High School Marine Debris Lesson 1 – Plastics in the Ocean
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Summary: Through articles, videos, and personal research students will investigate what marine debris is, origins of marine debris, and impacts of marine debris on marine ecosystems as well as human health.

Instructional Objectives:

1. Students will be able to define marine debris, to describe common items that make up marine debris, and to identify common sources of marine debris
2. Students will be able to describe the breakdown of plastic marine debris and the impacts of marine debris on marine food webs.
3. Students will be able to identify common chemicals found in plastic marine debris and discuss the impacts of these chemicals on human health.
4. Students will be able to identify the major global ocean and air currents that carry marine debris around the globe.

Ocean Literacy Principles:
http://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/

1. The Earth has one big ocean with many features.
5. The ocean supports a great diversity of life and ecosystems.
6. The ocean and humans are inextricably interconnected.

National Science Standards

High School Life Science

- Matter and Energy in Organisms and Ecosystems
- Interdependent Relationships in Ecosystems

High School Earth and Space Science

- Earth's Systems
- Human Sustainability

High School Engineering Design

- Engineering Design

AP Environmental Objectives:
http://media.collegeboard.com/digitalServices/pdf/ap/ap-environmental-science-course-description.pdf

I. Earth Systems and Resources

C. Global Water Resources and Use

VI. Pollution

A. Pollution Types

3. Water pollution

B. Impacts on the Environment and Human Health

1. Hazards to human health
   (Environmental risk analysis; acute and chronic effects; dose-response relationships; air pollutants; smoking and other risks)
2. Hazardous chemicals in the environment
   (Types of hazardous waste; treatment/disposal of hazardous waste; cleanup of contaminated sites; biomagnification; relevant laws)

Background Information:
The National Oceanic and Atmospheric Administration has defined marine debris as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes. Categories of marine debris include plastics, glass, processed lumber, metal, rubber, and cloth or fabric. Many of these materials break down over time and exposure to environmental conditions resulting in small particles. "Microplastics" are pieces of plastic that are less than 5mm in size. Microplastics can come from larger pieces of plastic that have broken down over time. Or, microplastics can be manufactured. For example, pre-production industrial plastic pellets or plastic "micro-scrubbers" in face wash are considered microplastics. For more information about types of marine debris and plastic marine debris please visit http://marinedebris.noaa.gov/learn-basics/types-and-sources, http://marinedebris.noaa.gov/info/plastic.html and http://marinedebris.noaa.gov/research/detecting-microplastics-marine-environment.

Marine debris is typically non-point source pollution that comes from either human activity in the land or at sea. Marine debris can enter the ocean ecosystem through a variety of sources including ocean platforms, derelict fishing gear, litter and discharge from storm drains, natural disasters, and poor management of manufacturing materials. Additional information can be found at http://marinedebris.noaa.gov/ and http://marinedebris.noaa.gov/learn-basics/types-and-sources

A great deal of marine debris has been carried to the oceanic gyres through both ocean and air currents around the globe, leading to the well known Pacific Ocean Garbage Patch discovered by Captain Moore. Several other similar garbage patches exist around the globe. These locations are fascinating to study and provide a wealth of information about how human activities can alter remote locations. However, the problem is larger than these garbage patches, as marine debris is found in every ocean and on every shoreline on the planet. For more information about the Pacific Ocean Garbage patch please visit http://marinedebris.noaa.gov/movement/great-pacific-garbage-patch and http://marinedebris.info/wiki/great-pacific-garbage-patch.

Time:
2- 3 50 minute class periods (time will depend on how tasks are assigned)

Materials:
1. Class copies of article "Garbage In Garbage Out" from Conservation Magazine January-March 2010 http://conservationmagazine.org/2010/01/garbage-in-garbage-out/
2. Access to the following videos
   http://www.sportdiver.com/plastic.paradise
   http://www.ted.com/talks/dianna_cohen_tough_truths_about_plastic_pollution
   http://www.ted.com/talks/capt_charles_moore_on_the_seas_of_plastic#t-336536
3. Student journals or access to online blog site.
4. Internet access.
5. Materials for student posters or presentations.
6. If students are unfamiliar with global air and ocean circulation you will need texts or online access to information regarding these concepts.

Procedure:
Part 1- An Introduction
1. Read aloud or have students read the article "Garbage In Garbage Out" from Conservation Magazine January-March 2010 http://conservationmagazine.org/2010/01/garbage-in-garbage-out/. Be sure to read the insert boxes "Breakdown", "Nurdle Soup" and "Plastic Sausage Machine" as well.

2. Have students answer the **Article Review and Reflection Questions** with the attached map of global air and ocean currents.
   Option- this could be done individually or as a round robin to facilitate more discussion among students.
3. Watch the videos as a class.
   http://www.sportdiver.com/plastic.paradise
   http://www.ted.com/talks/dianna_cohen_tough_truths_about_plastic_pollution
   http://www.ted.com/talks/capt_charles_moore_on_the_seas_of_plastic#t-336536
   After viewing the videos have students work in groups of 3 or 4 to reflect on the following questions:
   1. What are the most of the items that make up marine debris and where do they come from?
   2. How is marine debris an environmental problem?
   3. How is marine debris an economic problem?
   4. Briefly explain how much of the marine debris is broken down by chemical and physical forces.
   5. Is marine debris a "solvable" problem? Justify your answer.
4. Discuss the group answers to questions as a class.

Part 2- The Debris We See

5. Ask students to observe their community for an entire day or for several days and to look for potential sources of marine debris. **This may be started prior to the start of the lesson to allow adequate observation time.* Students should then create journal entries or discuss their findings on an online class blog. Entries should include the types of potential marine debris observed (or collected), possible or known sources of the items, and ideas about how to prevent found items from entering the natural environment, including the 5 Rs: reduce, reuse, recycle, redesign, and remove.
Option-You may choose to have students keep some of the debris they find to use in the art extension project (Lesson 4).

Part 3- Effects of Marine Debris

5. Students should choose one item found in their journaling to research. Have students conduct research to determine how the object breaks down in the ecosystem and how it could potentially enter the food web. Research should include a discussion of the most common chemical components of the item and the affects of at least one of the chemicals on ecosystems and/or human health.
6. Students should present their findings to the class. This can be done as "most wanted" poster for the object or chemical, a power point presentation, brochure, formal written report, or informational poster.

Part 4 – Tracing the Path of Marine Debris

7. In pairs, have students choose a piece of debris found while journaling and create a diagram, story, or cartoon to show the life of the item from its manufactured creation, to its use, through its path to the ocean and finally its life in the ocean as it breaks down. Each project should show the following:
   1. How and where the product was created or manufactured.
   2. How the product is used by consumers.
   3. The path the product takes to the ocean.
   4. How the product is broken down into smaller components (once in the ocean).

Possible Extensions:

1. EXTENSION: Conduct a LD-50 experiment showing toxicity of chemicals on living organisms such as aquatic plants.
2. EXTENSION: Have students invent an imaginary microbe that would break down the plastic fully into inert substances that can be incorporated into one of the biogeochemical cycles. Students must

address the adaptations of the microbe to break down the plastic, the energy source of the microbe, waste products of the microbe, and how the final substance could be incorporated into a biogeochemical cycle. Students could take project further by creating an imaginary business to sell the microbes invented by the class.

Additional Resources:
Resources for lesson.
Videos:
http://www.sportdiver.com/plastic.paradise
http://www.ted.com/talks/capt_charles_moore_on_the_seas_of_plastic#t-336536
http://www.upworthy.com/people-should-know-about-this-awful-thing-we-do-and-most-of-us-are-simply-unaware

Articles:
http://marinedebris.noaa.gov/info/patch.html
http://www.hngn.com/articles/11969/20130909/teen-invents-ocean-clean-up-device-remove-1-3-plastic.htm
http://news.nationalgeographic.com/news/2014/04/140404-garbage-patch-indian-ocean-debris-malaysian-plane/
http://conservationmagazine.org/2011/07/trash-fish/
http://www.npr.org/blogs/thetwo-way/2012/05/09/152350088/study-plastic-garbage-in-pacific-ocean-has-increased-100-fold-in-40-years
http://www.npr.org/blogs/thetwo-way/2010/04/flip_flops_in_arctic_and_other.html
http://marinedebris.info/wiki/great-pacific-garbage-patch
http://timesofindia.indiatimes.com/city/visakhapatnam/Scuba-diving-for-debris-free-marine-life/articleshow/32927516.cms
http://www.abc.net.au/environment/articles/2013/12/16/3911379.htm

Websites to aid research
http://marinedebris.noaa.gov/learn-basics/types-and-sources
http://marinedebris.noaa.gov/
http://marinedebris.info/wiki/great-pacific-garbage-patch
http://marinedebris.noaa.gov/info/patch.html
http://plasticpollutioncoalition.org/
http://water.epa.gov/type/oceb/marinedebris/
http://www.projectaware.org/project/marine-debris
http://education.nationalgeographic.com/education/encyclopedia/marine-debris/?ar_a=1

Name _____ Period _____ Date _____

Article Review and Reflection Questions

1. Who is Captain Charles Moore and what is his mission?

2. What are doldrums and gyres?

3. What types of plastics have been found in the Pacific Ocean Gyre?

4. What evidence suggests that plastic is making its way into the food chain?

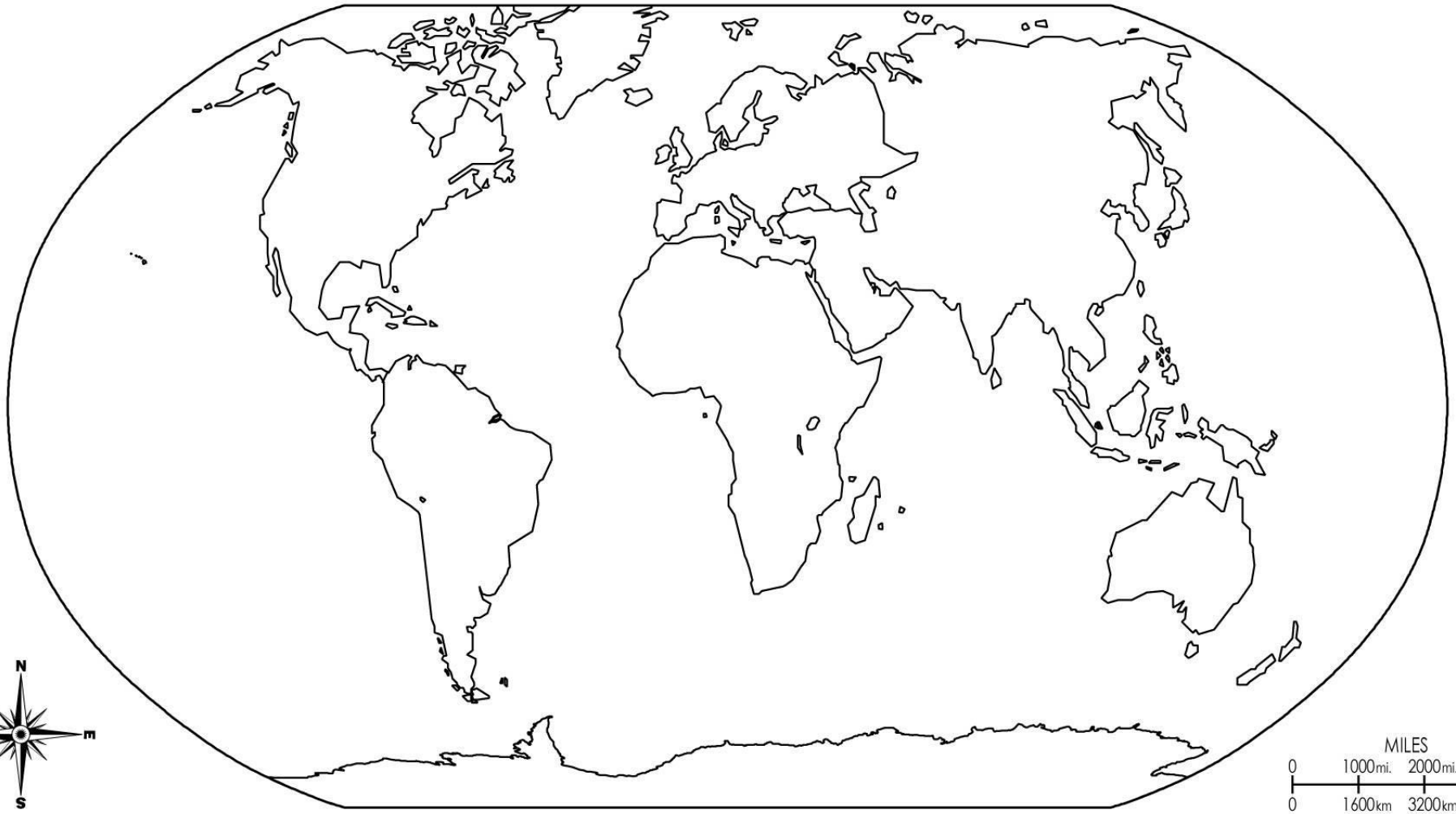
5. Why is the breakdown of plastic into micro particles (< 5 mm) a concern?

6. A) What are phthalates? B) In what types of products are they found? C) What are the possible affects of these chemicals on human health?

7. What is the endocrine system?

8. Using the map on the next page use blue arrows to show the major ocean currents on Earth and black arrows to show the major air currents over the oceans.
9. Imagine a piece of trash that enters the San Francisco Bay. Use red arrows to show the potential path of the item into the Pacific Ocean Gyre.
10. List at least 3 potential locations or origin of an item found in the North Atlantic Gyre.

Continents and Oceans of the World



11. Explain the breakdown of plastics. Why are they not considered to ever be “biodegradable”?

12. A) What do the numbers on plastic containers mean? B) Which ones have the best “aftermarket” use and what chemicals are in them?

13. What are some items in your life that might be made from recycled plastics?

14. What is PVC? Where is it found?

15. What is “cradle-to-cradle” manufacturing and how is it different than “cradle-to-grave” manufacturing?

16. In your opinion, will “wisdom eventually trump convenience and cheap disposability” as suggested in the article? Justify your answer.

17. Why are ecosheets better than plywood?