Going with the Flow

A Classroom Activity for *Ducks In The Flow - Where Did They Go?*

Summary:

Students use a simple model to discover that air moving over water causes the surface of the water to move horizontally. In writing and in a discussion, students relate this concept to surface currents in the ocean and the Great Lakes.

Student Learning Outcomes:

Students will be able to

- Relate the motion of surface currents (cause) to the motion of objects floating in the ocean and Great Lakes (effect)
- Relate the transfer of energy from wind moving across water (cause) to the horizontal movement of water (effect)
- Use the term “surface current” to explain horizontal movement of surface water caused by wind
- Explain that surface currents affect surface water, not deep water

Standards:

Ocean Literacy Essential Principles and Fundamental Concepts

- The Earth has one big ocean with many features.

National Science Education Standards

- (K-4) Position and motion of objects
- (5-8) Structure of the earth system
- (5-8) Motions and forces
- (5-8) Abilities necessary to do scientific inquiry

Grade Level: 3-5

Materials: (teams of 2-3 students)

- 5-6 quart clear plastic shoebox (1 per team)
- Water (to fill shoeboxes approximately ¾ full)
- Black construction paper (I per team)
- Bendable straws (1 per student)
- Paper towels (for clean up)
- Newspaper (to cover table/desk)
- *Going with the Flow Data Sheets 1-3* – (1 per student)
- For *Activity 1: Aluminum foil* (Each team crumples 20 one-inch squares into 10 loose balls that will float and 10 tight balls that will sink.)
- For *Activity 2: Rheoscopic fluid* (Dilute 150 ml of rheoscopic fluid in 3 L of water per team; the diluted fluid can be reused.)

Purchase Note: You can purchase rheoscopic (convection) fluid from many online vendors for approximately $10/L:

- Arbor Scientific - www.arborsco.com (# P8-5000)
- Carolina Biological - www.carolina.com (# GEO8450)
- Educational Innovations - www.teachersource.com (# RH-100)
- Fisher Scientific - www.fishersci.com (# S4520 or S4521)

Time: 1-2 class periods (45 minutes each)

For more information, please visit:
www.windows.ucar.edu/ocean_education.html

Activity 1 – Directions and Procedure

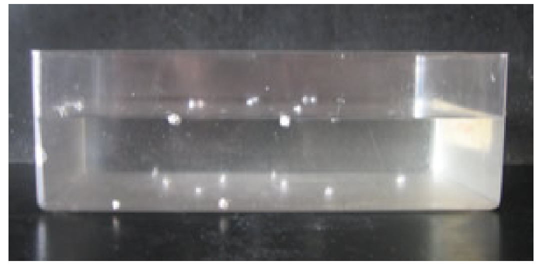

Figure 1: Some of the aluminum balls should sink and some should float.

1. ***Build the model***:

- Fill the ocean basin (shoe box) ¾ full with ocean water (water).
- Add the aluminum balls.
- Make sure that some sink to the bottom (deep water) and some float (surface water) – (Figure 1).
- Place the black paper under the model to improve visibility.

2. Relate the model to reality: Lead the class to complete the following graphic organizer and/or analogy notation on the board or overhead, prior to beginning the activity.

Graphic Organizer:

MODEL	REALITY (students answer)
Box	Ocean Basin or Great Lake basin
Water	Ocean or Great Lakes water
Air moving through the straw	Constant wind
Floating aluminum balls	Objects floating with the surface current or surface water molecules
Sunk aluminum balls	Objects deep in the ocean or deep water molecules

Analogy Notation:

Box : Lake Michigan Basin :: Air moving through straw : _______________

Answer: Constant wind

Box : Lake Michigan Basin :: Floating aluminum balls : _______________

Answer: Objects floating in the ocean or Great Lake or surface water molecules

Box : Lake Michigan Basin :: Sunk aluminum balls : _______________

Answer: Objects deep in the ocean or Great Lake/deep water molecules

Box : Lake Michigan Basin:: water : _________________

Answer: Ocean or Great Lakes Water

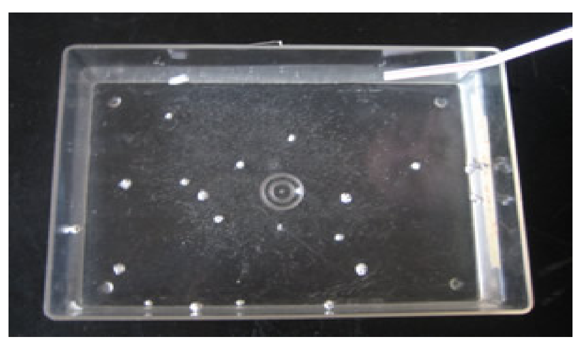

Figure 2: Straw placement while blowing.

3. ***Simulate wind***:

- The water begins still.
- Students place the shorter section of the bendable straws parallel to the surface of the water.
- One student in the team blows through the straw to simulate wind. Students blow horizontally (not down into the water) with the tip of the straw near the surface of the water and near the edge of the basin (shoe box) (Figure 2). The wind (blowing air) should be just hard enough to make ripples. With younger students, demonstrate the proper technique before beginning. The student creates wind in the same direction for 30 seconds.

Content Notes:

This models wind blowing across ocean water. The wind causes both little waves (ripples) and *surface currents. This activity simulates how wind makes surface water move by transferring energy to the water.*

The major ocean currents move in large cyclic patterns. This activity is not a good model for explaining that circulating pattern. The major ocean circulation occurs primarily because of the Coriolis Effect, which will be explained in the Ocean in Motion *activity.*

4. ***Observe the Motion***:

- The student not simulating the wind draws what s/he observes on *Data Sheet – Activity 1, Page 1* (Windy Observation boxes). S/he uses arrows to describe the motion and direction of the aluminum balls and wind (blown air).
- The student should differentiate between observations of floating balls and sunken balls.

Content Note: *The surface currents affect the floating balls but not the sunken balls; similarly, ocean surface currents do not affect deep water.*

5. Students switch roles. The second wind maker blows in the same direction and at the same intensity as the first wind maker. The second observer records his/her observations on his/her copy of *Data Sheet – Activity 1, Page 1* (Windy Observation boxes). Repeat until everyone has a turn at both roles.

6. ***Simulate Calm and Observe the Motion***:

- Students stop blowing and wait 5 seconds to simulate a brief calm (ocean wind stops blowing for a short interval).
- Students draw observations on *Data Sheet – Activity 1, Page 2* (Calm Observation Boxes).

Content Note: *This models short lulls in winds. The water does not immediately stop moving, because the wind transfers energy to the water. The water continues moving until the energy is dissipated as heat or transferred to the side of the basin (shoe box).*

7. ***Relate the model to reality***:

- Guide students to connect their observations of the model to the motion of water in the ocean and wind blowing over the ocean and to the *Ducks in the Flow – Where Did They Go?* storybook. The aluminum balls model objects floating in the ocean, such as the ducky in the storybook. The questions on *Data Sheet – Activity 1, Page 3* guide this discussion.

Key Points:
1) Wind makes surface water of the ocean (and Great Lakes) move.
2) Wind transfers energy to the water. When the wind stops for a brief amount of time, the currents continue to flow, because the water still has energy.
3) Objects floating in the ocean (or Great Lakes) will move with the currents. The ducky in the Ducks in the Flow, Where Did They Go? *storybook traveled, because it floated in surface currents.*
4) Surface currents affect the surface water; deep water does not move with the currents.

Activity 2 – Directions and Procedure

Content Note: *Children may think that the aluminum balls in Activity 1 moved only because the wind blew on the balls, as with the motion of a sailboat. Though not completely untrue, this focuses attention on wind power, not surface currents. In this second activity, children more directly visualize currents using rheoscopic fluid, as opposed to indirectly inferring currents using floating objects.*

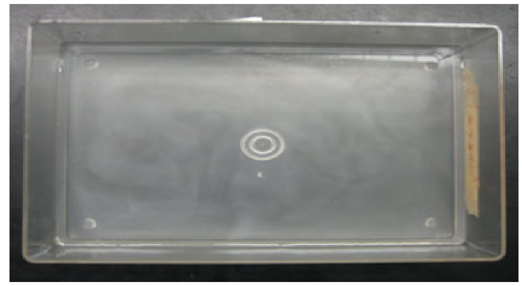

Figure 3: Water with Rheoscopic fluid before the “wind” is applied.

1. ***Build the model***:
- Fill the basin (shoe box) ¾ full with ocean water (diluted rheoscopic fluid) (Figure 3).
- Place the black paper under the model to improve visibility.

2. ***Relate the model to reality:*** Lead the class to complete the following graphic organizer and/or analogy notation on the board or overhead, prior to beginning the activity.

Graphic Organizer:

MODEL	REALITY (students answer)
Water with Rheoscopic fluid	Ocean or Great Lakes water
Box	Ocean Basin or Great Lake basin
Air moving through the straw	Constant wind

Analogy Notation:

For Beginners - Box : Lake Michigan Basin :: Water with Rheoscopic fluid : ______________

Answer: Ocean or Great Lakes Water

For Advanced Students - Box : Air moving through straw :: Lake Michigan Basin : ______________

Answer: Constant wind

3. ***Simulate wind***:
- The water begins still.
- Students place the shorter section of the bendable straws parallel to the surface of the water.
- One student in the team blows through the straw to simulate wind. Students blow horizontally (not down into the water) with the tip of the straw near the surface of the water and near the edge of the basin (shoe box) (Figure 4). The wind (blowing air) should be just hard enough to make ripples. With younger students, demonstrate the proper technique before beginning. The student creates wind in the same direction for 30 seconds.

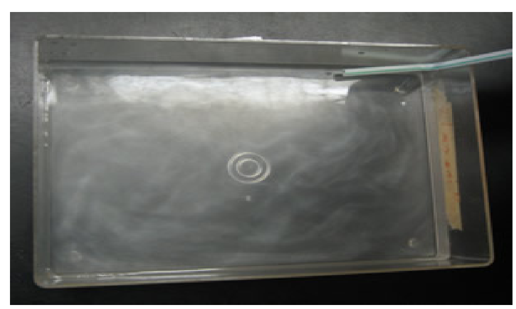

Figure 4: Water 10 seconds after “wind” begins to blow.

Content Notes: *This models wind blowing across ocean water. The ripples are not currents – they are little waves. This activity simulates how wind makes surface water move by transferring energy to the water.*

4. ***Observe the Motion***:

- The student not simulating the wind draws what s/he observes on *Data Sheet – Activity 2, Page 1* (Windy Observation boxes).
- S/he uses arrows to describe the motion and direction of the aluminum balls and wind (blown air).

5. Students switch roles. The second wind maker blows in the same direction and at the same intensity as the first wind maker. The second observer records his/her observations on his/her copy of *Data Sheet – Activity 2, Page 1* (Windy Observation boxes). Repeat until everyone has a turn at both roles.

6. ***Simulate Calm and Observe the Motion***:

- Students stop blowing and wait 5 seconds to simulate a brief calm (*ocean wind stops blowing for a short interval*).
- Students draw observations on *Data Sheet – Activity 2, Page 2* (Calm Observation Boxes).

7. ***Relate the model to reality***:

- Guide students to connect their observations of the model to the motion of water in the ocean and wind blowing over the ocean and to the *Ducks in the Flow – Where Did They Go?* storybook. The questions on *Data Sheet – Activity 2, Page 3* guide this discussion.

  Key points:
  1) Wind makes surface water in the ocean (and Great Lakes) move.
  2) Wind transfers energy to the water. When the wind stops for a brief amount of time, the currents continue to flow, because the water still has energy.
  3) Objects floating in the ocean (or Great Lakes) will move with the currents. The ducky in the Ducks in the Flow, Where Did They Go? *storybook traveled, because it floated in surface currents.*

Scientifically Accepted Explanation

In the classroom model, air blows over the surface water causing the water to move, pushing along more water, and setting up a miniature surface current. When wind blows over the ocean, the wind pushes the water and the water moves.

Some wind blows almost all the time. For example, the “Trade Winds” blow constantly over ocean water near Hawaii, and the “Westerlies” blow constantly over water off the west coast of the United States and Canada. These winds have been blowing in the same direction and fairly constantly for centuries. These constant winds push large, constant surface currents. Like the winds, surface currents are ancient and reliable.

In the model, the children stop blowing to simulate calm. Even if constant winds, like the Trade Winds, slow temporarily, the major ocean surface currents continue to move during these lulls, as in the model. Similarly, the direction of surface winds may temporarily change due to a storm. Nonetheless, the overall average direction and strength of the winds remains very constant, so the large surface currents in the oceans are very consistent.

Sometimes, wind blows and then stops, like a passing breeze or storm; it is inconsistent. Less constant winds can also cause small, short-lived surface currents. For example, if a child is fishing in a lake using a fishing float, and a breeze is blowing across the lake, the breeze may cause a temporary surface current that pushes the fishing float toward shore.

Surface currents are different from waves. Waves may cause floating objects (like the fishing float) to move up and down and back and forth, but the object will not ever progress in any one direction. The fishing float in this example will “bob” in the waves, but it will not be pushed to shore.

In the model, the aluminum balls move with the surrounding water – the water pushes the balls. The aluminum balls model objects such as the toy duck in *Ducks in the Flow – Where Did They Go?* Scientists track surface currents using special floating buoys called “drifters”. In the storybook, the toy ducks and other plastic animals that were lost overboard in a shipwreck served as accidental drifters and were also tracked by scientists to map surface currents.

In the classroom activity, the surface water moves while the deeper water remains still. Surface currents do not extend to the deeper parts of the ocean. In the classroom model, “deep” refers to a few centimeters. In the ocean, “deep” refers to over a hundred meters (in some places more than 200 m!), depending on the location and season. In the classroom activity, the surface currents did not move in a straight line because they bounced off the sides of the container. In the ocean, surface currents also bounce off the sides of the ocean basins. However, the large-scale swirling of surface currents all around the ocean is caused by the Coriolis Effect (see the *Ocean in Motion* activity).

More Advanced Explanation

When wind blows over water, wind transfers kinetic energy to water molecules. The water molecules then transfer kinetic energy to the water molecules in front and just below them, setting up the ocean-wide surface currents. This kinetic energy is the reason why the surface current in the model does not stop immediately, even when the “wind” is calm. It takes a few minutes for the energy to dissipate into heat energy or be transferred to the sides of the “basin”. The aluminum balls, floating plastic duckies, and drifter buoys move in currents because water molecules push against these objects.

The direction of the constant winds over the ocean (Westerlies, Easterlies, or Trade Winds) varies with latitude and depends on the Coriolis Effect. In the Northern hemisphere, the Trade Winds found at the latitude of Hawaii tend to blow south and are curved to the right, or west, due to the Coriolis Effect. The Northern “Westerlies” that affect most of North America tend to blow North and curve to the right, or east. The result of these winds can be seen in the surface current patterns in the ocean.

Connection to the Great Lakes

Surface currents are affected by the direction of the prevailing winds and Coriolis Effect, but they are also affected by the land masses that the moving water bumps into. This is particularly obvious in inland seas like the Great Lakes. Because the Great Lakes are smaller than the ocean, surface currents hit land sooner. Therefore, though Great Lakes’ surface currents resemble the swirls of the ocean surface currents, the patterns are more complicated. Surface currents in the Great Lakes change slightly on a daily, weekly, and monthly basis. Scientists take the average of these motions to discover the general trends in surface currents, which can be very useful for knowing where the surface currents may carry things like nutrients (chemicals that plants and algae need).

Connection to Social Studies

Surface currents have been used since ancient times to speed travelers across the sea, helping ancient Indonesians voyage to Madagascar and speeding the Vikings to Greenland. Did you know that Benjamin Franklin was one of the first to chart the Gulf Stream of the Atlantic Ocean? Mr. Franklin made eight round-trip voyages between North America and Europe.

Activity Extensions

- Imagine a place, where another shipwreck may occur and more plastic duckies may fall into the sea. Using a map of major surface currents in the ocean (gyres), predict possible places where the duckies may land. As a class, research the culture of other children in these imagined ducky landing sites.

- Listen to the song, “Wreck of the Edmund Fitzgerald” by Gordon Lightfoot. Research the location of this shipwreck that occurred in the Great Lakes. Predict where objects from this shipwreck may have moved, based on maps of Great Lakes’ surface currents. In what portion of the lakes would floating objects move faster? Slower?

- Use an encyclopedia to look up the Great Barrier Reef, Australia, and clownfish. If a clownfish managed to find his way into a surface current near the Great Barrier Reef, north of Brisbane, Australia, where might that clownfish end up?

Resources

Surface Currents and Winds in the Ocean

- UCAR's Windows to the Universe "Currents of the Ocean" - http://www.windows.ucar.edu/tour/link=/earth/Water/ocean_currents.html&edu=elem
- Museum of Science "Oceans in Motion" - http://www.mos.org/oceans/motion/currents.html
- NASA's "Ocean Motion and Surface Currents" (currents diagram) - oceanmotion.org/html/background/wind-driven-surface.htm
- NASA's "Ocean Motion" (winds diagram) - oceanmotion.org/html/background/equatorial-currents.htm

The Great Lakes

- Missouri Botanical Garden's "What's it like where you live?" - http://www.mbgnet.net/fresh/lakes/index.htm
- EPA's "Visualizing the Great Lakes" - http://www.epa.gov/glnpo/image/
- GLERL's Mean Circulation in the Great Lakes - www.glerl.noaa.gov/data/char/circ/mean/mean-circ.html

Photographs of Drifter Buoys

- NOAA's "The Global Drifter Program" - www.aoml.noaa.gov/phod/dac/gdp_drifter.html

Social Studies Connections

- "The Gulf Stream" (history) - http://fermi.jhuapl.edu/student/phillips/index.html
- Benjamin Franklin and Surface Currents, PBS Benjamin Franklin Weather Wise - www.pbs.org/benfranklin/l3_inquiring_weather.html
- TERC's "Study of Place (Franklin's map) - http://studyofplace.terc.edu/Activities/Activity.cfm?ActivityId=7&ActivityItemId=79
- Ancient Navigation and Surface Currents NOVA Online "Secret's of Ancient Navigation" - www.pbs.org/wgbh/nova/longitude/secrets.html
- Historical Shipwrecks in the Great Lakes Thunder Bay National Marine Sanctuary – http://thunderbay.noaa.gov/welcome.html
- Gordon Lightfoot: "Wreck of the Edmund Fitzgerald" – Song Lyrics - http://gordonlightfoot.com/wreckoftheedmundfitzgerald.shtml

This activity was developed by Laura Eidietis, Sandra Rutherford, Margaret Coffman, and Marianne Curtis. Parts of the activity were modified from the following sources:

- Tolman, Marvin N. *How are Ocean Currents Affected by Wind? Hands-on Earth science activities for grades K-6*, Second Edition, pp. 120-1, John Wiley & Sons/Jossey-Bass A. Wiley, San Francisco, 2006.
- VanCleave, Janice P., "Movers" in *Janice VanCleave's Earth Science for Every Kid*, pp.198-9, John Wiley & Sons, Inc., New York, 1991.

Illustrations by Lisa Gardiner
Graphic Design by Becca Hatheway

Going with the Flow

Name: ___________________________

Data Sheet - Activity 1, Page 1
(Aluminum Balls Activity)

Directions: Draw and describe what you observe. Imagine that you are looking down into the ocean basin from above.

KEY

→ Direction of movement

○ Floating balls

△ Sunken balls

Windy Observation

Balls in surface water (floating)

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Balls in deep water (sunken)

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Going with the Flow

Name: ___________________________

Data Sheet - Activity 1, Page 2
(Aluminum Balls Activity)

Directions: Draw and describe what you observe. Imagine that you are looking down into the ocean basin from above.

KEY

Direction of movement

Floating balls

Sunken balls

Calm Observation

Balls in surface water (floating)

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Balls in deep water (sunken)

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Going with the Flow

Name: ______________________

Data Sheet - Activity 1, Page 3
(Aluminum Balls Activity)

What did you observe?

Compare the motion of the balls at the top of the water and at the bottom of the water.

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What do you think?

Can wind cause currents on the bottom of the ocean?

(Circle One) YES NO Maybe

I think this because…

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What did you observe?

Compare the motion of the balls when the wind was blowing and when the wind was not blowing.

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Going with the Flow

Name: ______________________

Data Sheet - Activity 2, Page 1
(Aluminum Balls Activity)

Directions: Draw and describe what you observe.

KEY

Motion of water

Windy Observation

From Above

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From Side

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Going with the Flow

Data Sheet - Activity 2, Page 2
(Aluminum Balls Activity)

Name: ______________________

Directions: Draw and describe what you observe.

KEY

Motion of water

Calm Observation

From Above

From Side

Going with the Flow

Name: ________________________

Data Sheet - Activity 3
(Rheoscopic Fluid Activity)

What did you observe?

Compare the motion of the fluid when the wind was blowing to the motion of the fluid when the wind was not blowing.

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What do you think?

If the wind stopped blowing for a <u>short time</u>, would the ocean currents stop?

(Circle One) YES NO Maybe

I think this because…

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What do you think?

In *Ducks in the Flow - Where Did They Go?*, what caused the duck to travel so far?

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I think this because…

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