LESSON 1: Go With The Flow!

Teacher's Guide

Materials:
- Interactive whiteboard or projector with internet access and a StarLogo Nova account
- Individual copies of the Student Guide (on page 9 of this curriculum)

Objective: In this lesson, students will be introduced to a case study that helped scientists understand ocean currents, as well as how these can be modeled. After a discussion on what models are, students will see how computational models work using a basic programming language.

Inquiry Question: How do computers let us predict changes in systems?

Time Required: One class period. Extra time may be required for students to become acquainted with the StarLogo Nova program.

Science Standards Addressed:
6th Grade: SC.6.E.7.5, SC.6.N.1.3, SC.6.N.3.4
7th Grade: SC.7.N.1.3, SC.7.N.3.2, SC.7.N.1.5
8th Grade: SC.8.N.1.5, SC.8.N.1.6, SC.8.N.3.1, SC.8.E.5.10
Middle School Computer Science: SC.68.CS-PC.2.8, SC.68.CS-CS.1.2, SC.68.CS-CS.1.4, SC.68.CS-CS.1.3, SC.68.CS-CS.2.11

PROCEDURES

Step 1

Duck Drifters

To spark interest in this series of lessons, begin with a viewing of this video about a container of bathtub toys lost at sea that inadvertently became ocean current tracking devices. Students can also read the article about the bathtub toys on page 11.

Discuss answers to questions 1-6 in the student guide before moving on to Step 2.

YouTube video on bathtub ducks lost at sea
https://www.youtube.com/watch?v=eLMSMs6AYYc
(Note: this is a 6:25 video, but you can stop at 2:17)

Step 2

Computer-based mathematical models

Begin by asking students what a model is and how they are used in science. A concept map or word association activity may be useful to gauge levels of prior knowledge. When generating examples, encourage students branch out from the current subject to examples from their own experience or previous coursework.

Examples of physical models include many science demonstrations (cloud in a bottle, water tables, scale models and dioramas). Conceptual models could be many illustrations in a textbook, ball-and-stick models of molecules, or food chain/food web. Mathematical models include many scientific laws/equations, such as Newton's Laws and growth equations for bacteria populations. As mathematical models become more complex, such as ones that describe a large system with many parts, it becomes more practical to have a computer run the equations, which is where computer models come in.

Making observations with the StarLogo Nova application

This part of the lesson requires a free account with StarLogo Nova, which you can sign up for at http://www.slnova.org.

1. Load the sample model and show the class how it runs. Students will have a chance to edit models in a later lesson.
2. On a digital whiteboard, view a simple model by opening the ***Model Floating Ducks Ver1*** after logging into StarLogo Nova. This model includes 300 randomly moving ducks and no other variables. The model is two-dimensional, representing only surface waters. When setup is clicked, 300 ducks are dropped in the center. When run model is clicked, the ducks wiggle randomly. The result is an ever widening cluster of ducks. The graph shown as the code runs indicates the density of ducks (by showing the number of ducks with nearby neighbors).
3. Show students the code behind the model by scrolling down below the model workspace. They will see that there are “ducks” generated when setup is clicked and run program causes the ducks to move randomly.
4. After students have answered questions 10-13, use the ***think-pair-share*** approach to discuss answers with a partner and as a class.
5. Next, students will fill in the two-column chart in the student guide showing members of the ocean system such as plankton, fish, and sediment in the left-hand column. They should think about the variables (environmental conditions) that influence of the ocean system, such as water temperature, wind speed, salinity, etc.). Save a class list of student ideas about the members of the system and the variables on chart paper or a digital whiteboard to refer back to during these lessons. Students will notice that this simple model does not represent the flow of ocean currents.
6. Finally, open the ***Model Floating Ducks Flow Ver1*** (on a digital whiteboard for the class to see). This model has “widgets” that can be used to represent current speed and direction. Ask students to tell you which way the current moves where the bathtub toys were dropped. Change the setting in the model and test. If time permits, students can go to workstations and view the model and experiment with altering the code to represent the system.

Step 3

Introducing Students to StarLogo Nova

While many students will have been exposed to basic programming/coding, not all will be familiar with the concept. Coding is a way to give a computer commands, so that it “knows” what to do in a given program. Programming languages are used to “translate” commands humans can understand to ones that make sense for computers. Traditional coding involves lines of text that are typed by the programmer, and can be difficult to learn, especially for those without a computer science background.

Block-based coding, sometimes known as block based-programming, is coding within a programming language where instructions are mainly represented as blocks. Students put the blocks in a certain order, and, while this approach is more limited in its applications, it presents a lower barrier to entry and is commonly used to teach the basics of code at the K-12 level.

You may want to go through the **Student Guide to StarLogo Nova** first (which can be found in the Appendices), or between Lessons 1 and 2. Students should be given time to explore the program and try some of the functions before moving on to the next stage of the unit.

Name ______________________________**Class**______________________ **Period**____________

QUESTION: How do computers help us predict changes in systems?

ACTIVITY 1

Duck Drifters

Watch the video and answer these questions.

YouTube video on bathtub ducks lost at sea

1. How many ducks were in the container lost at sea?
2. What made the ducks move?
3. Where would you go today if you wanted to find one of the ducks?
4. What factors are important in determining where a duck will wash ashore?
5. What is the value of collecting data about the ducks' locations?
6. Show what the ducks revealed about ocean currents by adding arrows to this map:

Source: *https://commons.wikimedia.org/wiki/File:ColoredBlankMap-World-162E.svg*

ACTIVITY 2

Computer-based mathematical models

Scientific models are representations of the natural world. Models can be ***physical*** (a larger or smaller copy of an object). Models can be **conceptual** (representing a phenomenon with an illustration or system of organization). Models can also be ***mathematical*** (applying mathematical formulas and data to show events and make predictions about outcomes). These mathematical models often employ computers to make calculations and show results.

1. Give an example of a physical model ________________________________
2. Give an example of a conceptual model ______________________________
3. Give an example of a mathematical model ____________________________

In order to represent what happens to rubber ducks, or other materials in the ocean, we will use a computer-based mathematical model. Start by running a model of rubber ducks dropped in the ocean.

StarLogo Nova

Run the Model Floating Ducks Ver1 on StarLogo Nova (www.SLNova.org).

1. What things are shown in this model?
2. How does this model show a system (a group of related parts that make up a whole)?
3. Does this model show what really happens in the ocean system? Tell your evidence.
4. What other things could you add to make a better model to show the fate of ducks dropped into the ocean?

Members of the ocean system: the actual things in the ocean system (living and non-living)	**Variables**: environmental conditions that can vary and influence the system (such as currents and water temperature)

One way to refine this model would be to add code that takes into account wind direction and speed.

- Test out ***Model Floating Ducks Flow Ver1***. Does this do a better job of modeling the ducks?
- Examine the code. What is different about how this is programmed?

Reading: The Rubber Duckie Map – How Children's Toys Help Chart the Ocean

Reprinted with permission from Luke Hollomon, M.S.

The power of the storm was inescapable. The noise, unimaginable. Waves smashed into the sides of the 1,000-foot long ship, splashing freezing water over the deck and slamming into many of the 3,000 containers the ship carries on board. Most containers are held down by their own mass. Millions of car parts, floor tiles, and processed metals weather the storm in silent comfort. Waves like this are rare in the North Pacific, but not unheard of. Containers and the ships that carry them regularly endure conditions like this. Today though, there are an unlucky few containers stacked near the top of the 50ft. tall piles of metal. They became unbalanced and toppled into the ocean. As the containers plummeted into the deep, they struck each other and the ship, bursting open and spilling almost 29,000 rubber duckies and frogs into the ocean.

These *Friendly Floatees* brand toys were on their way from Hong Kong to Tacoma, Washington, but barely made it halfway. 12 containers were washed off the ship, spilling into the ocean and breaking open in the sea. After the waves died down and the huge metal containers slipped to the bottom of the sea, 29,000 rubber toys were left behind, silently bobbing up and down in the middle of the Pacific.

In the harsh environment of the North Pacific, the cardboard rapidly broke down and was either eaten by fish or thrashed apart by the waves. This released the rubber cargo into the wilds of the ocean and to the mercy of its currents. It also piqued the interest of a couple of oceanographers from Seattle.

Ocean currents are incredibly difficult to map. They don't appear on normal satellite images, they cover thousands of miles, and they're driven by invisible forces: wind, water density, and tides. Through the years, oceanographers have developed a toolkit that lets them map these invisible forces. Today, that toolkit includes advanced satellite imagery, mathematical models, and machine learning. In the past, this type of oceanographic work required a different type of tool. The drift bottle.

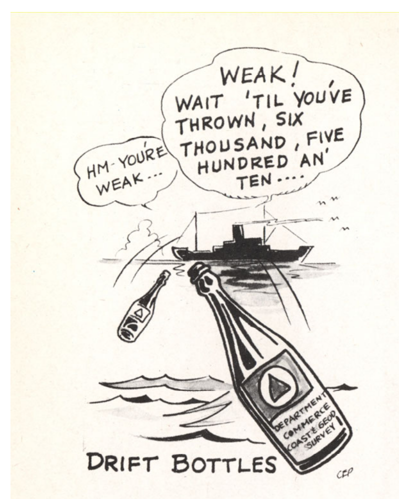
A 20th-century drift bottle found in Martha's Vineyard in 2013. From NOAA http://oceanservice.noaa.gov/news/apr14/message-in-bottle.html

The idea of a drift bottle is the same that's behind messages in bottles that have been dropped in oceans for thousands of years. Seal a message into a glass bottle, cap it tightly, drop it into the ocean, and hope.

Eventually, if you're lucky, someone will find the bottle washed up on a coastline, pop it open, and follow the instructions inside. Bottles beseech their finders to contact the researchers and send both the location and date where the bottle was found. With this information and the location of the original drop site, oceanographers can develop ideas about the direction and speed of ocean currents in the area.

The earliest known usage of this technique occurred in 310 BCE when Theophrastus, an ancient Greek philosopher, dropped his bottles into the Atlantic in order to prove that the Mediterranean is filled by oceanic inflow. Unfortunately, no records indicate if he received a response to his messages. We'll never know if Theophrastus was able to prove his hypothesis. He likely wasn't the first to use this technique, and certainly wasn't the last. Scientific messages in bottles have been used in this way ever since. The oldest message in a bottle ever discovered was scooped up in 2012, 98 years after a Scottish researcher dropped 1,900 into the North Sea.

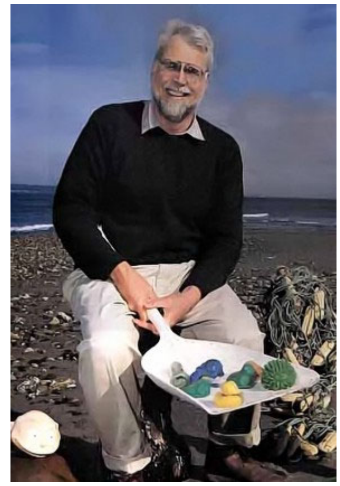
This old-fashioned method is even occasionally used today. Though inefficient due to bottle loss, breakage, and sinking (a 2012 drop of 2000 bottles has recovered only 70 so far), the message in a bottle method is still an effective way to map unknown ocean currents in an inexpensive manner. The National Oceanic and Atmospheric Administration, NOAA, still maintains maps and records from many of their bottle drops conducted in the last century.



Cartoon from Clarence E. "Pete" Pedersen, a cartoonist and former member of the Coast and Geodesic Survey team at NOAA. From NOAA

Due to the attrition rate in bottle drops, the practice has been used more out of necessity than idealism. There aren't many practices in science where losing 95% of your apparatus is considered an effective method. That's where the rubber duckies reenter the story.

29,000 rubber toys floating in the Pacific Ocean are a perfect stand-in for drift bottles. They float smoothly, they're recognizable, and they're free. They could only be more effective if each had a researcher's phone number printed on the side. Curtis Ebbesmeyer and James Ingraham, oceanographers who have devoted their lives to mapping ocean currents, saw their opportunity. Instead of releasing 1,000 bottles and retrieving 20–30, the researchers had 29,000 vectors to work with, giving them an expected return of over 600. No ethical researcher could dump this much flotsam into the ocean, but a natural experiment like this could not be missed.



A photo of Oceanographer Curtis Ebbesmeyer with flotsam he uses to monitor ocean currents. From http://vos.noaa.gov/MWL/dec2001.pdf

After the first Floatees washed up in Alaska in November 1992, the oceanographers contacted fishermen, beachcombers, and residents of the area to put them on alert for the missing toys that could wash up throughout the region. Over the next year, hundreds more washed up along the Alaskan coastline, contributing data to Ebbesmeyer and Ingraham's ocean current model. With this information, they were able to make predictions about what could happen to the rest of the duck armada, predicting their roundabout paths in the Pacific Ocean and indicating that some could reach the coasts of the United Kingdom. One intrepid little Floatee did hit the coast of Scotland on its own back in 2003, but many more are expected to replicate its journey in the coming years. The company that made them, First Years, Inc. are even offering a £50 bounty to anyone who recovers a Floatee in the United Kingdom.

If you're on the northern coasts of Asia, North America, or Europe this year, keep your eyes open for faded rubber bath toys nestled into the rocks. If you do find one, be sure to contact the researchers involved. You can find Curtis Ebbesmeyer and his writings on the subject at *flotsametrics.com* and *Beach Comber's Alert*.

In their 26 years of drifting the ocean, these little ducks have been frozen in sea ice, smashed into rocks, and hurled about in storms, but they continue their silent contributions to science and the world.

Ebbesmeyer and Ingraham's model, called Ocean Surface Currents Simulation (OSCURS), was partially built with data collected from the duck's movements around the ocean. OSCURS was developed and implemented at the Alaska Resource Ecology and Fisheries Management Division. They used the model to help fishing vessels navigate and fish the Gulf of Alaska for years. The current data could predict fish patterns, flotsam drift, and weather events. Eventually, the project ended and the data was folded into other models, but it continues to inform our knowledge about the ocean today. Even some of the crab trap drop sites used on *Deadliest Catch* could be inspired by the rubber duckie data.

You can get an idea of the complex ocean currents the ducks have ridden and helped map by watching this beautiful visualization NASA put together a few years ago. Billions of data points go into a model like this one, and these rubber ducks provided a few thousand of their own. Our knowledge of the ocean wouldn't be the same without them.

I like to imagine one resolute rubber duckie being frozen into arctic ice and swept toward the pole. Trapped in its frost-bound home, the toy sits deep beneath the ice, spending hundreds (or even thousands) of years in suspended animation. Eventually, polar researchers investigating climate change from our era take an ice core to inspect it for microbes and carbon dioxide content, and are left scratching their heads at the find. An ancient, bright yellow rubber toy staring back at them from ten feet below the ice. What a find that would be.

Source: https://medium.com/@lukehollomon/the-rubber-duckie-map-how-childrens-toys-mapped-the-ocean-bc13290ee3fc