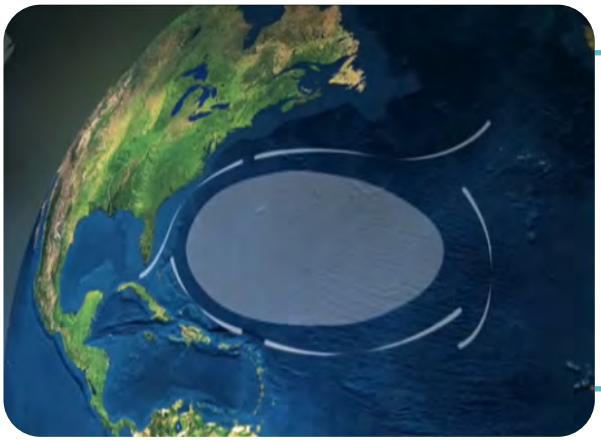
Investigating Gyre Science: Coriolis Effect



The Sargasso Sea is known as the sea with no shores, designated by major ocean currents, with Bermuda being the only land formation above sea level.

Photo Credit: Look Bermuda

FOCUS

Physical Oceanography

GRADE LEVEL

Secondary (UK) / 6-8 (US)

FOCUS QUESTON

Why are there gyres in the Ocean?

LEARNING OBJECTIVE

- The student will be able to identify the currents that bound and create the Sargasso Sea.
- The student will understand and be able to explain the Coriolis effect as it applies to gyres.

MATERIALS

Construction paper (for students to cut into one big circle)
Circle tracer (to fit construction paper)
Tack/push pin
Piece of corkboard or surface to push in pin
Rulers/pencils

AUDIO VISUAL MATERIALS

Overhead Projector

TEACHING TIME

One 45-minute period

SEATING ARRANGEMENT

Students should sit in pairs for this activity

KEY WORDS/ VOCABULARY

Gyre- Major rotational surface current systems in the ocean (5 major gyres)

Coriolis Effect- The "force" (not a true force) on moving particles resulting from the earth's rotation eastward. It causes moving bodies to deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. This deflection is more apparent at the poles and not seen at the equator.

Current- the motion of water as it flows down a slope, pushed by wind stress or tidal forces.

Equator- an imaginary line of latitude (0 degrees) on the earth surface that divides the earth into the Northern and Southern Hemispheres. The line is located equidistant from both North and South poles

Prime Meridian- an imaginary line of longitude (0 degrees) that divides the sphere of the earth into an Eastern and Western Hemisphere.

Physical Oceanography- the study of the physical conditions and physical processes within the ocean, including the way the ocean moves and the properties of the ocean waters in of themselves.

Latitude- Angular distance north to south of the equator measured at 0 degrees to 90 degrees at the poles

Longitude- Angular distance measured from the prime meridian (0 degrees) at Greenwich, England, east or west through 180 degrees

BACKGROUND INFORMATION

We know that the earths' surface currents influence the climate by taking the energy from the sun (concentrated near the equator, due to the tilt of the earth) and redistribute this heat to other areas. The Earth itself rotates on its axis at a tilt of 23.4 degrees. As the earth rotates around the sun with this tilt, the area of the equator is closest to the sun.

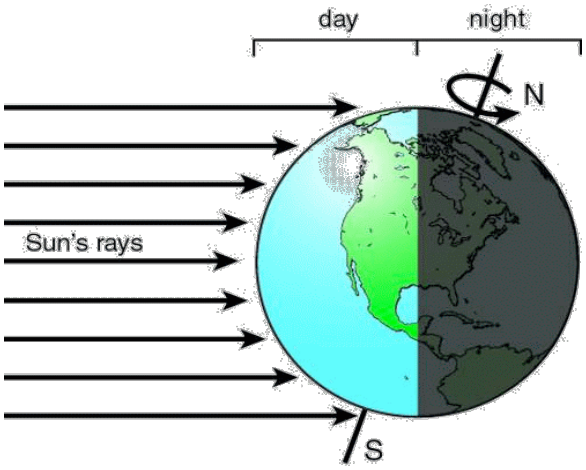


Figure 1: diagram showing earths 23.4-degree tilt and rays of the sun

Currents are driven by the wind as well as well as the difference in water temperature due the suns ability to heat the oceans. You can see that the earths' surface currents track the earths major wind belts.

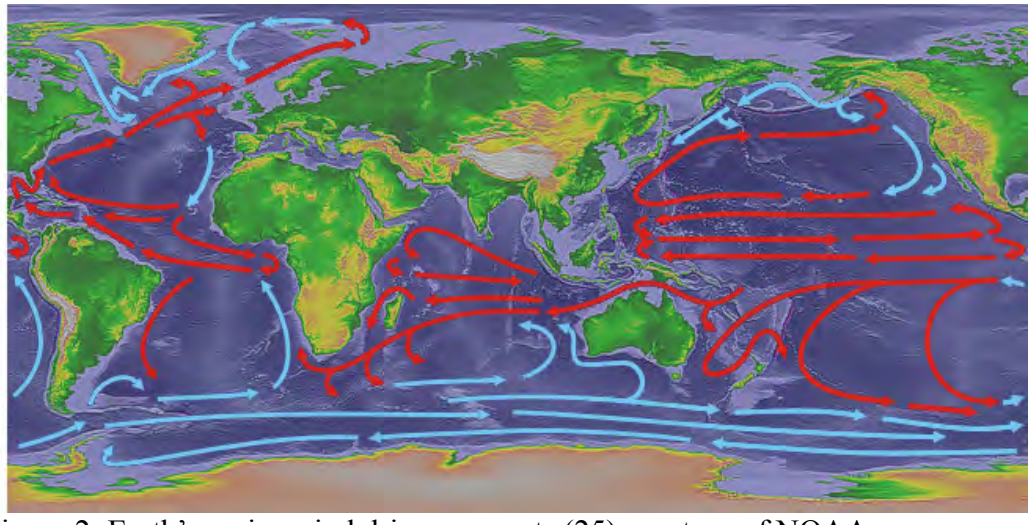


Figure 2: Earth's major wind driven currents (25) courtesy of NOAA

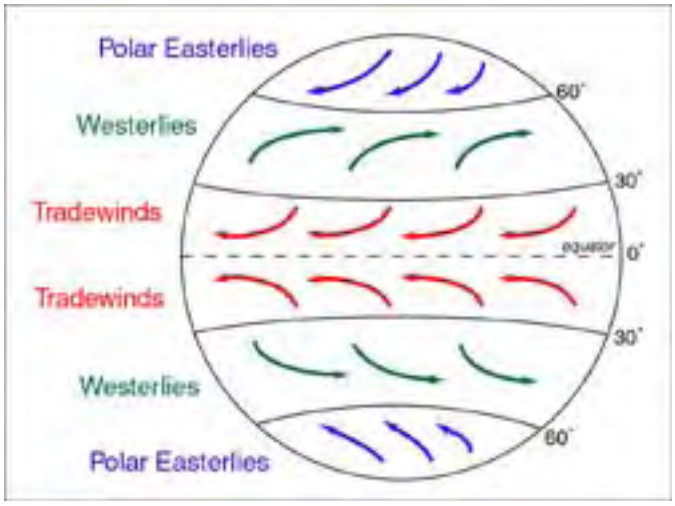


Figure 3: Earth's major wind patterns. If you look closely you can point out to students how the ocean tracks these winds. Photo courtesy of classroomatsea.net.

Because of the Coriolis effect you will notice that gyres move clockwise in the Northern Hemisphere and counter-clockwise in the Southern Hemisphere. This makes for a rotational movement of water known as a gyre. Bermuda specifically is located within the North Atlantic Subtropical Gyre. Within this gyre is the Sargasso Sea, named for the floating brown algae, *Sargassum*. This area is knows as the "sea with no shores" as the Gulf stream lies to the west, North Atlantic Drift to the North, Canary Current to the east, and North Atlantic Equatorial Current to the south. These borders are always changing depending on the Azores High Pressure center
seasonally.

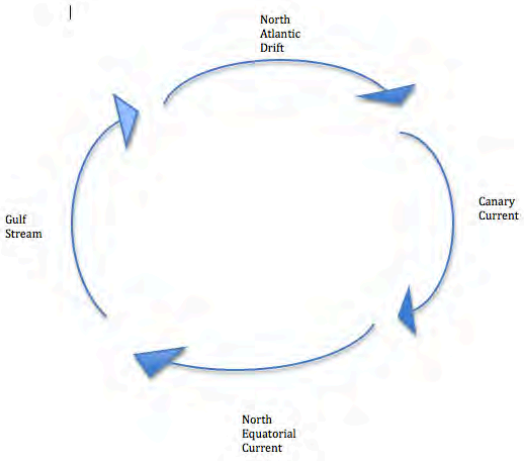


Figure 4: Major ocean surface currents that define the Sargasso Sea

The whirlpool-like movement of the waters of the Sargasso Sea accumulates not only rafts of *Sargassum*, but also other forms of marine debris. This activity will aid students in understanding the movement of the Sargasso Sea

LEARNING PROCEDURE:

- Show a map of the major gyres of the ocean and ask students if they see anything different about the movement of water in the Southern vs the Northern Hemispheres (http://i35.tinypic.com/20tkojo.jpg)
- Allow the students to conclude that they move in different directions
- Explain that the move in different directions is due to the Coriolis effect
- Introduce the Sargasso Sea using the following film clip
    - http://blog.lookbermuda.com/sargasso-sea
- Have the students after the video try and remember the 4 major currents that act as the boundaries of the Sargasso Sea
- To demonstrate the Coriolis effect in Northern vs. Southern hemispheres:
- Cut one piece of construction paper into a large circle using a circle template. This is going to be the area of ocean you are going to make your gyre
- Place your ocean on a piece of foam/cork board and place thumb tac in the middle of the earth.
- Place an x near the edge of one side of your ocean as seen in the photo below
- This X will be the base of your Western Boundary of the Sargasso Sea

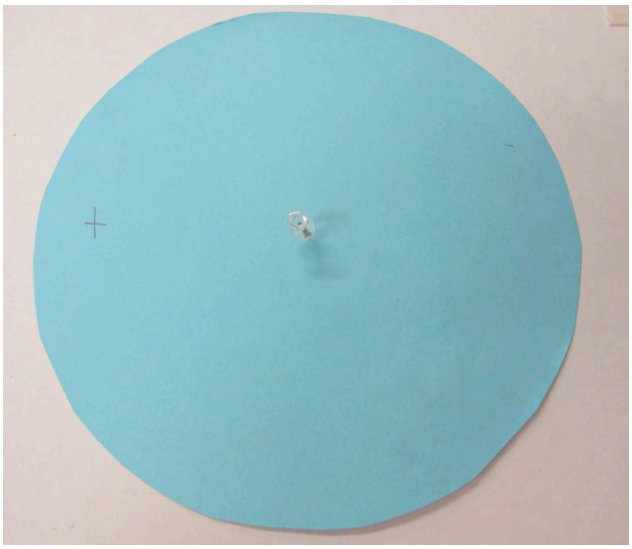


Figure 5: Mark an X on the edge of your gyre

- Hold the ruler diagonal to the X as shown in this photo.

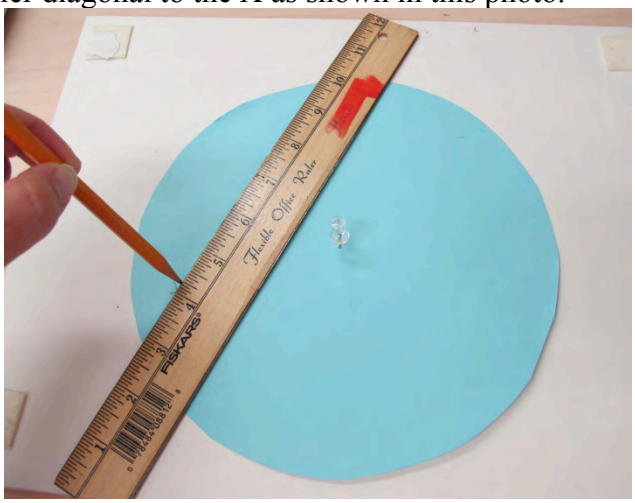


Figure 6: How to place the ruler to draw Western boundary

- Have one student rotate the earth in a counterclockwise direction while the other students draw a line about 5 inches long while holding the ruler. A curved line will result and will turn towards the right, just as the currents of the Sargasso Sea turn in to the right due to the Coriolis effect.
- Continue your arrows until all 4 of the major surface currents that border the Sargasso Sea are drawn and labeled. This demonstrates the Coriolis effect in the Northern Hemisphere (particles will bend to the right)
- Flip over your ocean and repeat the exercise turning counterclockwise. The line will curve to the left. This is what happens in the southern hemisphere. You can have the students look up major ocean currents that make up a gyre in the Southern Hemisphere here
    - http://www.srh.noaa.gov/jetstream/ocean/currents_max.htm
- Review for understanding:
    - Which currents bound the Sargasso Sea?
    - Why do the currents of the Sargasso Sea turn to the right?
    - What effects does that have on the sea itself? On Bermuda?

EXTENSIONS:

Merry-go-round

Another way to demonstrate the Coriolis effect is using the idea of a merry-go-round. The playground might have one for students to practice demonstrating the effect with foam balls, such as in the video link below.

http://www.youtube.com/watch?v=mcPs_OdQOYU

Drift Cards

Another extension may be exploring how scientists are exploring ocean currents and how they move by talking about Drift Card studies. There have been some really interesting cases of drift cards washing up on

beaches 33 years later! Learn about how NOAA and other organizations use drift cards to understand how oil and other pollutants will travel

http://the.honoluluadvertiser.com/article/2002/Dec/23/ln/ln32ajan.html

http://www.oar.noaa.gov/spotlite/archive/spot_driftcard.html

http://www.mnn.com/earth-matters/wilderness-resources/stories/what-can-28000-rubber-duckies-lost-at-sea-teach-us-about-

http://www.cbc.ca/news/story/2003/07/22/rubber_ducks030722.html

Using Radar to track Currents
http://marine.rutgers.edu/mrs/codar.html

Tracking and measuring plastics
Talking also about the accumulation of plastics within these gyres? Why does this happen, where does the marine debris go.
NASA:
http://oceanmotion.org/html/gatheringdata/flotsam.htm
Algalita:
http://www.algalita.org
5 Gyres
http://5gyres.org/
The Plastic Oceans Project
http://theplasticocean.blogspot.com/
Importance of currents to different professions:
http://education.nationalgeographic.com/education/activity/benefits-studying-ocean-currents/?ar_a=1

FUTHER READING:

http://www.education.noaa.gov/Ocean_and_Coasts/Ocean_Currents.html

http://www.education.noaa.gov/Special_Topics/Hands_On_Activities/Ocean_Motion.pdf

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

http://oceanservice.noaa.gov/facts/sargassosea.html

http://www.youtube.com/watch?v=7DVL0ugj1O4&feature=endscreen

http://tos.org/oceanography/articles/24-1_ebbesmeyer.pdf

OCEAN LITERACY PRINCIPLES:

Principle 1: The Earth has one big ocean with many features.
1c: Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the earths' rotation (Coriolis effect), the Sun, and water density differences. The shape of the ocean basins and adjacent land masses influence the path of circulation.
Principle 3: The ocean is a major influence on weather and climate.
3f: The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing and moving heat, carbon and water.
Principle 7: The ocean is largely unexplored
7d: New Technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

CLIMATE LITERACY PRINCIPLES:

Principle 1: The sun is the primary source of Energy for our Earth's climate system.
1D: gradual change in Earth's rotation and orbit around the sun change the intensity of sunlight received in our planet's polar and equatorial regions. For at least the last 1 million years, these changes occurred in 100,000-year cycles that produced ice ages and shorter warm periods between them.
Principle 2: Climate is regulated by complex interactions among components of the earth system.
2D: Covering 70% of Earth's surface, the ocean exerts a major control on climate by dominating Earth's energy and water cycles. It has the capacity to absorb large amounts of solar energy. Heat and water vapor are redistributed globally through density-driven ocean currents and atmospheric circulation. Changes in ocean circulation caused by tectonic movements or large influxes of fresh water from melting polar ice can lead to significant and even abrupt changes in climate, both locally and on global scales.
Principle 5: Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
5B: Environmental observations are the foundation for understanding the climate system. From the bottom of the ocean to the surface of the Sun, instruments on weather stations, buoys, satellites, and other platforms collect climate data. To learn about past climates, scientists use natural records, such as tree rings, ice cores, and sedimentary layers. Historical observations, such as native knowledge and personal journals, also document past climate change.