Predicting the Path of Marine Debris

Objectives:

Students will understand that air and water have different densities at different temperatures and that these density differences drive global and local patterns of air and water movement in wind and currents. They will recognize how Coriolis effect influences wind and current patterns, and how this can create ocean gyres. They will create a flow-chart of plastic movement to the ocean, detailing how physical factors power this movement and how people can stop it.

Concept:

Temperature-dependent gradients of density drive the movement of air and water in winds and currents. As hot air or water rises, cool air or water moves in to fill the space left behind. This movement is deflected by the rotation of the earth, called the Coriolis effect. Marine debris is transported by both winds and currents. Debris large and small tends to accumulate in ocean gyres, such as the North Pacific and North Atlantic.

Materials:

- Science notebooks
- Pencils
- Computer/laptop and projector or SmartBoard
- Handout: Blank Map
- Handout: Predominant Surface Currents in the Ocean
- Handout: Science from Bath Toys

Preparation:

Load the NOAA Global Science Investigator for marine debris in the North Pacific Gyre: http://www.csc.noaa.gov/psc/dataviewer/#view=mdebris.

Research to find out if there is local drift card information available for your area.

Print 1 copy of the Science from Bath Toys story to read as the teacher.

Students can use their maps from the Currents and Coriolis lesson. If you haven't done that lesson, make enough copies of the Blank Map and Predominant Surface Currents in the Ocean handouts for each student.

Introduction:

Begin by showing the "Majestic Plastic Bag" mockumentary on YouTube: http://www.youtube.com/watch?v=GLgh9h2ePYw).

At the conclusion of the video, ask students to write their reaction in their science journal.

As a group, brainstorm different pathways plastics follow to the ocean.

Have students sketch a quick flow chart of a piece of plastic's journey to the ocean.

Procedures & Activities:

Explain to students that marine debris is transported by winds and currents, which are driven by temperature differences in water and air masses.

Discuss the transport of plastic and floating debris across the globe's ocean. Explain that there is really only one ocean, and water moves around it in surface and deep ocean currents.

Predicting the Path of Marine Debris *Continued*

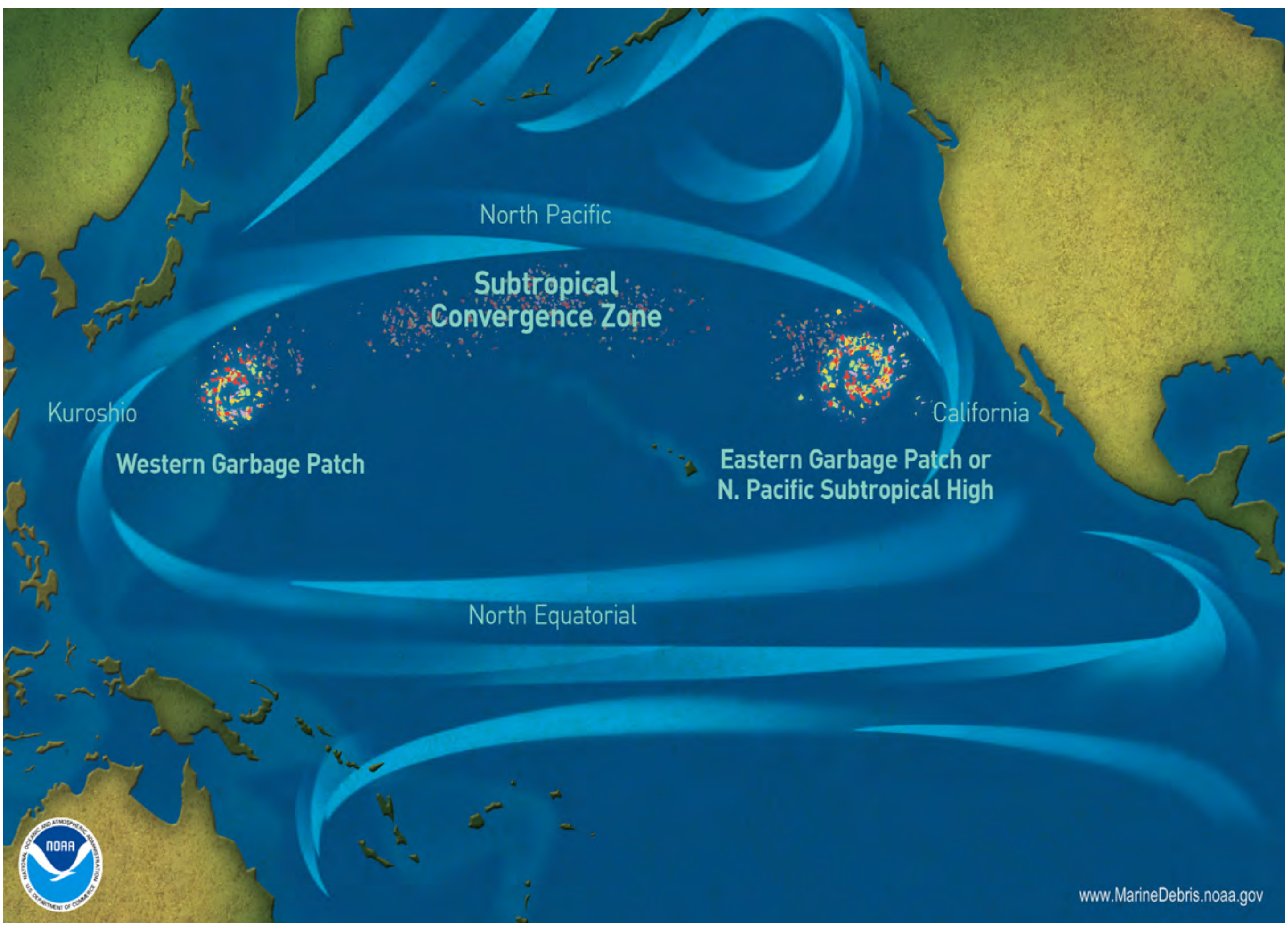
As currents are deflected to the right by the Coriolis effect (or to the left in the southern hemisphere), this creates a circular pattern. Water tends to 'pile up' within these circular currents, called gyres.

Currents concentrate marine debris in these gyres, creating what are sometimes referred to as 'ocean garbage patches'. These garbage patches are dynamic, shifting with the winds and the currents. The map below demonstrates where some of these 'garbage patches' are located. Map from the NOAA Marine Debris Program.

Use the Global Science Investigator to demonstrate the path of drifter buoys into the North Pacific Gyre: http://www.csc.noaa.gov/psc/dataviewer/#view=mdebris.

Pass out Blank Maps to students or have students use their Surface Current Map from the Currents & Coriolis Lesson. Work as a class to label the continents and ocean basins.

If you are using a blank map, provide a copy of the Predominant Surface Currents in the Ocean handout to students and have them transfer the currents onto their map.



Predicting the Path of Marine Debris *Continued*

Explain to students that one well-known container ship spill helped people to better understand currents and gyres.

"Friendly Floatees" bath toys were being shipped across the Pacific Ocean to be sold by The First Years, Inc. In early winter, 1992 a container filled with the toys (as well as 11 containers filled with other products) were lost overboard in the middle of the Pacific Ocean.

Tell students that, as you read the story, they should mark on the map the locations where the floatees made landfall, noting the year(s) they arrived there.

Read students the story of Science from Bath Toys.

Ask students to use their knowledge of currents and the information from the story to identify currents that might have transported the floatees. Can they figure out how the floatees ended up on those beaches? Are any of the floatee landfall locations surprising?

Finally, load the Ocean Surface Current Simulator (OSCURS): http://las.pfeg.noaa.gov/oscurs/.

Use OSCURS to predict the path of marine debris:

Drag the red balloon marker to choosethe starting point. You may also input latitude & longitude information below the map. You can zoom in closer to Alaska.

Choose a time period for the simulator to run. Input this information below the map. The simulator can be used for time periods as far back as 1967, but it is best to use a duration of run less than a year. (May 1967-May 1968, for example, or June 2013-January 2014). Time spans longer than a year can be too much for the simulator to process.

On the left side of the map, click "Run Model" and see the predicted track for the debris.

Below "Run Model" you can change the color of the track so it is easier to view different runs. You can also change the "Optional Parameters." The simplest parameter to adjust is the "wind current speed coefficient." This refers to how much of the object sits above the water and is subject wind forces. The default setting is 1.0, but larger objects such as big bottles may have a coefficient as high as 2.0.

Have students choose a scenario and location in the Gulf of Alaska, Bering Sea, Arctic Ocean, or North Pacific. For example, where would the debris go if a shipping container of shoes spills overboard in the middle of the North Pacific in an October storm or if a plastic bag blows off a commercial fishing boat in Bristol Bay in June?

Ask them to predict, based on their knowledge of predominant currents, where a piece of marine debris might travel if it went overboard in that location. Have them write their predictions in their science notebooks.

Run OSCURS. Does the simulated location match with the students' predictions?

Try changing the time and duration of the run. How is this track different than the first? What factors might be explain the difference?

Predicting the Path of Marine Debris *Continued*

Wrap-Up:

Finally, bring the concepts of wind and current to a local level. If you are located near the ocean, discuss whether your area experiences a day breeze on hot days. *(This is caused when the sun heats the land, causes warm air to rise from it. This space is then filled by cool air off the ocean. The reason the winds don't come straight off the ocean? Coriolis effect!)*

Talk about the factors that drive heat and cold in your area and how they might affect local transport of debris.

Ask students to explain in their science notebooks a local weather or current pattern based on the information presented in this lesson.

Discuss some of the areas local bodies of water are likely to "receive" debris from, and where local debris may end up. Use local drift card models to confirm predictions if available.

Ask students to revisit the flow chart they created at the beginning of the lesson. Have them identify the different physical factors that affect the transport of their plastic piece to the ocean. These physical factors will include the movement of water due to density gradients, but students should also consider such factors as wind, tides, and gravity. Ask them also to identify three ways that they could interrupt this flow of plastic to the ocean (ie. proper disposal of plastic, recycling, reusable bags, cleaning up litter, filtering technology, etc.)

Extensions & Lesson Connections:

This activity works well as a follow up to the "Density Differences: Air," "Density Differences: Water," and "Currents & Coriolis" lessons.

The Marine Debris Science Kit from C-MORE (Center for Microbial Oceanography: Research and Education) is an excellent resource for an extended lesson using OSCURS. Lesson 2 of this kit allows students to use OSCURS to extrapolate the origin of specific marine debris pieces based on information about the date it was lost, where it was found, and the date it was found. The lesson information can be accessed here: http://cmore.soest.hawaii.edu/education/teachers/science_kits/marine_debris_kit.htm and the kit can be requested through: http://cmore.soest.hawaii.edu/education/teachers/science_kits/requestform.htm.

Evaluation:

The initial flow charts serve as a pre-assessment, while the revised flow charts should illustrate student understanding of how weather systems and ocean systems affect each other and the transport of solids and liquids in the ocean, as well as the connection of watersheds to the ocean. Review the science journals and maps to assess students' understanding of predominant surface current patterns.

