Ducks Ahoy!

Plastic Debris and Ocean Currents

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Ducks Ahoy! Bath Toys, Marine Debris,Geography

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Early in the morning of January 10, 1992, the container ship *Ever Laurel*, traveling from Hong Kong to Tacoma, Washington, was blindsided by a powerful storm just miles from the International Date Line in the Pacific Ocean. As the crew hung onto the listing ship in 40-foot seas, twelve containers escaped from their steel bindings and plunged into the North Pacific. Among these containers was one carrying 28,800 bath toys manufactured by Kiddie Products, Inc.[1] That night, thousands of bath toys—plastic toy ducks, rabbits, frogs and beavers—began an ocean voyage that has spanned the last 20 years and captured the imagination of authors, scientists, and the public. (See Recommended Books, p. 7.)

At first, the bath toys floated on Pacific currents: some going south; others going north; and some finally landing on the Alaskan shores in November of 1992. Then, for more than a decade, the toys circulated through the currents of the Pacific Ocean. Some of the toys rode currents "through the Bering Strait into the Arctic ocean, where the pack ice conveyed them onward over the North Pole into the North Atlantic Ocean."[2] Wayward toys were found on a Maine beach in 2003, and across the ocean on a Scottish beach the same year.

Ducks as Data Points

Scientists, like oceanographer Curtis Ebbesmeyer, are gaining an unprecedented understanding of the nature of the world's ocean currents, specifically ocean gyres, through the study of floating debris, or flotsam.[3] The bath toys collected by beachcombers all over the globe are providing data that are being used to create models of ocean currents. Ebbesmeyer concludes that not only can items traverse the Subarctic Gyre, but they circumnavigate it in about three years (See gyre 9 on **HANDOUT A: Ocean Gyres**, p. 7). The data collected from the bath toys, as well as other flotsam, indicate that the ocean gyres are not merely cyclical tracks in the ocean, but they overlap, resembling interlocking gears. When two gyres meet, some of the flotsam from one is "handed over" to the other, which explains why bath toys lost in the Pacific Ocean could be found on Atlantic beaches.

ON THE COVER: A plastic toy duck rests among driftwood on the banks of the Ohio River near "Exit Zero" of Interstate 65. (This item is recent, local trash, and not part of the 1992 spill of plastic bath toys in the Pacific Ocean.) Albertus Gorman is an "artist and art activist" whose photographs of the banks of the Ohio River (and creations he's made from its flotsam) can be seen at his website, artistatexit0.wordpress.com. See also "Project Reclamation," a 2012 exhibit at the Carnegie Center for Art and History in New Albany, Indiana, www.carnegiecenter.org. (Courtesy AlbertusGorman/artistatexit0.wordpress.com).

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Credit: Nature Journal

Oceanographer Curtis Ebbesmeyer

Container ship, 2010.

Huhu Uet/commons.wikimedia.org

Sample of water from the North Pacific Gyre, 2010.

gristleoflife.wordpress.com/tag/great-pacific-garbage-patch

Of Ducks, Debris, and Gyres

Annually, the United States imports more than $300 billion worth of products from China. These goods are largely brought to the United States on cargo ships. Unfortunately, the story of the lost container of bath toys is not unique; thousands of tons of cargo are lost off containerships during transoceanic voyages every year.[4]

What happens to this lost cargo? Some sinks to the bottom of the ocean, some washes up on beaches, and some disintegrates near the surface, becoming part of the ever-increasing marine "garbage patches." There are eight documented garbage patches: four in the Pacific, three in the Atlantic, and one in the Indian Ocean. The largest is half the size of the United States, and is floating on the North Pacific Gyre. (**HANDOUT A: Ocean Gyres**, p.7). If they were combined, the garbage patches would cover an area twice the size of the United States.[5]

The debris in the world's oceans is from a variety of sources, in addition to lost cargo. Much of it is either intentionally dumped from ships or spills from storm drains, which carry trash from cities and towns into creeks and rivers, which finally empty into the ocean. No matter how the debris makes its way into the ocean's garbage patches, the problems that result are more than just aesthetic affronts. Much of the marine debris is non-biodegradable plastic.

As the plastics are exposed to the sun, they break into small pieces, resembling confetti or cloudy soup. Marine animals, including birds, often mistake these small particles of plastic for food, and the bits can block or perforate the digestive tract. It is not clear how this situation will affect the ocean's food chain, or ultimately the supply of seafood available to fishermen for harvesting and human consumption.[6]

Ducks in the Classroom

The saga of the lost bath toys is particularly well suited for middle grade social studies lessons focused on the topics of ocean currents (geography), global trade (economics), and human impact on the environment (public policy and global issues). Below are a series of lesson activities addressing these three topics, using the lost bath toys as unifying theme.

What is the duck's tale?

The story of the lost bath toys is easily introduced to the students through a read-aloud of the picture book *Ducky* written by Eve Bunting. We wish to note that although the book is written for a younger audience, the story is interesting enough to engage middle grades students. Additionally, reading the story is an effective introduction to the 1992 toy spill.

The book chronicles the journey of one duck lost in the 1992 spill—from its plunge into the sea and an encounter with a shark, to its washing ashore and being collected and charted

as part of a school assignment. During the read-aloud, students should be encouraged to keep a list of the duck's experiences, from being nestled in the shipping crate to its arrival on the Alaskan shore. After the book reading, students should share their lists and come to a consensus about the duck's journey. Was this just a fiction? To authenticate the book *Ducky*, students can then read the informational text, *Science from Bath Toys*, an on-line PDF document published by the Alaska Sea Grant, and examine **Handout A** and maybe one of the many on-line maps of ocean surface currents.[7] Students can compare what they had heard in *Ducky* with what they read in the article and what they see on a map. They can engage in a class discussion and create a Venn Diagram, comparing the fictionalized story with information from other sources. Some suggested discussion questions include:

- Through which regions of the world did the duck travel? How did you determine this?
- Since this is a plastic duck, it is obviously not swimming. What physical systems are working to move the duck through the water?
- The ducks are floating on the ocean's surface current. Using your experience in a bathtub, what are the forces moving the ocean's surface water?
- Where did the bath toys wash ashore? How often did this happen? What can scientists learn about ocean currents and gyres from these patterns?
- What predictions can you make about the future journey of any remaining bath toys?

What propelled the ducks to move around the Pacific Ocean?
During this discussion, introduce students to ocean gyres, the North Pacific Gyre in particular. Students can examine the dispersal of the toys, including when and where the toys washed ashore, leading to the deduction that it takes approximately three years to circle the Pacific Ocean on the North Pacific Gyre. Students may also note that the various ocean currents intersect, which enabled the toys to "jump" from one current to another, as evidenced by toys being found in Maine and Scotland.

You could also ask students to consider why shipping lanes tend to run along the northern edges of the northern hemisphere gyres. (It's shorter; they could try connecting ports with string on a globe. Introduce the concept of a great arc on a spherical surface). You could ask students to think about why there is more traffic in the northern than southern hemispheres (There's more land and greater population). Students might consider what that implies for where debris is most likely to go.

How much does the United States trade with (buy from and sell to) China?
The toys' odyssey around the Pacific and beyond is a good beginning for a discussion about international trade, and why the toy spill was likely to happen in the Pacific Ocean. To introduce the discussion of global trade, we suggest an information-gathering activity in which students record and map the manufacturing locations of a number of household items. While items in the classroom may be used, we suggest (for efficiency) that the teacher gather the household goods prior to the class meeting. Include a bath toy in the gathered items.

Working in groups, students classify the items into categories (e.g. toys, technology, clothing, school supplies, food, etc.), record where each item was manufactured, and mark those locations onto a world map (e.g., plastic duck = China). Colors dots, representing various product categories, can be placed on a map. Students then make observations about the data; the most prevalent will likely be that most of these goods were manufactured in China.

Following this observation, provide students with a table of import and export data for China and the United States (**HANDOUT B: U.S.-China Trade**, p. 8). Using the data from the mapping activity and this handout, students can engage in a discussion about international trade, considering some or all of these suggested questions:

- What rank is China among nations that sell goods to the United States? (Line F)
- What costs must a company consider when determining where to manufacture its goods?
- Why do you think so many of our manufacturing goods come from Asia, and China in particular?
- Wages for employees in China's manufacturing sector are going up.[8] Do you think that will impact China's dominance in world manufacturing?
- What impact do you think the trade relationship between the United States and China has on diplomatic interactions between the two countries?

Following the class discussion, students can demonstrate their understanding of the trade relationship between China and the United States by creating a political cartoon or through a writing activity.

What might be the environmental implications of thousands of ships making transoceanic voyages each year?
Moving the manufactured goods from one continent to another is most often done on cargo ships.

The melting of Arctic ice due to global warming has opened the Arctic Ocean to year-round shipping.[9] There are several geography-related challenges of navigating through Arctic Ocean shipping lanes, such as the lack of accurate maritime maps for the Arctic. Shipping through Arctic waters is extremely dangerous, but it could bring possible benefits (e.g., a reduction of shipping-related carbon pollution due to shorter travel distances) and costs (e.g., the negative impact on Arctic wildlife

An albatross skeleton on Midway Atoll showing plastic in its abdomen.

La Monde Verte/ lamodeverte. wordpress.com

from increased sea traffic and spills) to the environment. Several tiny toys made their way through the Arctic into the Atlantic, without the help of any icebreaking ships. Were they harbingers of things to come? (**HANDOUT C: (1) World Shipping Routes; (2) Polar Shipping Routes**, p. 9)

What happened to the rest of the bath toys?
Although a number of the bath toys have made their way to shore, 96.7 percent of the lost toys remain in the world's oceans, according to Curtis Ebbesmeyer's calculations.[10] To transition to a discussion of the human impact on the world's oceans and waterways, ask the students to predict what happened to the bath toys that have not washed ashore. They will likely be able to reason that the toys have either sunk, disintegrated, or are still floating in the ocean. In other words, the bath toys are marine debris.

A four-minute video produced by PBS, "Trash on the Spin Cycle," which is part of the Jean-Michel Cousteau Ocean Adventures series, is an excellent resource that concisely describes the North Pacific Garbage Patch and the impact of marine debris on the environment and wildlife. It's free online.[11] Ask students to think aloud about the following questions after they watch the video (or pause the video at appropriate spots):

- How does garbage end up on the beaches of the northwestern Hawaiian islands?
- How much of the ocean debris comes from land? (As opposed to being dumped from ships)
- Where else could the debris originate?
- What are the possible effects of ocean garbage patches on marine life? On humans?

Students will likely be most intrigued by the effect that persistent plastic debris has had on wild bird populations that often mistake the debris for food. Bits of plastic may not be poisonous, but they can disrupt digestion. For example, if a parent bird feeds plastic to its young, the juvenile bird may starve even as its stomach "fills up."[12] Also, invasive species can ride along with the plastic debris, which can bring diseases or ecological disruption to distant coastlines.

Oceans and Public Policy

How can people and governments reduce the environmental impact of shipping and protect the oceans generally?
There are national and international agencies and NGOs (nongovernmental organizations) that are involved in laws of the sea and global ocean conservation. Mirroring the three branches of the U.S. government, there are issues of legislation, enforcement, and adjudication of agreements and laws. Scientists and oceanographic laboratories have an important roll to play, showing the public what is happening under the water, out of view. Citizens can learn about the struggles of the past that led to our current laws that attempt to protect our watery world, and get involved in some facet of the issue that they care most about. (**HANDOUT D: Public Policy and the Oceans,** p. 10)

The Local Scene: Ponds, Creeks, Lakes, and Rivers

Add immediacy to the topic by bringing the story closer to home—to our local waterways. To facilitate this transition from global to local issues, display photos of plastic ducks found along the bank of the Ohio Riverover the years, as posted by photographer Albertus Gorman at his website, "Artist at Exit 0 Riverblog."[13] To have students begin to grasp the extent of debris flowing in our nation's waterways, they could analyze one photograph of garbage accumulating underneath a bridge.[14] Have students closely examine one-quarter of the photo at a time, making careful notes about what they observe in each quadrant. Then reveal the entire image and ask students to describe the photo, make predictions about where and when it was taken, and to write a caption that they think best describes what they see.

The natural extension of this image analysis is to ask the class to think about how the garbage got into the river in the first place. Move the class conversation to a discussion of ways that we could clean up our local river and shoreline, and how we can prevent debris from entering local waterways. Bottle bills, state laws that require a deposit and return (often 5 cents) on beverage cans and bottles, have been shown to reduce litter, but they are controversial.[15] (**HANDOUT E: Bottle Bills: Can a Law Reduce Plastic Pollution?,** p. 11)

Ducks in Context

This is not the first time that society has had to face the impact of its inventions and industries on the marine environment. Ask students to take turns reading aloud each of the entries on **HANDOUT F: Timeline of Ocean Conservation**, p. 12–13), which lists events in recent history. Then divide the class into five small groups and allow them 5 minutes to focus on a specific topic. Group 1 reexamines Handout E, looking for examples of popular culture (books, TV shows, and movies) that refer to the oceans and humanity's impact on them. Then group 1 reports back to the class with its findings. Group 2 searches for examples of problems created by technology, and then shares its findings. Group 3 finds examples of national and international legislation. Group 4 finds examples of citizens organizing, petitioning, or protesting. Group 5 finds examples of specific organisms that are being harmed, and that we might try to conserve. Individual students (or small groups) can read more deeply about any topic by visiting the websites cited on the Handout F. One group could be assigned to learn about "nurdles," a word that piques the curiosity of any middle school student (**HANDOUT G**, **Nurdles**, p. 14**).**

Concluding Thoughts

The story of the lost bath toys has fascinated many readers over the last 20 years. The image of the iconic rubber duck floating on the vast Pacific Ocean is both intriguing and troubling. Beyond the "cute" factor of the bath toys' story, there are significant lessons to be learned. The journey of the lost bath toys provides a way to teach about the geography the world's oceans, which are always in motion with currents, gyres, and vertical mixing. (See the Back Page) The shipping of the toys from China to the United States is an excellent place to start a discussion of international trade, particularly between the United States and China. And the fate of the uncollected toys is a logical connection to the discussion of the issue of ocean garbage patches, debris in our waterways, and policies (from local to international) to protect our marine environment. A rubber duck may seem insignificant, but there is a lot to learn from its odyssey through the Pacific.

Notes

1. Curtis Ebbesmeyer and Eric Scigliano, *Flotsametrics and the Floating World: How One Man's Obsession with Runaway Sneakers and Rubber Ducks Revolutionized Ocean Science* (New York: Harper Collins, 2009). Watch and listen to the author at flotsametrics.com/media.php.
2. Curtis C. Ebbesmeyer, "Beachcombing Science from Bath Toys," beachcombersalert.org/RubberDuckies.html.
3. Ebbesmeyer and Scigliano.
4. Sharon Silke Carty, "When Cargo Gets Lost at Sea Firms Can See Big Shortages, Losses," *USA Today* (August 4, 2006), www.usatoday.com.
5. Ebbesmeyer and Scigliano. Also, ocean surface current and global wind maps are shown in color at www.seos-project.eu/modules/oceancurrents/oceancurrentsc02-p03.html.
6. National Oceanic and Atmospheric Administration, "Marine Debris Program," Marine Debris Information, (2012): marinedebris.noaa.gov/info/faqs.html. See also the resources at www.education.noaa.gov.
7. Online PDF at seagrant.uaf.edu/marine-ed/curriculum/grade-7/investigation-1.html. Alaska Sea Grant is part of the School of Fisheries and Ocean Sciences at the University of Alaska Fairbanks and part of the National Sea Grant Program, a division of NOAA.
8. David Conrads, "As Chinese Wages Rise, US Manufacturers Head Back Home," *The Christian Science Monitor* (May 10, 2012), www.csmonitor.com.
9. Max Paris, "Arctic Ocean May Open to Regular Shipping by 2017," Canadian Broadcasting Company News (April 23, 2012), www.cbc.ca/news.
10. Ebbesmeyer and Scigliano.
11. Jean-Michael Cousteau Ocean Adventures, *Trash on the Spin Cycle* (4-minute, online video; New York: PBS), Lesson plan and video, www.pbs.org/kqed/oceanadventures/educators/kure/debris.html.
12. "What Happens When Seabirds Ingest Debris?" marinedebris.noaa.gov/info/faqs.html#7; "Plastic Debris in the World's Oceans," www.unep.org/regionalseas/marinelitter/publications/docs/plastic_ocean_report.pdf. "Marine Debris: What We Know," marinedebris.noaa.gov/info/plastic.html#whatis.
13. Many of the pictures on artist Albertus Gorman's website are taken from the Falls of the Ohio State Park in Jeffersonville, Indiana, including those in the duck photo collection, artistatexit0.wordpress.com/about/kentucky-lucky-ducky-collection.
14. The picture we use in this activity was taken near the Falls of the Ohio following weeks of rain and flooding along the Ohio River. See artistatexit0.wordpress.com/2011/03/08/ohio-river-high.
15. Steven S. Lapham, "'Bottled or Tap?' A Controversy for Science, Economics, and Society," *Social Education 73*, no. 5 (September 2009).

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HANDOUT A

Ocean Gyres

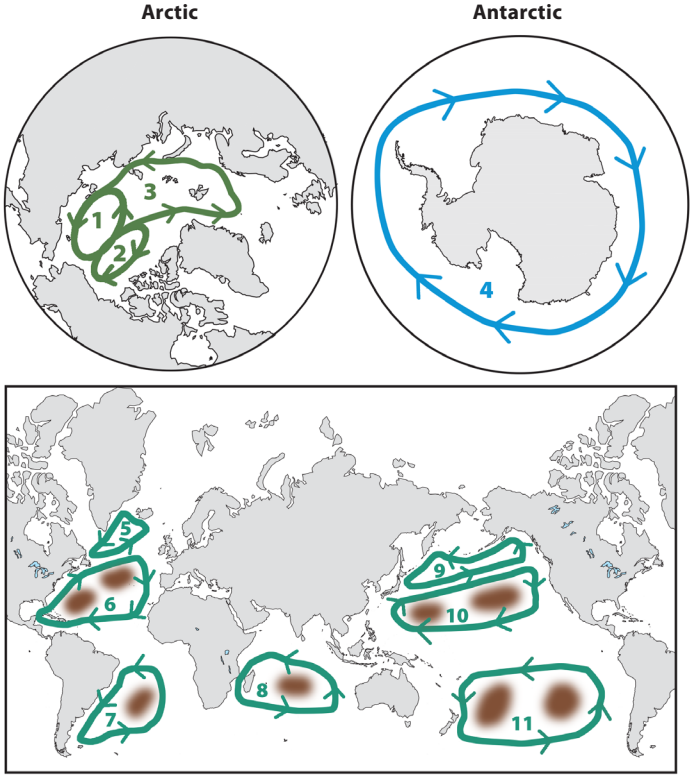
The lost ducks traveled the Pacific Ocean along gyre 10, the North Pacific Gyre; and 9, the SubArctic Gyre. Some of them traveled about the Arctic in gyres 1, 2, and 3—the Beaufort Gyre. Some of them traveled under ice flows all the way to the Atlantic Ocean, propelled partly by the forces of the Beaufort Gyre and the transpolar drift. (You can see on the second map that, on the other side of the planet, Antarctia is circumnavigated by a gyre, 4).

You've probably heard of the Gulf Stream, which brings warm water from the Caribbean Sea to the northeastern coast of the United States. Well, that's just the western side of gyre 6, the North Atlantic Gyre (6, on the lower map).

Curt Ebbesmeyer, in his book *Flotsametrics*, graphed these gyres and numbered them. There are many more gyres of various sizes and flow patterns that are not shown here. Take a look at "The Arctic: Ocean Circulation," a graphic for students by Woods Hole Oceanographic Institution, at **www.divediscover.whoi.edu/arctic/circulation.html**. The main force propelling these gyres is the heat of the sun.

The eight known garbage patches are also shown within gyres 6, 7, 8, 10, and 11 on the lower map. Flying over them in a plane, however, you would not be able to detect them with your eyes. Each patch is a murky cloud of small plastic bits, slowly decomposing in the water. Why, do you think, the continents of North and South America are shown twice on the lower map?

Source: Curtis Ebbesmeyer and Eric Scigliano, *Flotsametrics and the Floating World* (Washington, DC: Smithsonian, 2009). Visit flotsametrics.com.



Recommended Books

For Children

Eve Bunting, *Ducky* (New York, Clarion Books, 1997). Inspired by the events of the 1992 bath toy spill, this colorful 32-page picture book chronicles the journey of one rubber duck traversing the Pacific Ocean.

Eric Carle, *10 Little Rubber Ducks* (New York, Harper Collins Books, 2005). Also inspired by the story of the lost bath toys, this picture book, while targeted for a young audience, addresses the concepts of the movement of goods and services and cardinal directions.

For Youth

Loree Griffin Burns, *Tracking Trash: Flotsam, Jetsam, and the Science of Ocean Motion* (Boston, Houghton Mifflin, 2010). In this non-fiction book, the author introduces the work of Curtiss Ebbesmeyer and other oceanographers exploring the science of flotsam.

Rachel Carson, *The Sense of Wonder* (New York: Harper, 1998). This edition, with photographs by Nick Kelsh, introduces readers to the writing of a preeminent biologist and conservationist as she describes a walk with her nephew along the rocky coast of Maine.

For Young Adult Readers

Donovan Hohn, *Moby-Duck* (New York, Penguin Group, 2011). This book is part memoir and part informational text. The book chronicles the author's journey as he investigates the lost bath toys and their fate.

Curtis Ebbesmeyer and Eric Scigliano, *Flotsametrics and the Floating World: How One Man's Obsession with Runaway Sneakers and Rubber Ducks Revolutionized Ocean Science* (New York, Harper Collins, 2009). Ebbesmeyer and his coauthor outline how the scientific study of flotsam is changing oceanographers' understanding of ocean currents.

HANDOUT B

U.S.-China Trade in 2011

A	**U.S. Exports to China** (Measured in U.S. $)	$1.50 trillion	
B	Key Exported Items	Agricultural products (soybeans, fruit, corn), industrial supplies (organic chemicals), capital goods (transistors, aircraft, motor vehicle parts, computers, telecommunications equipment), consumer goods (cars, medicines)	
C	Who Buys U.S-made Goods? (Shown for Comparison)	1. Canada 19.0% 2. Mexico 13.3% 3. China 7.0% 4. Japan 4.5%	Percent = value of goods sold to a nation divided by total value of goods sold to all nations
D	**Imports from China**	$2.24 trillion	
E	Key Imported Items	Agricultural product, industrial supplies, capital goods (computers, telecommunications equipment, motor vehicle parts, office machines, electric power machinery), consumer goods	
F	Whose Goods Does the U.S. Buy? (Shown for Comparison)	1. China 18.4% 2. Canada 14.2% 3. Mexico 11.7% 4. Japan 5.8% 5. Germany 4.4%	Percent = value of goods bought from a nation divided by total value of goods bought from all nations

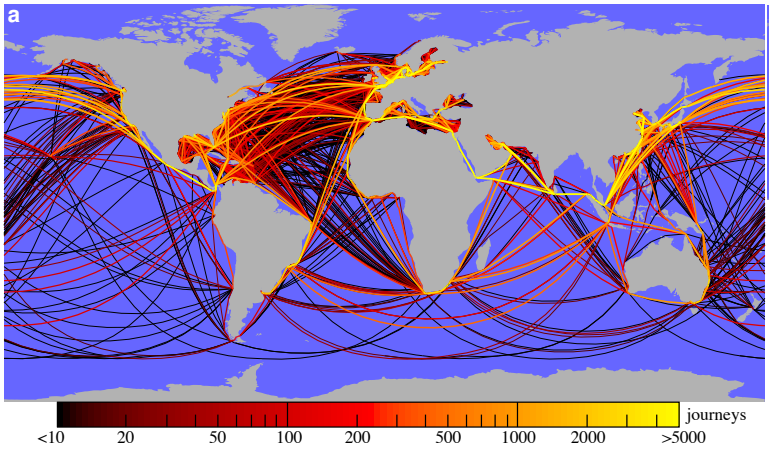
Source: CIA World Factbook.

H. Sudoneighm/commons.wikimedia.org

Seattle, Washington, container port in 2009.

HANDOUT C

World Shipping Routes



Source:
P. Kaluza et al., page 18 at http://arxiv.org/pdf/1001.2172v1.pdf.

Polar Shipping Routes

Source:
people.hofstra.edu/geotrans/eng/ch1en/conc1en/img/Map_Polar_Routes.pdf

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HANDOUT D

Public Policy and the Oceans

Students might want to research some of these controversial topics as individuals or in small groups:

- Arctic Waters: Drilling for Oil and Year-round Shipping Lanes
- Overfishing; Coral Reef Health; Whaling
- Pollution from Ships and from Land
- Global Warming and Coastal Flooding
- Nationalism v. International Cooperation on Ocean Issues

As they look into these controversies, students should investigate these groups and the work that they do:

NATIONAL AGENCIES and NATIONAL LAWS

Visit **www.education.noaa.gov** and find out what the acronym NOAA stands for and what this agency of the federal government does. What role does the Environmental Protection Agency play in maintaining the health of our waterways? (**www.epa.gov/lawsregs/topics/water.html**) Investigate how the Clean Water Act of 1972 came about (**www.epa.gov/lawsregs/laws/cwa.html**) and examine current controversies about its enforcement (**www.nwf.org/Wildlife/Policy/Clean-Water-Act.aspx**).

INTERNATIONAL AGENCIES and INTERNATIONAL LAWS

Will nations go to war over ocean resources? The UN's 1982 Law of the Sea Convention "is an unprecedented attempt by the international community to regulate all aspects of the resources of the sea and uses of the ocean, and thus bring a stable order to mankind's very source of life" (**www.un.org/Depts/los/index.htm**). It includes a procedure for settling disputes between nations. Although the United States participated in the writing of this law, the U.S. Congress has yet to ratify it (**www.state.gov/e/oes/lawofthesea**).

NONGOVERNMENTAL ORGANIZATIONS (NGOs) and their CAMPAIGNS

Students can find and contact a local organization through the Clean Water Network (**www.cleanwaternetwork.org/about**) and work with their teacher to develop appropriate service learning activity that involves local waterways. The health of the oceans is advocated by NGOs such as the Ocean Conservancy, **www.oceanconservancy.org** and Oceana, **oceana.org**.

The Product Policy Institute, **www.productpolicy.org**, advocates clean practices for industry.

*These are a just few of the centers of action and information in the field of clean water conservation. There are local and state laws and agencies; other federal agencies (such as the Bureau of Land Management); other NGOs such as various "clean river campaigns;" and other international organizations (such as Greenpeace and the Pacific Institute) that students could learn about. The point of view of bottled water companies (**www.bottledwater.org**) and the shipping industry (**www.worldshipping.org**) can also be explored.*

Ocean Conservancy/marinedebris.noaa.gov

NOAA Marine Debris Program/marinedebris.noaa.gov

Ocean Conservancy/marinedebris.noaa.gov

Citizens organize in Texas to monitor and clean beaches.

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HANDOUT E

Bottle Bills: Can a Law Reduce Plastic Pollution?

Have you noticed discarded plastic bottles lying near the storm drain, or littering the creek near your school? Plastic pollution in streams, rivers, and lakes, has been measurably reduced in states that have enacted a "bottle bill." Such a law requires stores to collect a deposit (often 5¢ upon purchase) and give a refund (upon return) for glass and plastic beverage containers.

To date, ten U.S. states have bottle bills (many of those states are also campaigning for updates and expansion), and still others have active campaigns for new bottle bills. There's lots of information about such state legislation at the webpage of **BottleBill.org**, **www.bottlebill.org/legislation/usa.htm**, which favors such laws. The Pacific Institute has useful reports and fliers, **www.pacinst.org/topics**. The beverage industry, however, lobbies against such legislation whenever and wherever it's proposed, and even seeks to repeal established laws (**www.ecori.org/waste-issues/2011/5/28/bottle-bill-repeals-pushed-by-industry.html**).

What are the pros and cons, the costs and consequences, of a statewide bottle bill? What is the status of this issue in your state?

Albert Gorman / artistatexit0.wordpress.com

Flotsam in high water near the Falls of the Ohio, 2011.

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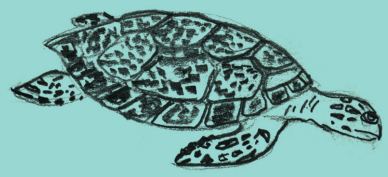
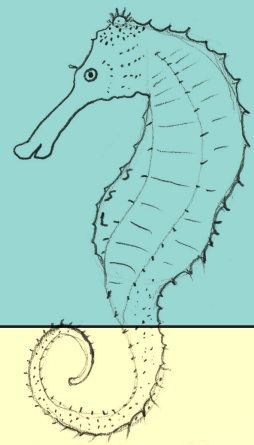
HANDOUT F

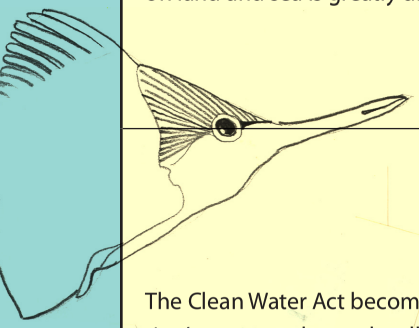


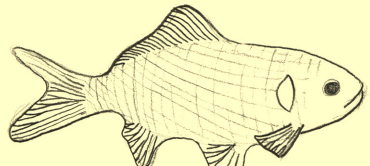


A Timeline of Ocean Conservation

Steven S. Lapham

The United States explodes a nuclear bomb, codenamed "Bravo," on the Bikini islands, making them too contaminated for humans to visit. Fallout poisons the *Lucky Dragon* , a Japanese tuna fishing boat, killing one crewmember (1954). See "The 'Bravo' Test" at **www.pbs.org/wgbh**	**1950**	Rachel Carson's *The Sea Around Us* wins the National Book Award, making her an international voice for the public understanding of science (1952). She'd worked for 15 years with the U.S. Fish and Wildlife Service. **www.rachelcarson.org**
U.S., United Kingdom, and U.S.S.R. (the Soviet Union) sign the Nuclear Test Ban Treaty. Bomb tests continue underground, but the danger of radioactive fallout on land and sea is greatly diminished (1963). **www.jfklibrary.org** *The Undersea World of Jacques Cousteau* runs for nine seasons on ABC TV, beginning in 1968. **www.cousteau.org**	**1960**	Rachel Carson's book *Silent Spring*, about the danger of manmade chemicals such as DDT, inspires the global environmental movement (1962). **www.pbs.org/moyers/journal** A fire on the oily surface of the Cuyahoga River in Cleveland captures the nation's attention (1969). (A fire 17 years earlier caused more than $1 million in damage.) **www.epa.gov/greatlakes/aoc/cuyahoga.html**
The first Earth Day marks what many consider to be the birth of the modern environmental movement (April 22, 1970). **www.earthday.org** The Clean Water Act becomes law, which aims to protect the quality of the nation's water, and to make all lakes, rivers, and coasts safe for swimming and fishing (1972). EPA reports in 2012 that 2/3 of U.S. waterways are that clean. Before this law, 1/3 were. **www.epa.gov/lawsregs/laws/cwahistory.html**	**1970**	Richard Nixon signs a law creating the Environmental Protection Agency (EPA). Its regulations for clean air and habitat preservation bring economic and health benefits to humans (1970). **www.epa.gov/history** Also in 1970, the creation of NOAA (National Oceanographic and Atmospheric Administration) brings together agencies of coastal survey (est. 1807), weather (1870), and fisheries (1871). **www.history.noaa.gov** A new life form—six-foot long tubeworms—is discovered thriving next to "poisonous" ocean-floor vents (1977). **news.nationalgeographic.com**





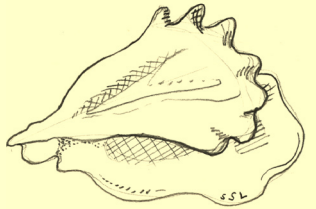
James E. Hansen and six other NASA scientists publish their research article, "Climate Impact of Increasing Atmospheric Carbon Dioxide" (1981).

The Law of the Sea Treaty (the Third UN Convention on the Law of the Sea) is adopted (1982). Although the U.S. usually works within the treaty, the U.S. Senate has not ratified it. **www.unlawoftheseatreaty.org**
stream.wsj.com (article of July 16, 2012)

IWC (International Whaling Commission, est. 1946) announces a complete ban on commercial whaling, but "research killings" and hunting by a few dissenting nations continue (1982). **wwf.panda.org**

1980

Agents of the French government bomb the *Rainbow Warrior*, a Greenpeace ship as it sits at harbor in New Zealand, killing a crewmember (1985). France was testing nuclear bombs underground on the Moruroa Atoll. **www.greenpeace.org/international/en**



The ship *Exxon Valdez* runs aground and spills 11 million gallons of oil into Alaska's Prince William Sound (1989). Although one of the biggest spills in U.S. history, it does not even rank among the top 50 biggest oil spills that have occurred in the world. **www.evostc.state.ak.us**

A container ship spills 28,000 bath toys into the Pacific Ocean (1992). **marinedebris.noaa.gov/info/faqs.html**

A yacht-race captain discovers the Great Pacific Garbage Patch (1992). NOAA scientists had predicted its existence four years earlier.
education.nationalgeographic.com marinedebris.noaa.gov/info/patch.html

www.pacinst.org/topics

1990

The Atlantic Cod Fishery collapses (1992). For nearly 500 years, the Grand Banks off Newfoundland was the richest fishery in the world, an "endless" source of food for humankind. **www.foreignaffairs.com** (July/August 1999)

Despite the ban on fishing, the Atlantic cod population has not recovered.
www.bostonglobe.com (March 4, 2012)
archive.greenpeace.org/comms/cbio/cancod.html

SpongeBob SquarePants (2000) and *Finding Nemo* (2003) popularize ocean life for kids.

IPCC (Intergovernmental Panel on Climate Change) announces a broad consensus among scientists that pollutants are a major cause of the Earth's rising air temperatures. Warming oceans also bring rising in sea levels (2001). **www.ipccfacts.org/history.html**

2000

Oceana is the largest international NGO focused solely on ocean conservation (est. 2001). **oceana.org/en**

NASA scientists warn that global warming could disrupt the Gulf Stream, plunging Europe (ironically) into a new ice age.
science.nasa.gov/science-news/science-at-nasa (March 5, 2004)

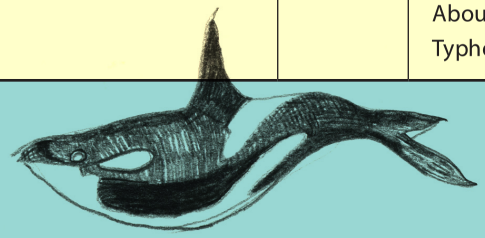
Melting arctic ice creates new opportunities for commercial shipping and oil and gas drilling. The first ship ever to cross the Arctic Ocean from China arrives in Iceland. **www.reuters.com** (Aug. 17, 2012)

Scientists find that in the last 27 years, half of Australia's Great Barrier Reef coral has died. **www.pbs.org/newshour** (Oct. 2, 2012) **ocean.si.edu**

2010

The biggest spill in history: rig Deep Water Horizon of BP (British Petroleum) catches fire and sinks, killing 11 rig workers and releasing 200 million gallons of oil into the Gulf of Mexico (2010). **oceana.org/en**

About 148 tons of "nurdles," tiny plastic beads, pollute Hong Kong beaches after Typhoon Vincent (2012). **news.discovery.com**



HANDOUT G

Middle Level Learning 46, p. M14

Do You Brush with Nurdles?

Steven S. Lapham

The word "nurdle" has two definitions: (a) the tip of the curl on a bead of toothpaste on your brush; and (b) a tiny plastic pellet that is usually melted down in a factory, by the bucketful, to make a plastic object. The plastic industry has lost nurdles by the billions during transport from refinery to factory, like a spill in 2012 of several tons of nurdles in Hong Kong harbor during a typhoon.

The pellets themselves are non-toxic, but they are prone to absorbing toxins from the surrounding environment, such as mud at the bottom of a river. If a fish eats the now-toxic nurdles, then the fish's flesh may become toxic. People eating fish they've caught might be exposed to mercury, PCBs, or other dangerous substances.

Many facial scrubs, shampoos, and some brands of toothpaste pack thousands of clean (non-toxic) "micro-nurdles" into each product to provide gentle abrasion to a surface, like your teeth or skin. So when you brush your teeth, you might have mouth full of plastic nurdles. The plan for the "final resting place" of these micro-beads in your toothpaste is to go down the drain. But where do they go from there?

If you and your parents want to see a few micro-nurdles, take a teaspoon of a product in your home that advertises an abrasive or "exfoliating" quality. Dissolve the sample in a bowl of hot water, then strain it through a piece of black cloth. Those little round bits are likely to be polyethylene or polypropylene micro-beads. Don't rinse them down the drain, but place them in the trash, or inside a plastic bottle that you recycle.

Extended Producer Responsibility (EPR) is a policy goal, whereby a company considers the entire lifecycle of its product, and makes sure there are no negative human health or environmental impacts. The companies that use these microbeads as scrubbers in their products do have some alternatives, such as using bits of hard seed husks for abrasive grit. Should micro-nurdles be part of consumer products? Are the manufacturers and shippers of nurdles doing everything they can to assure that these plastic pellets do not pollute our waterways?

Discovery News

A handful of nurdles collected on the Hong Kong beach after Typhoon Vincent in 2012.

Learn more about Nurdles at:
www.epa.gov/region9/mediacenter/nurdle-plastic-pellets

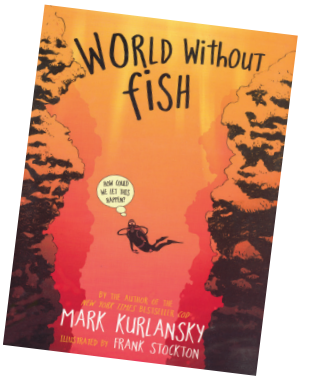
5gyres.org/posts/2012/08/19/the_nurdle_in_your_nurdle_do_you_brush_with_plastic

news.discovery.com/earth/hong-kong-nurdles-cleanup-120809.html
nurdle.org

Learn more about Extended Producer Responsibility at:
www.productpolicy.org/content/about-epr

Middle Level Learning 46, p. M15

Water Rescue: *The Cod's Tale* and *World Without Fish*



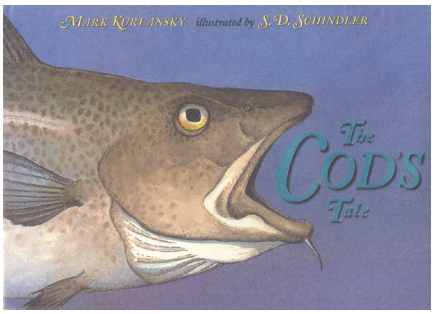
Steven S. Lapham

The Cod's Tale by Mark Kurlansky, illustrated by S. D. Schindler. G. P. Putnam's Sons (Puffin Books), 2001, 48 pp., $12.23.

World Without Fish by Mark Kurlansky, illustrated by Frank Stockton. Workman Publishing, 2011, 184 pp., $ 12.37.

The picture book *The Cod's Tale* by Mark Kurlansky was a 2002 Notable Social Studies Trade Book and a Selector's Choice on that list (one of the 12 reviewers liked it "with particular enthusiasm"). The book summarized for elementary and middle school readers one of Kurlansky's books for adults, *Cod: A Biography of a Fish that Changed the World*. Elementary teachers find the picture book especially useful because it dovetails well with a curriculum about Colonial America and the Industrial Revolution. Salted cod was a key component of early New England's economy (including the slave trade). The brute power of industrial fishing (ships with diesel engines, huge nets and trawls, and on-board freezers) eventually depleted Atlantic cod populations, causing the entire Atlantic cod fishing industry to collapse in 1992. A ban is still enforced, and after 20 years the species has not recovered.

Kurlansky, who worked as a commercial fisherman before becoming a *New York Times* bestselling author, recently wrote another outstanding book—this one for slightly older (middle and high school) readers, *World Without Fish*. If this book had a subtitle, it could be "The Bad News Gets Worse." But don't let that discourage you from sharing this entertaining and inspiring book with your students. There is also hope and a call to action.



Kurlansky has worked closely with illustrator Frank Stockton to create a graphically enticing narrative. The main text is double spaced for easier reading, and many pages feature a photograph and caption that help the reader visualize the topic at hand, such as a certain species of fish or piece of fishing equipment. Main messages are emphasized with capital letters in a marking pen font of contrasting colors.

A most inventive feature is that each of the 11 chapters ends with a colorful one-page comic book-style narrative: a father and daughter, who both love the sea, observe the depletion of fish in the world's oceans as they age over the course of 30 years or so. The fish gradually disappear from their dinner plates and favorite snorkeling sites, despite the false optimism and faulty reasoning of other characters. It's a scenario that's all too likely to happen.

The effect of such a mix of graphic styles in a single book could be visual chaos. *World Without Fish*, however, is logically organized. Children might approach the book from any angle and get happily caught up in it. For example, you could savor the book à la *National Geographic Magazine*. (Flip through it looking at the pictures, then go through it again reading the captions. Now thoroughly hooked, surrender to reading whole sections.)

Or you could opt for the comic book approach. (Read sequentially through the 11 pages that depict the story of Kram, the father, and Ailat, his daughter. This in itself would give you the main lessons of the book.)

In the classroom, a teacher might read aloud the story of Kram and Ailat over the course of 11 days, then assign chapters to student pairs, who report back to the whole class about what they discover.

There's plenty of science, history, economics, and public policy in *World Without Fish* to link to any middle school curriculum. And for kids who want to do something about the problems of overfishing and pollution, there are resources at the back and suggestions for action. For example, after reading this book, I would never purchase orange roughy (See pp. 46–49 and the list of "best choice" fish to buy on p. 178). U.S.-farmed tilapia is an ocean-friendly choice, and when I buy it, I'm supporting a sustainable industry. I can live with that.

Middle Level Learning 46, p. M16

Ocean Gyres

The lost ducks traveled along Ocean Gyres. Copy the gyres on **HANDOUT A** onto these maps. Then draw in the eight known garbage patches.

Source: Curtis Ebbesmeyer and Eric Scigliano, *Flotsametrics and the Floating World* (Washington, DC: Smithsonian, 2009). Visit flotsametrics.com.