Mapping Friendly Floatees: Ship to Sanctuaries

Grade Level

5–8 or higher

Timeframe

45 minutes or more

Materials

- Presentation and student handouts (available to download)
- Red, blue, and/or black markers, crayons, or pens
- Computer, projector and screen
- *Optional:* Student access to the internet and devices; a document camera

Key Words

Coriolis effect, GIS, gyres, ocean currents, trade winds

Standards

NGSS: MS-EES-2-6.
CCSS: W.6.10. SL.6.4.
Ocean Literacy Principles: 1, 6.
Climate Literacy Principles: 1, 2.
Details at end of lesson

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National Geographic Society

&

National Marine Sanctuary Foundation

What happened after a storm tossed nearly 29,000 bath toys into the ocean?
Image: Adaptation of a photo by jplenio from Pixabay

Activity Summary

Students explore ocean phenomena through the story of floating toys that traveled far and wide after a shipping disaster. They predict where the toys might have traveled, then use ocean current and prevailing wind information to revise their predictions. Locations of toys that washed ashore are then added to maps with latitude and longitude coordinates, along with paths of ocean currents and prevailing winds. Students think about the causes of the forces and discuss as a class, preparing them to create models of the interrelated phenomena. Enrich / Extend options include creating paper models to better understand the Coriolis effect.

Learning Objectives

Students will:

- Be able to explain how energy provided by the Sun influences global patterns of oceanic and atmospheric movement.
- Analyze locations of found objects from the ocean to draw conclusions about oceanic and atmospheric forces that drive the flow of energy on Earth.
- Explain how scientists were able to analyze data from an ocean disaster in 1992 to help us better understand ocean currents.
- Argue from evidence about how changes in oceanic and atmospheric forces could impact life on Earth.

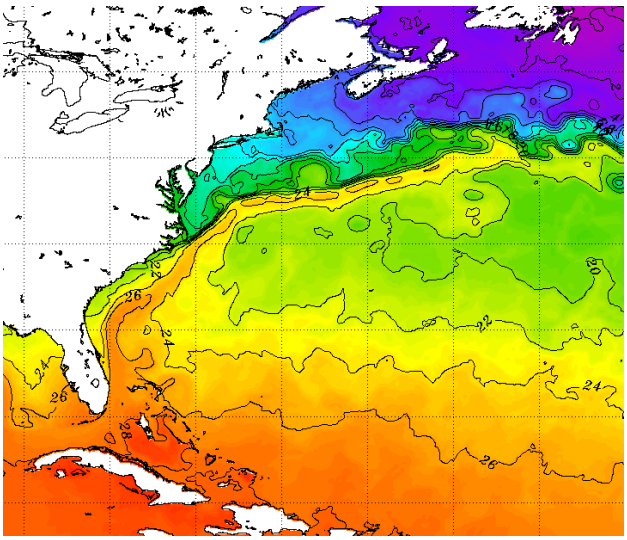
Background Information

In 1992, a cargo ship carrying approximately 29,000 bath toys (mostly rubber ducks) spilled in the northern Pacific Ocean. These so-called Friendly Floatees have been drifting ashore for more than 30 years, sometimes in surprising parts of the world—not only Alaska, but also Hawaii, Australia, Indonesia and Chile. By the early 2000s, a few had even been found as far away as Maine and the British Isles. It is presumed that many Friendly Floatees are still adrift at sea, including in the infamous North Pacific Gyre (the location of the so-called Great Pacific Garbage Patch). The destinations they have reached, and the time it took for them to wash ashore, have helped scientists better understand the complex dynamics of ocean surface currents.

Ocean Currents

Ocean currents are continuous and directed movements of ocean water driven by winds, water density and tides. In addition to water, currents also move people and goods, debris and pollution. Currents occur on the ocean's surface and in its depths, flowing both locally and globally. Coastal and sea floor features influence their location, direction and speed.

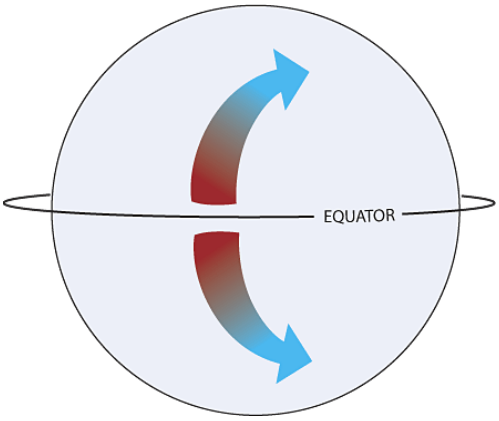
Large-scale surface ocean currents are driven by global wind systems that are fueled by energy from the Sun. These currents transfer heat from the tropics to the polar regions, influencing local and global climate. The warm Gulf Stream, originating in the tropical Caribbean, for instance, carries about 150 times more water than the Amazon River. The current moves along the U.S. East Coast across the Atlantic Ocean towards Europe. The heat from the Gulf Stream keeps much of Northern Europe significantly warmer than other places equally as far north.



A map showing sea surface temperature in the North Atlantic Ocean. Warmer and cooler waters are shown in contrasting colors and all water south of the Gulf Stream current is much warmer than the water north of it. Image: NOAA/NESDIS

Coriolis Effect

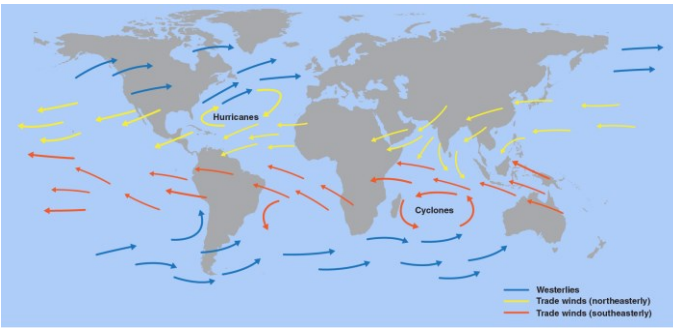
Earth's rotation results in the Coriolis effect, which also influences ocean currents. Similar to a person trying to walk in a straight line across a spinning merry-go-round, winds and ocean waters get deflected from a straight-line path as they travel across the rotating Earth. This phenomenon causes ocean currents in the Northern Hemisphere to veer to the right and in the Southern Hemisphere to the left.



A model of the Coriolis effect
Image: NOAA

Trade Winds

The trade winds are prevailing easterly winds that form between about 30 degrees north and 30 degrees south of the equator. The Coriolis effect, in combination with an area of high pressure, causes these prevailing winds to move from east to west on both sides of the equator across this 60-degree "belt." As the wind blows to about five degrees north and south of the equator, both air and ocean currents come to a halt in a band of hot, dry air. This 10-degree belt around Earth's midsection is called the Inter-Tropical Convergence Zone, more commonly known as the doldrums.



The map illustration uses arrows to represent prevailing winds, including trade winds shown with red and yellow arrows. Image: NASA/JPL-Caltech

Gyres

Gyres are large systems of rotating ocean currents. There are five major gyres: the North and South Pacific Subtropical Gyres, the North and South Atlantic Subtropical Gyres, and the Indian Ocean Subtropical Gyre. In some instances, the term “gyre” is used to refer to the collections of plastic waste and other debris found in higher concentrations in certain parts of the ocean.

National Marine Sanctuaries

National marine sanctuaries are a network of underwater areas in the ocean and Great Lakes that protect America's most iconic natural and cultural marine resources. Sanctuaries are found on the East and West Coast, Gulf of Mexico, northwestern Hawaiian Islands and American Samoa. Some of the Friendly Floatees have appeared within or near sanctuaries, including Olympic Coast National Marine Sanctuary and Papahānaumokuākea Marine National Monument. One intriguing question we suggest asking is, “Could these Friendly Floatees eventually reach every national marine sanctuary and monument?”

What’s a Rubber Duck Actually Made Of?

Rubber (including both natural and synthetic rubber) and plastics are related in that both are carbon-based polymers that can be made from either plant-based materials or fossil fuels, although the vast majority currently come from fossil-based fuels. In fact, different kinds of plastics are often combined in various ratios to create materials that have hybrid properties. In general, additives in synthetic rubbers make them more flexible and stretchable at room temperature, while some other plastics tend to be harder and more brittle.

Like plastics, synthetic rubber does not biodegrade, and though recycling rubber is possible, it can be challenging.

Learn more:

“Ocean Currents.” NOAA: https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-currents

“Ocean Currents.” National Geographic Society: https://education.nationalgeographic.org/resource/ocean-currents

“Coriolis Effect.” NOAA: https://oceanservice.noaa.gov/education/tutorial_currents/04currents1.html#1

“What is a gyre?” NOAA: https://oceanservice.noaa.gov/facts/gyre.html

“What are the trade winds?” NOAA: https://oceanservice.noaa.gov/facts/tradewinds.html

Vocabulary	
Coriolis effect	The deflection of circulating air due to Earth's rotation: deflected toward the right in the Northern Hemisphere and toward the left in the Southern Hemisphere
GIS	Geographic Information System: a computer system for capturing, storing, checking and displaying data related to positions on Earth's surface
Gyres	A large system of rotating ocean currents
Marine debris	Litter that ends up in ocean basins and other large bodies of water
Ocean currents	Continuous and directed movements of ocean water driven by winds, water density and tides: on the ocean's surface and in its depths, flowing both locally and globally
Trade winds	Prevailing easterly winds that circle the Earth near the equator

Preparation

- Download the "Mapping Friendly Floatees" presentation and handout materials.
- Make copies of (or share online) the "Our Global Ocean" and "Mapping Friendly Floatees" handouts for students.
- Gather blue, red and black (or gray) markers, pens and/or crayons for students to share.
- Practice doing the ArcGIS Online activity described under Explore below. ArcGIS Online accounts are not required. However, more features are available, including the ability to save maps and search more layers, if you have a free ArcGIS for Schools Bundle. You can request one at https://www.esri.com/en-us/industries/k-12-education/schools-software/request.

Procedure

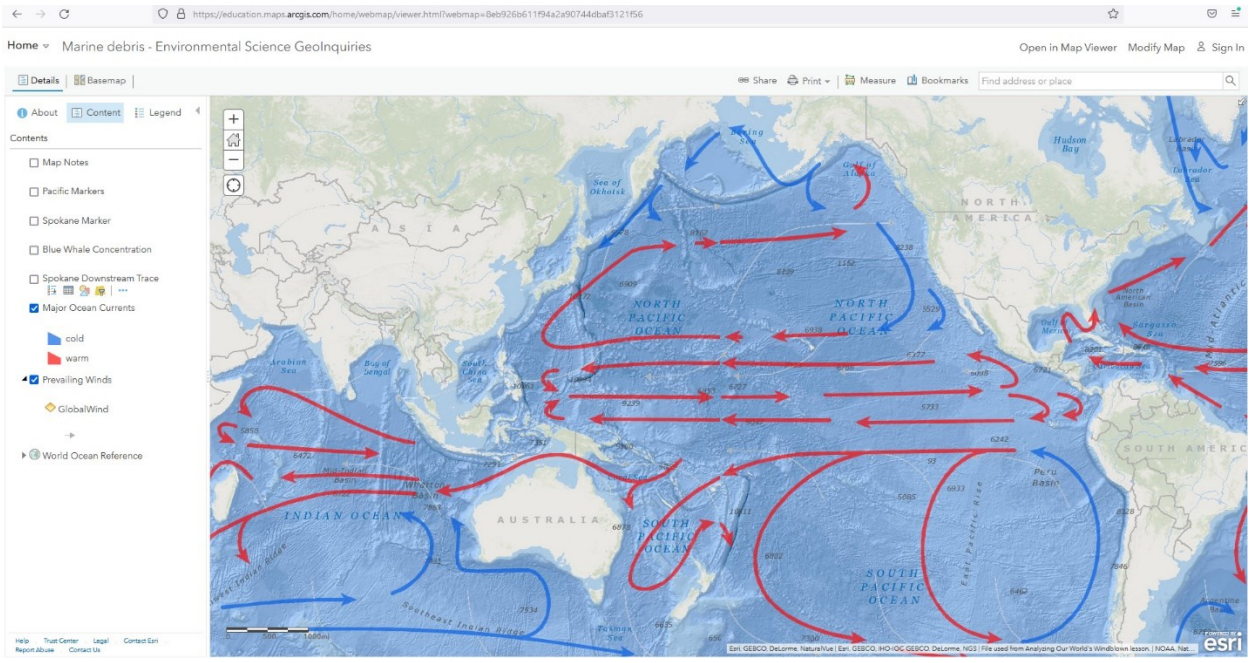
Engage

- Open the "Mapping Friendly Floatees" presentation. Show students a rubber duck, which may be made of rubber or plastic and/or the photo of a group of them on slide 1. Ask the students to, "Imagine that they are rubber ducks on a ship traveling from Hong Kong, China to the U.S." (Click to show the cargo ship with containers.) "Suddenly, a storm slams into their ship and washes their cargo container overboard. The damaged container spews them into the turbulent North Pacific ocean basin, where they are now sloshing around with about 29,000 rubber ducks and other bath toys."
- Ask students to think about what would happen to them next. Pass out the "Our Global Ocean" maps, one for each student, and ask them to think about what they know about the ocean to help them predict where they, part of the so-called Friendly Floatees, might have traveled to and why. They can turn to a neighbor to discuss, recording their ideas on the map and/or in science notebooks.
- After a minute, ask the pairs to share their ideas. Tell them that today they will be exploring this mystery by imagining that they are not just storm-tossed rubber ducks, but also

oceanographers (scientists that study the ocean) and ocean explorers tasked with predicting where the toys would go and finding some of them.

Explore

- Share a link to the "Marine debris map" from ArcGIS Online with students, or present it to the class with a projector: https://tinyurl.com/mr28xuzd. (The complete link is http://education.maps.arcgis.com/home/webmap/viewer.html?webmap=8eb926b611f94a2a90744dbaf3121f56.) We suggest that students explore the software while you demonstrate the steps below via the projector.
- Ask students to mark the location where the Friendly Floatees went overboard: 45° north latitude, 178° east longitude. Tell them that they can use the Search tool (magnifying glass and field that says "Find address or place") and type "45N, 178E" then hit enter. It will add a point on the map and zoom in to the location. Tell students they can click the link that says Add to Map Notes on the box that appears to mark the point on the map. They can zoom back out using the "–" button in the upper-left corner of the map (below the "+" and home buttons) to see the whole map, including the pin showing the location of the spill.
- Show students that on the left side of the screen they can click Details > Content. This shows available map layers, which they can turn on and off with the checkboxes. Show them how they click the Major Ocean Currents layer. Ask them why they think the cartographer (map maker) chose the color-coding system that she did. If they click "Major Ocean Currents" they will get more information to test their ideas (blue=cold ocean currents, red=warm currents).



- Check the box to show the Prevailing Winds layer, which shows faint gray arrows that model the most common winds, such as trade winds.
- Ask students to use the additional scientific/Geographic Information System (GIS) information about ocean currents and prevailing winds to revise their predictions about

where the nearly 29,000 Friendly Floatees might have traveled. They can record these predictions on their paper maps, in science notebooks or by searching for coordinates in ArcGIS Online to add them to the map.

- Pass out the "Mapping Friendly Floatees" handout and ask students to follow the instructions to add the actual locations of some of the toys from the 1992 disaster to their map. Ask them to think about how those locations compare to their predictions of where the toys might go. Is anything surprising?
- Ask them to follow the rest of the instructions to complete the modeling activity and answer the questions. Tell them they will have 15 minutes to work and should be ready to share their ideas with the class.
- Circulate through the class and pass out blue, red and black (or gray) markers, pens and/or crayons for students to share. Answer and ask questions to help students think about the phenomena and complete the activities. Tell them when there are 5 minutes and then 2 minutes left to work. They should prepare to share their ideas about the questions.

Explain

- Ask students to share their ideas. If you have a document camera, one or more students can share their ocean models showing important forces that moved the Floatees. Discuss how the ocean currents and prevailing winds shown on the map were only models of the most important currents and winds. The actual path of debris in the ocean can vary widely based on many other factors. Ask what other factors might affect marine debris as small as a rubber duck or a piece of plastic.
    - Possible responses include waves, storms, tides, wind, solar energy, passing ships, migrating animals and landforms creating physical barriers.
- Fill in gaps, correct misunderstandings, and clarify meanings of terms like ocean currents and gyres as they arise. Discuss how the Sun's energy is a primary force that drives the ocean currents and wind. Contrast how it warms areas near the equator versus areas near the poles.
- Share one or more video clips to help students better understand important concepts.
    - "How Do Ocean Currents Work?" (4:33) from TED-Ed video, is one option: https://ed.ted.com/lessons/how-do-ocean-currents-work-jennifer-verduin. You can pause at 0:33 to show the locations where more Floatees have been identified. Ask students, "How did their predictions match actual locations of recovered Floatees shown in the video and data table on the handout?"
    - NOAA's "Ocean Currents" (3:23) includes other forces at work: https://oceanservice.noaa.gov/podcast/apr14/mw123-currents.html. Ask students to record new things they learned on the handouts and/or in science notebooks.
- Ask students to update their ocean models with additional information they are learning and new ideas they have. Discuss how there are certain predictable patterns of water and air movement that scientists have studied. Explain that these patterns are not constant,

and the path of the Friendly Floatees has shown us that there is still much more we need to learn about how the ocean works.

- Ask students if they noticed any similarities between the Major Ocean Currents and the Prevailing Winds layers on the ArcGIS map. Possible responses:
    - Both tend to move in curves – clockwise in the Northern Hemisphere and counter-clockwise in the Southern Hemisphere.
    - However, there are exceptions to these general patterns, especially as water approaches the polar latitudes, both North and South.
- Discuss how one of the main forces driving ocean currents and wind patterns is the rotation of the Earth, which produces an interesting phenomenon called the Coriolis effect that causes ocean currents and winds to curve. See the links at the end of the Teacher Background section for more details.
- Show the map of the national marine sanctuaries and monuments from the presentation or website: https://sanctuaries.noaa.gov. Ask students to share their ideas about which national marine sanctuaries might have been visited by the Friendly Floatees. These should include Olympic Coast National Marine Sanctuary and Papahānaumokuākea Marine National Monument, locations of two of the recovered Floatees listed in the data table.

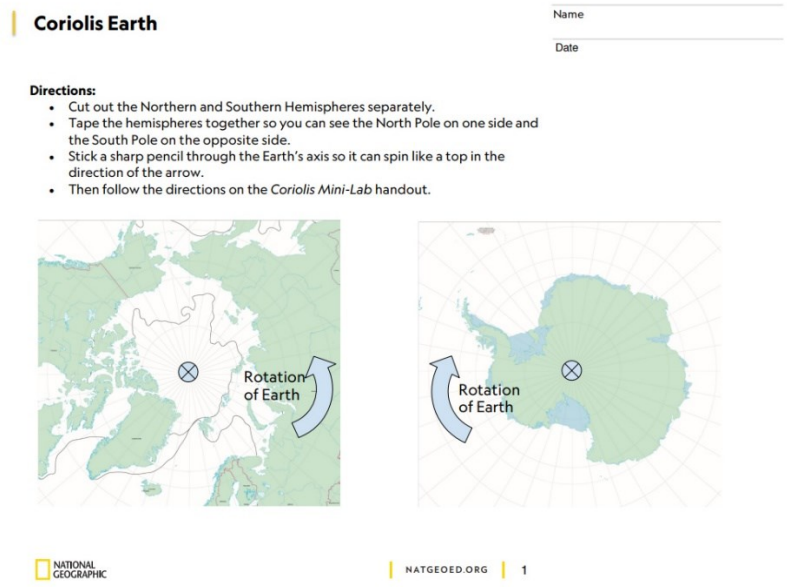
- Ask students: "Could these Friendly Floatees eventually reach every national marine sanctuary and monument?" Give them a minute or two to discuss the question with a partner.
- Discuss student ideas and how all the ocean basins in our global ocean, as well as the Great Lakes, are all connected, and how all of our sanctuaries and monuments could eventually

be impacted by the floating toys, especially as they degrade into microplastics. These tiny pollutants can float on the ocean's surface, sink into its depths and be ingested by marine life like fish that are also consumed by us as it passes through food chains.

- Discuss how oceanographers and others have used our increased understanding of the ocean to discover where much of our floating plastic is collecting, such as in rotating ocean gyres, to try to reduce the problem. Ask students to share their ideas for how we can reduce the urgent problem of plastic in the ocean.

Enrich/Extend

- Pass out copies of the "Coriolis Earth" activity from National Geographic Society: https://media.nationalgeographic.org/assets/file/CoriolisEarth.pdf. Ask students to create the spinning model Earth by following the instructions. See a discussion of the activity in the lesson that inspired this one and a "Coriolis Mini-Lab" handout / answer key at https://www.nationalgeographic.org/activity/follow-friendly-floatees.



- Show the short "Ocean Plastics: Explorers in the Field" video from National Geographic: https://education.nationalgeographic.org/resource/ocean-plastics. Invite students to brainstorm other strategies to prevent plastic from getting into the ocean and ways to remove it. Encourage students to present their ideas to the class and discuss which of them might be most feasible and impactful.
- Ask students to reflect on how changes in oceanic and atmospheric forces could impact life on Earth. They should argue from evidence about ocean currents, prevailing winds, and how the climate is changing, including ideas about how it might impact your local area and other parts of the world. They could also include steps that are already being taken—and could be taken—to mitigate the impacts.
- Invite students to use the Ocean Surface Current Simulator (OSCURS) to help predict the paths that future plastic added to the ocean might take: https://oceanview.pfeg.noaa.gov/oscurs.

Evaluate

- Review student answers to questions, map models and science notebooks. Evaluate their participation in class and group discussions.
- Ask students to develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of oceanic and atmospheric circulation that determine regional climates (MS-ESS2-6). They could start with the simple paper model of the Earth from the "Coriolis Earth" activity in the Enrich / Extend section or use a medium of their choice, such as a color illustration or 3D clay model with labels.
- Ask students to summarize their understanding of all the forces that have allowed the Friendly Floatees to move so far from the site of the disaster in 1992. They can present this information in a medium of their choice, such as a multi-panel cartoon, video or skit.

Education Standards	
Next Generation Science Standards	Ecosystems: Interactions, Energy, and Dynamics • MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. Science and Engineering Practices: • Developing and Using Models • Constructing Explanations and Designing Solutions Crosscutting Concepts: • Cause and Effect • Systems and System Models
Common Core State Standards	Writing: W.6.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. Speaking and Listening: SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes.
Ocean Literacy Principles	1. The earth has one big ocean with many features. (a, c, e) 6. The ocean and humans are inextricably interconnected. (d, g)
Climate Literacy Principles	1. The Sun is the primary source of energy for Earth's climate system. (a, c) 2. Climate is regulated by complex interactions among components of the Earth system. (a, b)

Additional Resources

"The Coriolis Effect: Earth's Rotation and Its Effect on Weather." Article from National Geographic Society and video from PBS Learning Media: https://education.nationalgeographic.org/resource/coriolis-effect

"The Geography of Ocean Currents" lesson plan from National Geographic Society: https://www.nationalgeographic.org/activity/geography-ocean-currents

"Modeling Oceanic Transport of Floating Marine Debris." NOAA: https://marinedebris.noaa.gov/sites/default/files/publications-files/Modeling_Oceanic_Transport_of_Floating_Marine_Debris.pdf

"Ocean Currents and Climate." National Geographic Society: https://education.nationalgeographic.org/resource/ocean-currents-and-climate

"What are Trade Winds?" NOAA SciJinks: https://scijinks.gov/trade-winds

Find your local tides and currents by state: https://tidesandcurrents.noaa.gov

For More Information

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