the sand giving off more heat.*

5. Which material cooled quicker.... the sand or the water ? *Sand*

   Review your answer to question 3 (above), then explain why the water took longer to lower its temperature.

   Answer: *The heat capacity of water is much higher than that of the sand. The water was able to absorb a lot more heat than the sand. When placed in cooler surroundings both materials were losing heat, but the water had a lot more heat to lose than the sand, so it takes a longer time to cool down.*

   *** In this way warm currents such as the Gulf Stream can carry heat for long periods of time and thousands of miles as they have absorbed huge quantities of heat in tropical and sub-tropical locations. (They have a lot of heat to lose.)*

6. At the beach, why is it that the sand feels so hot on your feet whereas the water feels so cool… even though they are getting equal exposure to the Sun.

   Answer: *The heat capacity of the sand is lower than the water. The water was able to absorb large amounts of this heat without raising its temperature and stays cool.*

7. During the summer, locations along the coast experience cooler temperatures than places inland. How does the ocean's high heat capacity help explain these temperature differences.

   Answer: *Due to the higher heat capacity of water, it is able to absorb and take away much of the heat from the air, keeping air temperatures cooler near the coast.*