Plastics in Society

Created by Center for Alaskan Coastal Studies

Essential Questions

How do people affect coasts and the ocean?
How can people protect coasts and the ocean?
What is the role of technology in protecting our coasts and the ocean?

Enduring Understandings

- *Pollution knowingly or unknowingly introduced into the ocean by people can have negative effects on marine ecosystems.*
- *You can minimize the solid and liquid pollution you are introducing into the ocean.*
- *Making informed decisions as a consumer helps to protect the ocean.*
- *You can create new ways to care for the ocean and get others involved.*
- *Technology can have unintended consequences.*

Objectives

Students will understand important characteristics about plastics and how these properties affect the fate of plastic as marine debris. They will connect their personal use of plastics with the problems of marine debris and design ways to minimize the improper disposal of plastics.

Concept

Plastics are a unique and relatively recent technology created by linking monomers together. A variety of polymers and chemical additives are used to make a range of plastics with diverse characteristics. Different types of plastics have different properties that affect the likelihood that the plastic will end up as marine debris and also how the plastic may affect the marine environment. Individuals have great power as plastic users to change their own consumption and disposal habits and influence others to minimize plastic waste.

Words to Know

Monomers- Monomers are small molecules which may be joined together in a repeating fashion to form more complex molecules called polymers.
Polymers- Polymers are natural or manmade chemicals made of many repeating units called monomers

Materials

- Science notebooks
- Pencils
- Elmer's Glue (1 cup for every 2-4 students)
- Borax (1 teaspoon for every 2-4 students)
- Food coloring (optional)
- Mixing bowls (1 for every 2-4 students)
- Mixing cups (1 for every 2-4 students)
- Spoons (1 for every 2-4 students)
- Ziploc bags
- Variety of plastic products
- Laptop/computer and projector or SmartBoard
- Internet connection
- Handout – "Estimated Life Span of Plastic Products"
- Handout – "Polymer Recipe"
- Handout – "Plastics by Number" chart
- Handout – "CoastWalk 2012 Plastic Data"

Handouts provided at the end of this document.

Background:

Over 100 billion pounds of plastic were produced in 2013, and this figure has been steadily increasing from year to year. The amount of plastic produced annually has grown approximately 40-fold between the 1950s and 2005. Looking at our lives today, it's hard to think of how we could exist without plastic. But plastic is actually a relatively new addition to the world. It was first created by Alexander Parkes in 1862. He showed off this new product to the public, which we later came to know as celluloid, at the Great International Exhibition in London. The term "plastics" was coined by chemist Leo Hendrik Baekland to describe his invention of the first fossil fuel based polymer, which he created in 1907. After the First World War when manufacturing techniques were refined and petroleum was readily available, plastics started their rise to popularity. However, they did not start to become common until after the Second World War, and there are still people alive who can remember a life without plastic in it.

According to the American Chemistry Council, the plastic production process often begins by treating components of crude oil or natural gas in a "cracking process." This process creates hydrocarbon monomers such as ethylene and propylene. The monomers are then chemically bonded together to form chains called polymers. Simply put, polymers are chemicals made of many repeating units. They can be made by nature or in a lab and some examples include spider silk, hair, silly putty, rubber and DNA. Brainstorm with the class on why polymers are useful (because they are strong!)

Preparation

Set up computer and projector or SmartBoard to show the "How It's Made Plastic Bags" video by the Discovery Channel on YouTube (https://www.youtube.com/watch?v=8CfL5xl2N1Q).
This video on YouTube sometimes begins with advertisements, so play through these during your preparation.

Prepare a sample polymer by mixing 1 cup white Elmer's glue with 1 cup warm water, and a drop or two of food coloring, if you'd like. Combine 1 teaspoon of borax powder with ½ cup warm water. Mix well and then pour into glue mixture, stirring well with a spoon. Once the molecules start to link up forming a polymer, use your hands to knead it.

Arrange these ingredients, mixing bowls, and measuring spoons and cups on a back table for students to use themselves during the lesson.

Introduction

Ask students to look around the room and take note of all the plastic. Think about all the things we use every day that are made of plastic. Play a Scattergories-style game to brainstorm plastic items or uses with the students. To do this, think of a category of plastics, or a place they are used.

Topics could include “Plastics used in clothing” or “drinks served in plastic,” etc. Split the students into groups and have each group brainstorm items in that category in a given amount of time: 30 seconds to three minutes. At the end of every round, have the groups share their lists. Each group gets points for each unique response they come up with. Discuss how prevalent plastic is in society and explain that over 100 billion pounds of plastic was produced in 2013.

Procedures and Activities

“Show “How It’s Made – Plastic Bags” – a YouTube video by the Discovery Channel. http://www.youtube.com/watch?v=8CfL5xl2N1Q For younger students, you may want to show the video without sound and narrate the process in a more age appropriate language.

Explain that the plastic production process often begins by treating components of crude oil or natural gas in a “cracking process.” This process creates hydrocarbon monomers such as ethylene and propylene. The monomers are then chemically bonded together to form chains called polymers. Simply put, polymers are chemicals made of many repeating units. They can be made by nature or in a lab and some examples include spider silk, hair, silly putty, rubber and DNA. In the video, the polyethylene is a polymer made of ethylene monomers. Brainstorm with the class why polymers are useful (they are strong and can be flexible), and have students write in their science notebooks at least three important uses for polymers. Choose one or more of the activities below.

Create a Polymer and Discussion

Next, reveal your sample polymer and explain to students that they will make their own polymer using borax and glue. In fact, the glue is actually already a simple polymer, but the borax crosslinks the polymers in the glue to create a more complex polymer … a type of plastic! Divide students into groups of 2-4 people. Each group will need 1 mixing bowl and 1 mixing cup, as well as a spoon. Send groups back one or two at a time to the back table to measure 1 cup of glue and 1 cup warm water (and food coloring if you choose to use it) into their mixing bowl and ½ cup warm water and 1 teaspoon of borax into their mixing cup. Students should then return to their desks, mix the borax mixture into the glue mixture and stir well. When they notice their slime starting to take shape as monomers link into polymers, students should remove the slime from the leftover water and knead with their hands. Give students some time to play with and observe their completed polymer. Then have the students split the polymer among each member of their group and store in Ziploc baggies.

Photo-degradation Discussion

After making a polymer, explore more about how plastics interact with the natural world. Because of its hardy molecular structure, plastic takes a long time to break down. Although we have estimates as to how long based on current rates of degradation, no one is really sure because plastics haven't been part of the world long enough to know. Another problem is that plastics are not biodegradable. If you bury plastic in the ground and come back in any number of years, it will be intact. Biological organisms, like bacteria and worms cannot decompose it. However, plastics are photodegradable. When exposed to sunlight for prolonged periods of time, the chains that form plastic polymers begin to crosslink. Cross-linking makes plastic brittle and breakable. As more cross-links happen, plastics break into smaller and smaller pieces. You have probably seen examples of this if you have ever left a plastic bag in the sun too long or seen the cracked dashboard of an old car. Because it takes so long to breakdown, plastic isn't like other kinds of trash. When it ends up in our landfills and in our oceans, it doesn't just go away. Have students write in their science notebooks three ways it is beneficial that plastics don't biodegrade and three ways it is harmful that plastics don't biodegrade.

Plastic Types and Trends

Examine different plastic products and look for the number on the bottom. Divide students into groups of 2-4 people. Provide students with the Plastic Number Chart and a variety of plastic items. The plastic recycling number on each product indicates the type of polymer and other chemicals in the plastic. Ask students to sort their plastics by recycling number and then identify what polymers are used in what products. Have them record this information in their science notebook, then come together as a class to list the different products found for each category of plastic. Discuss how some types are more easily recycled while others are more difficult to recycle. Also explain that some numbers of plastics contain or can accumulate toxins. Ask students to think about what this might mean for marine debris issues.

Have students work in their groups to hypothesize what types of plastics are most likely to become marine debris, writing their hypothesis in their science notebooks with an explanation of their reasoning. Have students consider how common each type of plastic is, where products of that type might be used, and how people dispose of them. For example, PETE (type #1) may be common in marine debris because many PETE products like soda bottles are used at the beach and on the water. Present students with data from CoastWalk and have them determine if their hypothesis is supported or not supported by this data.

Wrap-Up & Extensions

Finally, brainstorm solutions to our plastic problem. Ask students to identify where we can cut down on plastic waste most easily (single use items). Have each student identify one disposable plastic item they can cut back on or eliminate from their personal use. Then, have students work in groups of 2-4 to develop an action plan to cut back on plastic pollution in their school or community. Provide examples of successful efforts, such as plastic bag bans, plastic recycling, and reusable water bottles. Have students begin by identifying at least three sources of plastic waste in their school or community, and then give them 15-30 minutes to work as a group to create a draft action plan to minimize plastic waste from one of those sources. Once all groups have developed an action plan, have groups present their ideas. Discuss the action plans as a class and decide on one to pursue. Work as a class to revise the chosen action plan and implement it. Depending on the level of the class and the plan you choose, this may be a simple endeavor or may require further time both in and out of class.

Evaluation

Observe student participation during group work. The successful creation of polymer slime and sorting of plastic types can be used as a measure of cooperation, student understanding, and ability to follow multi-step directions and measure ingredients. Review student science notebook entries, including: uses of polymers, pros and cons of plastic not biodegrading, and plastic type hypothesis. Evaluate these entries for completeness, effort, and understanding of the concepts. Use the rubric to evaluate draft action plans and presentations.

Estimated Life Span of Plastic Products

Note: These figures are estimates, but highlight how long plastics could last. We don't really know how long these things will be around because they haven't been in existence long enough to test. These numbers are based on observed photodegradation rates and extrapolation from them.

Derelict Fishing Gear ~ Tens to Hundreds of Years

Foam Buoy ~ 80 years

Disposable Diaper ~ 450 years

6-pack rings ~ 400 years

Plastic bottle ~ 450 years

Monafilament Fishing line ~ 600 years

Plastic Bag ~ Hundreds of years

Mylar Balloon ~ Hundreds of Years

Cigarette Butts ~ Hundreds of Years

Source: NOAA Fisheries Service. NOAA Fisheries Service, Southeast Regional Office, Protected Resources Division. (2006). *Marine debris: Impacts in the Gulf of Mexico.* Retrieved from website: http://sero.nmfs.noaa.gov/pr/pdf/Marine%20Debris%20in%20GOM.pdf

Polymer Recipe

Ingredients (per batch):

1.5 Cups Warm Water
1 Cup Elmer's Glue (8 oz bottle)
1 Teaspoon Borax
Food Coloring (optional)

Other Materials (per group):

1 Mixing bowl
1 Mixing cup
1 Mixing spoon
1 Ziploc bag for each student

Directions:

1. Measure 1 cup of glue and 1 cup warm water into a mixing bowl.
2. Stir in one to two drops of food coloring (optional).
3. Measure ½ cup warm water and 1 teaspoon of borax into a separate mixing cup.
4. Stir well to dissolve borax powder.
5. Pour the borax/water mixture into the glue/water mixture.
6. Stir well.
7. The slime will start to take shape as polymers link into larger polymers. When this happens, remove slime from leftover water.
8. Knead polymer slime with your hands.
9. Take some time to observe your slime.
10. Split the polymer between group members and seal it into the Ziploc bags.

Plastics By Number

The numbers tucked inside the recycle symbol on the bottom of plastic products tell you more than what recycling bin to toss it in. Those numbers reveal a lot about the characteristics of the plastic, how easy it is to recycle and chemicals it contains.

#	Type of Plastic	Common Products	Characteristics	Concerns	Commonly Recycled?
1	Polyethylene Terephthalate (PET/PETE)	beverage bottles, clothing, carpets mouthwash bottles; peanut butter, salad dressing & other food containers	clear, tough, heat resistant, moisture/gas barrier	May allow bacteria to accumulate; a common type of land-based marine debris	Yes
2	High Density Polyethylene (HDPE)	milk jugs, household cleaner containers, juice bottles, shampoo bottles, cereal box liners, motor oil bottles, yogurt & butter tubs	moisture barrier, chemical resistant	Generally considered safe for human use; a common type of land-based marine debris	Yes
3	Vinyl or Polyvinyl Chloride (V/PVC)	food wrap, shampoo bottles, Clear food packaging, cooking oil bottles, medical equipment, piping, windows	transparent, chemical resistant, long term stability, good weatherability, stable electrical properties	May contain dangerous chemicals, including phthalates and DEHA; as marine debris, these chemicals can leach into the environment	No
4	Low Density Polyethylene (LDPE)	squeezable bottles, shopping bags, clothing, carpet, frozen food, bread bags, food wraps	tough, flexible, transparent, low melting point, stable electrical properties	Generally considered safe for human use; bags pose a special threat as marine debris as they can cause entanglement problems and are often ingested	Increasing
5	Polypropylene (PP)	yogurt containers, ketchup bottles, syrup bottles, medicine bottles, automobile battery casings	chemical resistant, a high melting point, making it ideal for hot fill liquids, excellent resistance to water and to salt and acid solutions	Generally considered safe for human use; a common type of land-based marine debris	Increasing
6	Polystyrene (PS)	take-out containers, CD cases, egg cartons, meat trays, and disposable plates and cups. medical packaging, laboratory ware	general purpose polystyrene: clear, hard and brittle Expandable Polystyrene (EPS): stiff, lightweight, thermal insulation.	May leach harmful chemicals, especially when heated; a common type of land-based and disaster-related debris; looks like fish eggs and plankton as it breaks into smaller pieces, posing a threat to animals that might ingest it	No
7	Other (includes ABS copolymers, polymethyl methacrylate,poly urethane, nylon, polycarbonate)	sunglasses, iPod cases, computer cases, nylon, 3- and 5-gallon water bottles, bullet-proof materials, foam insulation	varies	Varies – some types are generally considered safe while others may contain harmful chemicals; as marine debris, type 7 ropes, nets, and fishing line pose special risks for entanglement	No

Sources: American Chemistry Council (http://plastics.americanchemistry.com/Life-Cycle#majorplastics) Nation of Change (http://www.nationofchange.org/numbers-plastic-bottles-what-do-plastic-recycling-symbols-mean-1360168347)

CoastWalk Data By Plastic Type Number

The data below describes some common plastic products collected during the 2012 CoastWalk in Kachemak Bay. Items collected during the clean up are divided into categories based upon typical uses of the item, rather than plastic type number. However, because certain types of plastic are used commonly for certain products, it is possible to make a guess as to the likely plastic type(s) for each category.

	Number of Pieces	Likely Plastic Type
Plastic Beverage Bottles	354	#1
Fishing Line	90	#1, #7
Bleach/Cleaner Bottles	19	#2
Motor Lubricant & Oil Bottles	20	#2
Buoys/Floats	52	#2, #3, #6
Bags (Paper & Plastic)	669	#2, #4
Shotgun Shells/Wadding	168	#2, #4
Bait Containers/Packaging	16	#2, #4
Caps, Lids	432	#2, #4, #5
Fishing Lures	20	#3, others
6-pack Holders	78	#4
Plastic Sheeting/Tarps	62	#4, #7
Straws, Stirrers	242	#5
Cups, Plates, & Utensils	186	#5, #6 (some #1, #2)
Fishing Nets	22	#5, #7
Rope/cable	216	#5, #7
Strapping Bands	48	#5, #7
Diapers	20	#5, others
Food Wrappers/Containers	525	#6, #5, #4
Tobacco Packaging/Wrappers	61	#6, #5, #4
Foam pieces	3102	#6, #7
Cigarettes/Cigarette Filters	4019	#7
Building Materials	261	#7, others

Information on types of plastic used in common categories of marine debris from: NOAA Marine Debris Program. NOAA Marine Debris Program, Marine Debris Monitoring and Assessment Project. *Marine debris survey photo manual*.
http://marinedebris.noaa.gov/sites/default/files/photo_guide.pdf

CoastWalk 2012 Data

The data below describes marine debris collected during the 2012 CoastWalk in Kachemak Bay. It has been divided into two source categories (Land-Based/ Personal Use and Marine Industries & Recreation) as well as items of local concern. This data does not differentiate items that may have originated in a container ship spill or natural disaster. Toys within the “Land-Based/Personal Use” category might include some items from container ship spills. Building Materials within the “Land-Based/Personal Use” category and the Foam Pieces within the “Items of Local Concern” may include items from natural disasters.

Land-Based/Personal Use	# of pieces
Shoreline & Recreational Activities	
Beverage Cans	822
Bags (Paper & Plastic)	669
Food Wrappers/Containers	525
Caps, Lids	432
Beverage Bottles, plastic, 2-liter or less	354
Beverage Bottles, glass	335
Straws, Stirrers	242
Clothing, Cloth	197
Cups, Plates, Forks, Knives, Spoons	186
Shotgun Shells/Wadding	168
Pull Tabs	117
6-pack Holders	78
Toys	51
Balloons	25
Medical/Personal Hygiene	
Diapers	20
Condoms	8
Tampons/Tampon Applicators	6
Syringes	3
Smoking-Related Activities	
Cigarettes/Cigarette Filters	4019
Cigar Tips	132
Tobacco Packaging/Wrappers	61
Cigarette Lighters	26

Dumping Activities	
Building Materials	261
55-gallon Drums	65
Cars/Car Parts	29
Tires	12
Batteries	8
Appliances (refrigerators, washers, etc.)	2
Total Land Based/Personal Use	**8853**

Marine Industries & Recreation	# of pieces
Rope/cable	216
Fishing Line	90
Crates	75
Plastic Sheeting/Tarps	62
Buoys/Floats	52
Strapping Bands	48
Light Bulbs/Tubes	27
Crab/Lobster/Fish Traps	26
Fishing Nets	22
Oil/Lube Bottles	20
Fishing Lures	20
Bleach/Cleaner Bottles	19
Bait Containers/Packaging	16
Pallets	12
Total Marine Industries & Recreation	**705**

Debris Items of Local Concern	
Styrofoam pieces	3102
Plastic Pieces	1548

Overall Total	**14208**

Sponsors

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