The Effects of Marine Debris on Ecosystems

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?
How do physical processes influence human effects on marine ecosystems?
How do biological processes influence human effects on marine ecosystems?
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.
- Weather systems and ocean systems have major influences on each other and the transport of solids and liquids in the ocean.
- Organisms in marine environments interact with one another and are interdependent in many ways.
- Harm to one species can affect the entire food web.
- Biological processes can magnify the impacts of human effects.
- Technology can have unintended consequences.

Objectives

Students will understand the three major effects of marine debris on ecosystems: entanglement, ingestion and toxic pollution. They will be able to describe the process of bioaccumulation as it relates to plastics and toxic pollutants attached to plastic. They will connect their personal consumer choices with the effects of marine debris on the marine environment, and design and evaluate ways to mitigate the ecosystem effects of marine debris.

Concept

Marine debris has many effects on marine ecosystems. The three main effects are entanglement, ingestion and toxic pollution. The effects of ingestion of plastic pieces and toxic pollution are magnified by the process of bioaccumulation, whereby top predators accumulate plastic or toxins when they consume prey that have ingested these plastics or toxins.

Materials

- Science notebooks
- Pencils
- Handout with estimated life span of plastic products (provided at end of document)
- “Birds and Plastic Ingestion” PowerPoint presentation
- “Marine Debris Effects on Ecosystems” PowerPoint presentation
- Photos of entangled animals (see PowerPoint)
- Photos of plastic ingested by animals (see PowerPoint)
- Rubber bands
- Many 2-5 foot strands of monofilament fishing line or large clump of monofilament (For help acquiring monofilament line, contact the Center for Alaskan Coastal Studies)
- 2 thick pieces of rope
- Poker chips, pieces of colored paper, or other game pieces
- Sample of photodegraded plastic from gyre
- Laptop/computer and projector or SmartBoard

Background

This lesson focuses on the effects of marine debris in ecosystems. Three major effects of marine debris in the ocean ecosystem are entanglement, ingestion and water pollution. Entanglement refers to what happens when animals get caught in pieces of debris such as fishing line, nets, rope, soda rings and plastic bags. The mobility of these animals is threatened by entanglement, hindering their ability to acquire food, evade predators, and, in the case of marine mammals, sea turtles and birds, reach the surface for oxygen. Entanglement can also cause physical injuries and sores as the animals struggle against the debris they are caught in and grow larger than they were when they were originally entangled.

Ingestion refers to what happens when animals consume marine debris. Photodegraded plastic often breaks into smaller and smaller pieces until it is about the size of plankton. These tiny plastic pieces (< 1 mm) are called microplastics. Microplastics are often ingested by small fish, baleen whales, filter feeders such as mussels, and other marine organisms. Larger pieces are sometimes targeted by predators such as albatross and sea turtles because they look like prey items, namely squid and sea jellies. The ingestion of marine debris can cause both direct and indirect problems. The animals consuming the plastic can starve because their stomachs are filled with plastic rather than food. Dwindling populations of sea birds, sea turtles and especially forage fish can disrupt entire food webs because low populations decrease availability of prey to predators up the food chain. When forage fish or benthic invertebrates consume microplastics, the plastic is stored in the digestive system or absorbed into the animal's circulatory system, and accumulates there. When these forage fish with microplastics in their bodies are in turn eaten by larger fish, marine mammals, and birds, those microplastics make their way up the food chain. A large top predator can accumulate quite a lot of plastic in its system. This process is called bioaccumulation.

Bioaccumulation contributes greatly to the severity of the third major effect of marine debris: water pollution. As these pieces of plastic float throughout the ocean column they begin to provide unnatural habitat for tiny microbes. These microbes are attracted to plastics because the rough surface of the plastic provides an excellent surface for the microbes to cling to. As these plastics become home for microbes, they also begin to absorb Persistent Organic Pollutants (POPs) from surrounding seawater. These POPs are trace insecticides, pesticides and industrial chemicals. When these plastics are ingested by animals, the microbes are digested and POPs subsequently absorbed into the animal's fatty tissue. Then the animal's predator eats its prey, digesting that fatty tissue and accumulating the POPs into the predator's fatty tissue. Records of bioaccumulation of toxic POPs through eating plastics have been recorded in sea birds and top predator marine mammals such as orcas. Plastics that contain POPs can also leach them into the surrounding water, so areas with large amounts of marine debris can have high level of toxic pollutants in the water column. These pollutants can be absorbed from the water into adult marine animals as well as their egg and larval stages.

Preparation

Set up computer and projector or SmartBoard to show the "What's an Ocean Garbage Patch" video on Youtube (http://www.youtube.com/watch?v=J-gqJAsXiKQ). This video on Youtube sometime begins with advertisements, so play through these during your preparation. Gather the photos you will use. Prepare the tug of war by tying two loops of rope to the monofilament clump/pieces to create a line that can be pulled on from both sides. Sort your game pieces. You will want approximately 100 or more of them. Of these, 80 percent should be one color, to represent plankton, and 20 percent should be another color, to represent plastic. If you'd like to make it even trickier, use more colors. Have all the colors except one represent plankton, with the final color being plastic. This way, students won't be able to guess which color they should avoid during the game.

Introduction

Begin by showing the "What's an Ocean Garbage Patch" video on Youtube (http://www.youtube.com/watch?v=J-gqJAsXiKQ). At the conclusion of the video, ask students to write their reaction in their science journal. Ask students to write predictions of how long different plastic products persist in the marine environment. Pass out the handout with the timeline of how long plastics last in the environment. Because these times have never been tested (plastics haven't been around long enough), they are an unproven estimate, but do demonstrate that plastics far outlast the time they spend being used. Compare the timeline to the predictions students made. Discuss that plastics photodegrade rather than biodegrade. That is, as plastics are exposed to ultraviolet rays (UV-b), the secondary bonds (plasticizers such as phthalates) between the polymer chains begin to break down. This causes the plastics to become brittle and break into smaller and smaller pieces, now polymer chains. Things that biodegrade are broken into smaller pieces by bacteria or other biological actions. Biodegradation returns the object to compounds found in nature, whereas photodegradation breaks plastics down to the synthetic polymers, but not natural molecular compounds.

Procedures and Activities

Ask students to brainstorm how wildlife and ecosystems are affected by marine debris. Have students record their ideas in their science notebooks, and write all of their concerns on the board. If they do not include entanglement, ingestion or water pollution on the list, help them to add those concerns. Explain to students that all of these effects are important to consider and work to mitigate, but the three greatest concerns related to marine debris in marine ecosystems are entanglement, ingestion and toxic pollution. The following activities and discussions help to illustrate these concerns. Choose one or more.

Entanglement Challenge

Begin by addressing entanglement with the entanglement challenge. For the entanglement challenge, call up six to ten volunteers, or pass rubber bands out to your entire class. Have them put one hand behind their back and extend the other hand. Put a rubber band around their pinky and forefinger over the back of their second and third fingers. The goal is to simulate a bird or other animal with plastic around their neck. They have to remove the debris just by wriggling their hand as a bird would have to remove the debris by somehow shrugging it off. Explain that they must try and remove the rubber band without using any aid from their hand, body or other people. Give them a time limit, usually 10-30 seconds. After the time limit expires, record how many people succeeded in escaping from entanglement. Discuss as a group why it was hard to remove the rubber band, and whether it is difficult for animals to escape from entanglement in the wild.

Fishing Line Tug of War

Continue to explore issues of entanglement with monofilament tug-of-war. Fishing line collected from line recycling receptacles is used for this activity and tied between two ten-foot ropes. For help acquiring monofilament line, contact the Center for Alaskan Coastal Studies. This activity can also be done with six-pack rings, but they have fortunately become less prevalent in marine debris. Be aware of what is behind your participants to ensure safety, as their goal is to snap the line. This works best outside. Start by tying a rope to a loop on each end of a clump of monofilament line and have one student on each side of the line (begin with the younger students in a mixed crowed) pull each rope. Remind them that this is not a traditional tug-of-war, but that they are using cooperation and teamwork to break the line. Have them pull – and the audience cheer – when you raise your hand and have them stop when you lower your hand. Continue adding students until the fishing line snaps. After the students have either broken the line or failed to do so, talk about the difficulties an animal in the wild would have detangling themselves from something like fishing line.

After the Entanglement Challenge and/or Fishing Line Tug of War, ask students to write in their science notebooks three ways that entanglement can hurt animals. If they need help, encourage them to think about basic animal survival needs and how entanglement can hinder their ability to fill these needs. As a class, discuss the different effects of entanglement that students brainstormed and show photos of entangled animals.

At this point, move on to the impacts of ingestion and pollution. Show students photos of albatross that have consumed plastics and other images of marine debris ingestion. If you would like to delve deeper into the specifics of albatross and marine debris, use the "Birds and Plastic Ingestion" or "Marine Debris Effects on Ecosystems" PowerPoint presentations.

"Food Web" Tag (Bioaccumulation)

Play this game without telling the students the point of the game. You can call it food web tag. Designate 2-3 secondary consumers that can be orcas or humans. Tell the rest of the students that they are primary consumers, in this case fish. Spread at least 100 game pieces across a wide area (80 percent of them should be one color for plankton, with 20 percent another for plastic). Tell the primary consumers their goal is to collect as much "food" as possible- don't mention that some of the chips aren't plankton until the end. A few seconds after they begin, let the secondary consumers loose to tag primary consumers. Every time a primary consumer is tagged by a secondary consumer, they must give up their poker chips. After play is stopped, count how many plastic chips each consumer has. Discuss how the primary consumers often don't ingest enough toxins to affect them, but secondary consumers accumulate the toxin loads of everything they eat. Discuss how plastic that is ingested by one animal can make its way into that animal's predator and so on up the food chain. This is called bioaccumulation, because the plastic – or other pollution – accumulates the farther you go up the food chain

After "Food Web" Tag, explain that the issue of bioaccumulation goes beyond the plastic itself. As plastic floats through the ocean column, it begins to provide unnatural habitat for tiny microbes that are attracted to plastics because the rough surface of the plastic provides an excellent surface to cling to. As these plastics become home for microbes, a biofilm forms on them. This microbe biofilm absorbs Persistent Organic Pollutants (POPs) from surrounding seawater. These POPs are trace insecticides, pesticides, industrial chemicals and other toxic pollution in the water. When these plastics are ingested by animals, the microbes are digested and POPs subsequently absorbed into the animal's fatty tissue. Then the animal's predator eats its prey, digesting that fatty tissue and accumulating the POPs into the predator's fatty tissue. Records of bioaccumulation of POPs through eating plastics have been recorded in sea birds and top predator marine mammals such as orcas. Some toxins, such as lead and phthalates, are purposefully added to plastics when they are manufactured to make them more flexible or heat-resistant. These toxins, just like the POPs, can bioaccumulate through both ingestion and leaching into the water.

Wrap-Up & Extensions

Finally, lead a discussion about how students can affect these problems. Talk about the Center for Alaskan Coastal Studies, or BoatU.S., (http://www.boatus.com/foundation/monofilament/) fishing line-recycling program as a great example of how potential entanglement items can be taken out of the environment. Also, the decreased occurrence of six-pack rings in marine debris is linked to consumer choices. Awareness that these products caused problems in the marine environment led to a significant reduction in the manufacturing of these harmful products.

Ask students to revisit their science notebooks and review the potential ecosystem effects of marine debris they wrote down at the beginning of the lesson. Break them into small groups 2-5 people and have them work together to discuss potential ways to mitigate these effects. Encourage them to think not only of ways to clean up marine debris, but also ways to prevent certain types of marine debris (toxic, fishing line, etc.) from ever entering the ecosystem or ways to change the nature of marine debris (fishing line that breaks down more easily, etc.). Have each group decided on their top two solutions and describe them in their science notebook. Come together as a class and have each group present their top two solutions. Discuss the pros and cons of each. Explain that every technology has both positive and negative effects, so the above all best thing they can do is reduce their use of single-use plastics such as plastic bottles, straws, utensils, take out containers, etc. The less plastic is thrown away, the less is available to make its way into the marine environment.

Evaluation

Review student science notebook entries, including: reactions to the video, ways wildlife are affected by marine debris, effects of entanglement, and ways to mitigate the effects of marine debris on the ecosystem. Ways to mitigate the effects of marine debris on the ecosystem should be evaluated for synthesis and application of the material learned. The other entries can be evaluated for completeness and effort.

Sponsors

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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 Debris in GOM.pdf.