5 GYRES
SCIENCE TO SOLUTIONS

TrawlShare STEM to Stern

Marine Plastic Pollution Educational Units for Students Learning at Sea

Photo: 5 Gyres

"The sea, the great unifier, is man's only hope. Now, as never before, the old phrase has a literal meaning: we are all in the same boat."

— Jacques Yves Cousteau

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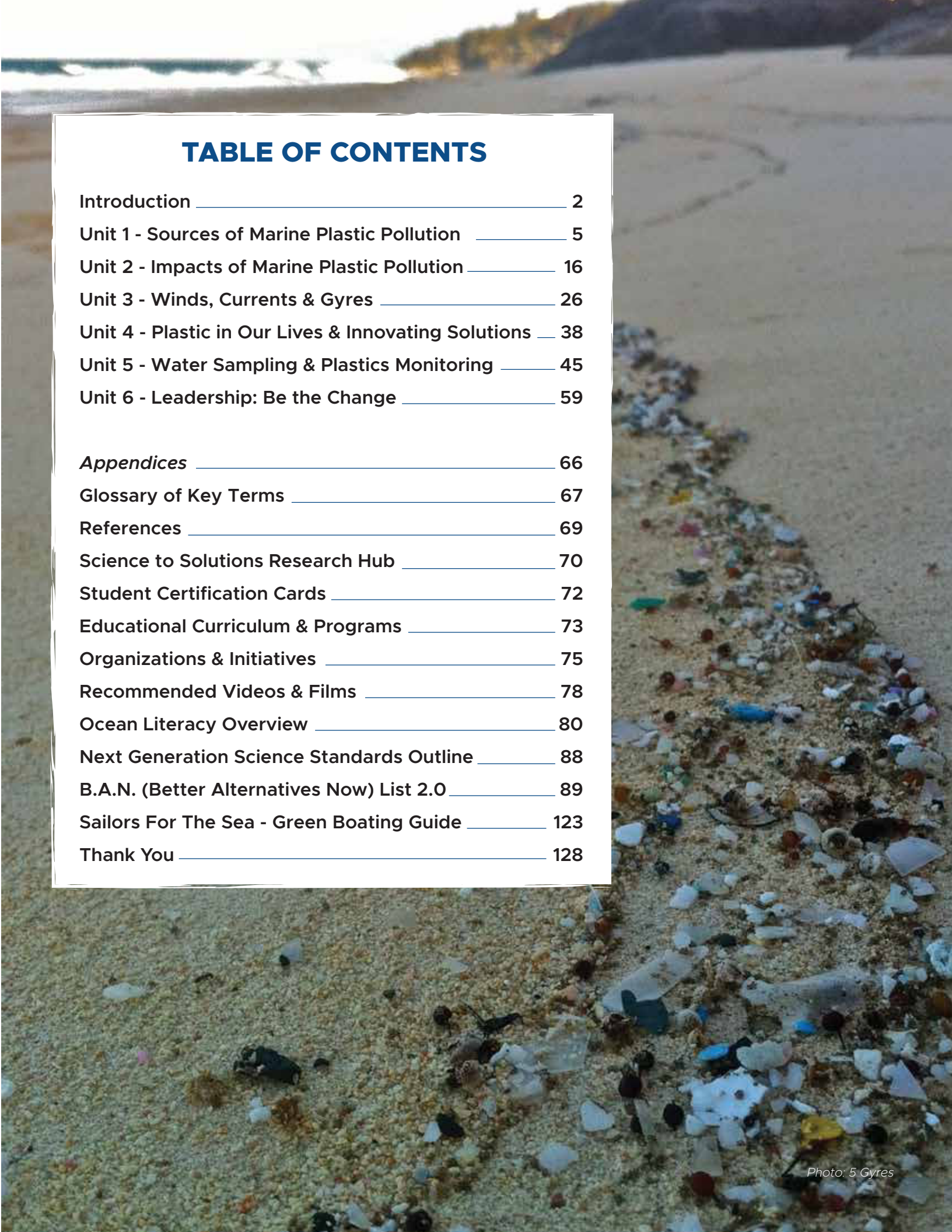


Photo: 5 Gyres

INTRODUCTION

Sail training ships around the world are teaching young people the skills they need to become collaborative team players, strong leaders, good communicators, and responsible members of society. The act of learning at sea provides youth with the opportunity to experience life far from land, surrounded by the beauty of the open ocean. The 5 Gyres TrawlShare STEM to Stern program will help sail trainees continue to develop these skills and explore their new appreciation for the marine environment while they discover the sources and consequences of marine plastic pollution.

What is Marine Plastic Pollution?

Marine plastic pollution has become a global problem which impacts the health of marine ecosystems worldwide. Whether you choose to call it plastic pollution, marine debris, beach litter, ocean rubbish, or trash, plastics are bad news for our ocean. Marine plastic pollution can range in size and source, from vast fishing nets lost at sea to single-use plastic food packaging to the microscopic synthetic fibers shed from our clothing. Plastics can entangle or be ingested by marine animals throughout the food web, threatening their health and wellbeing and potentially impacting fisheries important to international food supply. Though everyone on Earth is affected by plastic pollution, collectively we have the power to stop it through education, action, and innovation.

Who is 5 Gyres Institute?

The 5 Gyres Institute is working to educate the public about the threats of plastic pollution and empower them with the knowledge they need to drive change within their own communities. We harness the power of citizen science through our TrawlShare program to collect data that is used to understand the distribution of plastic pollution throughout the world's ocean. Our research is used to help inform international and local policy change on the production, use, and waste management of plastics.

Understanding the TrawlShare STEM to Stern Program

The experiential educational units included in TrawlShare STEM to Stern are designed to work in conjunction with the TrawlShare program but can be executed onboard sailing vessels that do not possess a 5 Gyres trawl. This instructional booklet is an adaptation of the ***5 Gyres Institute's Catch the Wave NGSS Curriculum*** and it is designed specifically for students learning aboard sailing vessels at sea. It is accompanied by a vast collection of resources including photos, videos, articles, and infographics which can support each individual unit and are available for download through our web site for instructors and students alike. To access the materials or inquire about how you can borrow a 5 Gyres trawl to help contribute to our research, please visit https://www.5gyres.org/trawlshare.

Photo: 5 Gyres

Unit Structure

The program is designed to integrate seamlessly into the experiential education format of sail training. Each unit has a flexible timeframe that can range between 25 minutes to two hours, allowing for easy incorporation into your sailing schedule and existing onboard activities. The units do not need to be delivered in a specific order, allowing your ship's crew to choose the activities that will appeal to your participants as well as the amount of time they can dedicate to educating about marine plastic pollution while you are at sea.

Learning Objectives

Each unit is driven by the active participation of your sail trainees. Key questions have been developed to encourage students to think critically about the marine environment, their own daily activities, and how the two intersect. Instructional guides are provided to help you drive conversation and problem solving amongst participants. The activities in each unit are designed to appeal to a variety of learning styles in small group settings.

Resources and Materials

Each unit is designed to require very few materials. In some cases, the tools and resources for activities can be found on board your vessel or be purchased onshore for a nominal cost. The units include visual materials such as photos, infographics, and videos which can easily be displayed on a tablet, laptop, or television screen aboard your ship.

In an effort to minimize waste, this program does not require you to print extraneous worksheets or activity books for the students participating in the program. You may choose to print the included student certification cards to distribute to your sail trainees which feature a link to the 5 Gyres website where they can find more information about marine plastic pollution and sign up to become a 5 Gyres Ambassador.

Alignment with Educational Standards

This program is written for the high school level, but some activities will appeal to students of all ages. Through the lens of sail training, these units allow participants to gain a better understanding of the marine environment, how they are inextricably connected to the ocean, and how plastic pollution negatively impacts animals and marine ecosystems worldwide. Each unit is aligned with three sets of standards.

Sail Training

Sailing ships around the world provide sail training programs in countless formats ranging from short eco-tourism, historic, or cultural "day sails" to full educational instruction during "semesters at sea" spread over the course of several months while crossing oceans. Sail Training International defines sail training as not the act of learning to sail, but more importantly, learning from sailing, learning from the ship, learning from the sea, and learning from ourselves. Activities aboard sail training ships often challenge participants with activities that encourage self-reliance, good communication, teamwork, leadership, and resilience.

Ocean Literacy

The Ocean Literacy Campaign is a collaborative effort by hundreds of scientists and educators working together to create a more ocean literate society. Ocean literacy is an understanding of the ocean's influence on you and your influence on the ocean. Understanding the ocean is essential to comprehending and protecting this planet on which we live. An ocean-literate person understands the importance of the ocean to humankind, can communicate about the ocean in a meaningful way, and is able to make informed and responsible decisions regarding the ocean and its resources (National Geographic Society and National Oceanic and Atmospheric Administration, 2013). An in-depth outline of the seven essential principles of ocean science literacy can be found in the appendices of this booklet.

Next Generation Science Standards

The Next Generation Science Standards (NGSS) have been developed by expert educators and scientists in the United States of America and are currently in various stages of implementation across states who have opted to adopt them. The standards are a set of performance expectations that students should be able to do; they represent an integrated three-dimensional approach to teaching and learning science, based on: eight science and engineering practices, disciplinary core ideas, and seven cross cutting concepts. The three dimensions work together to help students build an understanding of science through foundational concepts of science, investigation of the natural world, and exploration of common themes and connections. An outline of the NGSS is also included in the appendices.

Photo: Annie McBride

Using the 5 Gyres TrawlShare STEM to Stern program

This program and its supporting materials are available for download in its entirety from the 5 gyres web site at http://www.5gyres.org/stem-to-stern. It is recommended that all documents, videos, photos, and diagrams are downloaded onto a ship's tablet or laptop prior to setting sail. Printing a hard copy of the program and images is a great foundation and the educational units will really come alive for your participants if you have the ability to view the recommended videos.

Additional Resources

The appendices of this booklet include a glossary of key terms pertaining to marine plastic pollution and the information and activities featured within this program. Also included are outlines for Ocean Literacy and the Next Generation Science Standards. The B.A.N. (Better Alternatives Now) List 2.0 has been included as well as portions of the Green Boating Guide designed by Sailors for the Sea.

For instructors or students looking to dive deeper into the science of marine plastic pollution, the 5 Gyres Science to Solutions Research Hub hosts an extensive list of papers and summaries at http://www.5gyres.org/science-research-hub.

Web links to additional educational programs and curriculum on marine plastic pollution have also been included as resources for educators interested in conducting land-based programs. Lastly, we encourage you to explore a list of related projects and organizations are making waves around the globe.

Photo: Erika Delemarre

1 SOURCES OF MARINE PLASTIC POLLUTION

Photo: Wolfram Burner

OBJECTIVES

In this unit, participants will learn about how watersheds connect the land to the sea. They will think critically about the sources of plastic pollution and how the watershed transports it to the coastlines and the ocean. They will consider how maritime activities can contribute to the marine plastic pollution. They will work in small groups to create a narrative about plastics and share it with others.

DURATION

30 minutes to 1 hour 10 mins

10 - 30 mins for discussion and viewing of recommended videos

5 - 10 mins for Activity 1.1

20 - 30 mins for Activity 1.2

ALIGNMENTS

Sail Training

communication, environment, human values, responsibility, community, critical thinking

Ocean Literacy

1. The Earth has one big ocean with many features. F, G

6. The ocean and humans are inextricably interconnected. D, G

NGSS

SEP 1: Asking questions

DCI - LS 2: Ecosystems: Interactions, energy and dynamics; C. Roles of water in Earth's surface processes

DCI - ESS 3: Earth and human activity

CCC 2: Cause and Effect: Mechanism and explanation

CCC 5: Energy and matter: Flows, cycles and conservation

RESOURCES

Printed Materials

- ***MARPOL Annex V Placard*** (America's Boating Club)
- ***MARPOL General Overview*** (NAMEPA)
- ***Plastic Ocean*** (Ocean Conservancy)
- ***How Does Plastic End Up in the Ocean?*** (Ocean Action Pod)
- ***Story of A Plastic Spoon*** (Ocean Action Pod)

Supplies

- A variety of small plastic items (Suggested: Plastic bag, toothbrush, fork, straw, bottle cap, ruler, pen, candy wrapper, clothes-pin/peg, hair comb, etc.)

Scientific Research

More information can be found on the 5 Gyres Science to Solutions Research Hub: http://www.5gyres.org/science-research-hub

RECOMMENDED VIDEOS

What is Marine Debris?
by NOAA (Length: 2:00)
https://www.youtube.com/watch?v=FfSFKEM5Psc

What is a Watershed?
by Caring for Our Watersheds (Length: 1:00)
https://www.youtube.com/watch?v=QOrVotzBNto

Where Does Marine Debris Come From?
by NOAA (Length: 2:00)
https://www.youtube.com/watch?v=FN9FF7VH4ig

The Majestic Plastic Bag – A Mockumentary
by Heal The Bay (Length: 4:00)
https://www.youtube.com/watch?v=GLgh9h2ePYw

The Story of Three Plastic Bottles
by Emma Bryce on TED-Ed (Length: 4:00)
https://www.youtube.com/watch?v=_6xlNyWPpB8

KEY TERMS

precipitation, topography, watershed, gravity

INTRODUCTION

When we're out at sea, especially once we lose sight of the shore, it's easy to feel far away and disconnected from our lives at home on land. If we switch our perspective, we can think about how the water around us connects us back to land. The ocean is one great body of water that touches the shores of islands and continents around the world, connecting distant communities to each other. While we're sailing, you may notice plastic floating in the water around the ship. We're going to spend some time exploring how plastic pollution gets into the sea.

DISCUSSION

ASK: ***To begin, let's consider the different uses of plastic. What do we use plastic for at home? How about at school? And on this ship?***

Critical Thinking

Discuss different types and uses of plastic in their everyday lives in the different settings starting from the moment they get up in the morning until the moment they go to bed.

Guide the Discussion

Suggest common single-use plastic items such as bags, straws, cutlery, and food wrappers, expanded polystyrene (Styrofoam) containers, etc. Common items such as carpet, furniture, and clothing made with polyester are also made of plastic.

Photo: NOAA

ASK: ***What do we do with these plastics when we're done with them? When we "throw something away" or "toss it out" where does it go? Where is "away" and "out?"***

Critical Thinking

Brainstorm and discuss students' different perceptions.

Guide the Discussion

Suggest recycling, trash/rubbish collection, the landfill, and littering in the natural environment. Discuss what happens to the plastic in these different scenarios.

ASK: ***Can you think of ways that trash/rubbish is sorted in your home, at school, and on the ship?***

Critical Thinking

Discuss common waste management systems available in their home area(s) and onboard the vessel.

Guide the Discussion

Ask students how their waste and recyling is handled at home. Do they know what's done with it at school? How do they help sort and manage it on the ship? Where does it go when you're in port?

Photo: 5 Gyres

ACTIVITY 1.1 - MARPOL ANNEX V

Challenge students to locate the MARPOL Annex V posting or placard that outlines on your ship. MARPOL Annex V outlines the international regulations for dumping at sea. (Hint: It is usually posted in the ship's galley or chart house.)

Duration

20 - 30 minutes

Resources

MARPOL Annex V placard from your ship. If one is not readily available, use the example from the United States (See resources, Pg 10).

America's Boating Club

Guide the Discussion

Discuss MARPOL Annex V regulations and how they apply to the area you're sailing through. (See resources, Pgs 11-12)

DISCUSSION

ASK: ***Do you think that most plastic pollution in the ocean comes from human activities on land or out at sea?***

Critical Thinking

Students brainstorm how maritime activities can contribute to marine plastic pollution.

Guide the Discussion

Suggest plastic items that could come from cargo shipping, commercial fishing, recreational boating, aquaculture, shipwrecks, etc. Maritime activities around the world can sometimes result in plastic items such as fishing lines, nets, and buoys, or general plastic waste inadvertently being lost or purposefully discarded into the ocean.

SAY: ***There is a common misconception that marine plastic pollution comes from ships, but most of it actually originates from human activity on land. Globally, we make and use more than 300 million metric tons of petroleum-based plastic per year, but less than 10% of it is recycled. This results in an estimated 8 million metric tons of plastic ending up our ocean every year. That's the equivalent of a garbage truck of plastic being dumped into the ocean every minute and this amount could double by the year 2030 and triple by 2050*** (Neufeld et al., 2016).

Look! *Infographic:* ***Plastic Ocean*** by Ocean Conservancy (See resources, Pg 13)

Recommended Video: ***What is Marine Debris?*** by NOAA (Length: 2:00)
https://www.youtube.com/watch?v=FfSFKEM5Psc

DISCUSSION

ASK: ***How does trash/rubbish get from land into the ocean?***

Critical Thinking

Discuss the different ways plastics could be transported from land into the sea.

Guide the Discussion

Suggest humans littering, and the effects of natural elements such as rain, wind, snowmelt, animals such as birds, etc. all transporting the plastic to rivers, coastlines, and out to sea.

Look! *Infographic:* ***How Does Plastic End Up in the Ocean?*** by Ocean Action Pod
(See resources, Pg 14)

Recommended Videos:

What is a Watershed?
by Caring for Our Watersheds (Length: 1:00)
https://www.youtube.com/watch?v=QOrVotzBNto

Where Does Marine Debris Come From?
by NOAA (Length: 2:00)
https://www.youtube.com/watch?v=FN9FF7VH4ig

SAY: ***A watershed is the area of land where all of the water drains into the same place. It is based on topography (the shape of the land) and is determined by landforms such as mountains or hills. On one side of the mountain, water from precipitation (rain or snowmelt) and man-made sources may drain down into a lake; on the other side it may drain into a river and then out into the ocean. Each side of the mountain is a different watershed because water drains into two different locations. Gravity, the downward force of attraction exerted on all objects on Earth, affects the movement of water and plastics into the ocean*** (5 Gyres Institute, 2018)***.***

ASK: ***Can you think of nearby rivers or streams in our city and/or your neighborhood at home? Are they clean or dirty? Do you know where they connect to the sea?***

SAY: ***Watersheds reach far inland, with streams and rivers connecting landlocked areas to the sea. Watersheds transport important sediments and minerals into the sea but can also transport pollution such as plastic items that haven't been properly disposed.***

Photo: 5 Gyres

DISCUSSION

ASK: ***What are actions you think you could take at home, school and/or on the ship to keep plastic from ending up in the ocean?***

Critical Thinking

Discuss different activities that happen in each setting the the plastics that are used in each.

Guide the Discussion

Encourage students to brainstorm beyond just "recycle more" or "don't litter." Suggest they think about reducing waste by replacing their use of disposable plastics by using things like reusable bags and water bottles or refusing plastic straws when they go out to a restaurant.

ACTIVITY 1.2 - ADVENTURE THROUGH A WATERSHED

In this activity, participants will apply what they have learned about watersheds and their connectivity to the ocean to create a narrative about a plastic item going on an adventure and escaping out to sea.

Duration

20 - 30 minutes

Resources

- A variety of small plastic items.
  (Suggested: Plastic bag, toothbrush, fork, straw, bottle cap, ruler, pen, candy wrapper, clothespin/peg, hair comb, etc.)

Look!

Infographic: ***The Story of a Plastic Spoon*** by Ocean Action Pod
(See resources, Pg 15)

Recommended Videos:

The Majestic Plastic Bag – A Mockumentary
by Heal The Bay (Length: 4:00)
https://www.youtube.com/watch?v=GLgh9h2ePYw

The Story of Three Plastic Bottles
by Emma Bryce on TED-Ed (Length: 4:00)
https://www.youtube.com/watch?v=_6xlNyWPpB8

1. Split large group into small groups of 2 - 4 students.
2. Assign a single plastic object to each group.
3. Instruct groups to think creatively to develop a story about how their plastic item went on an adventure and ended up in the ocean.
4. Their story must include:
   - Their assigned plastic object
   - At least three elements of the watershed
   - Two humans
   - Two mechanical modes of transportation (bike, car, bus, truck, train, boat, rocketship, etc.)
   - Two animals of their choice
   - A happy ending
5. After 10-15 minutes, bring the groups back together to share their stories.

Guide

Suggest the team members use facial expressions, voices, action, and props to act out the different characters, objects, and actions in their story.


Under the MARPOL agreement and U.S. federal law, it is illegal for any vessel to discharge plastic or garbage containing plastics into any waters. Additional restrictions on dumping non-plastic waste are outlined below. All discharge of garbage is prohibited in the Great Lakes or their connecting or tributary waters. Each knowing violation of these requirements may result in a fine up to $500,000, and up to 6 years imprisonment.
3 nautical miles from shore and anywhere in U.S. Lakes, Rivers, Bays, Sounds.
ILLEGAL TO DUMP
Plastic
All other trash
3 to 12 nautical miles offshore
ILLEGAL TO DUMP
Plastic
Dunnage, lining & packing materials that float. All other trash if not ground to less than one inch.
12 to 25 nautical miles offshore
ILLEGAL TO DUMP
Plastic
Dunnage, lining & packing materials that float.
Outside 25 nautical miles offshore
ILLEGAL TO DUMP
Plastic
State and local regulations may further restrict the disposal of garbage.
LET'S ALL DO OUR PART TO PROTECT THE OCEANS!

MARPOL

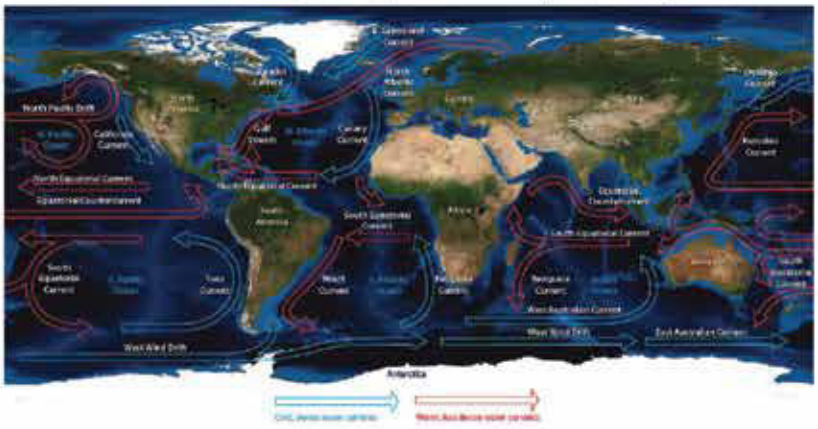
International Convention for the Prevention of Pollution from Ships

Oceans, lakes and rivers are the cradle of life on our planet.

Without them, no life on earth would exist. Unfortunately, the world's oceans, lakes and rivers have been seriously endangered by the actions of humans. The most serious threat is pollution, primarily from land-based sources and runoff, and includes oil, noxious liquids and harmful substances, sewage, garbage, and greenhouse gas emissions.

MARPOL International Convention for the Prevention of Pollution from Ships is an agreement, or convention, written by the members of the International Maritime Organization (IMO) to control and prevent pollution from ships. Its objective is to preserve the marine environment by regulating the handling of oil, garbage, sewage, noxious liquids, harmful substanes and air emissions aboard a vessel and to minimize damage from operational or accidental discharge of such substances into the water. To ensure the sustainable development and future operation of the maritime industry, we must all work together to prevent pollution and restore our world's oceans, lakes and rivers to healthy conditions.

IT'S ALL CONNECTED - Oil, garbage and other materials travel around the entire world due to ocean currents, affecting marine life and people everywhere.



Seafarers are especially entrusted with stewardship of the oceans.

Compliance with MARPOL regulations, when combined with accurate documentation, thorough training, and proper contingency planning will help marine organizations stay proactive in environmental preservation.

Take action today - join NAMEPA to help us "Save Our Seas!"

North American Marine Environment Protection Association

ANNEX I : Oil Pollution

Discharging oil in the water can kill plants and animals by coating them with oil, suffocating them. Shipboard sources of oil pollution include engine room bilges, fuel tanks, bunkering operations, cargo operations (loading/discharging), tank washings, and ballasting/de-ballasting accidents. Generally, oil or oily mixtures should not be discharged into the water. When operationally necessary, these substances should only be discharged using special equipment and outside of prohibited areas.

ANNEX II : Noxious Liquid Substances

Many chemicals are poisonous to sea life, so great care should be taken before dumping any liquid into the water. Chemicals can also contaminate the fresh water drinking supply for humans and make fish unsafe to eat. A complete list of noxious liquid substances is listed in the International Bulk Chemical Code (IBC) book, which classifies various liquids in terms of what level of hazard they pose to marine life and people if discharged into the sea. Check the MARPOL rules before discharging anything into the water.

ANNEX III : Harmful Substances

Pollution of other harmful substances into the marine environment may come from loss overboard of harmful packaged goods. Standards exist for packing, labeling, documenting, stowing and limiting quantity of harmful substances. A list of substances that are classified as marine pollutants can be found in the International Maritime Dangerous Goods (IMDG) code. Accidental loss overboard of containers, especially those which are known to contain marine pollutants, must be always be reported to shore authorities.

ANNEX IV: Sewage

Sewage is any drainage and waste from toilets and urinals, medical areas like dispensaries and sick bays, and any locations that contain living animals. When untreated sewage is discharged into the sea, harmful bacteria and other disease-causing agents can spread, plants and animals can become sick, and the health of people who rely on seafood to eat or fresh water to drink is threatened. Having an approved sewage treatment system on board is critical.

ANNEX V : Garbage

Garbage, especially plastic (which doesn't biodegrade), can kill animals when they become entangled or eat it. While the biggest source of coastal pollution is from people ashore, ships are also responsible for minimizing the impact. It is illegal to discharge all materials other than certain types of food and animal waste anywhere at sea. Review the MARPOL regulations, the vessel's Garbage Management Plan or the placard in the garbage storage area of your ship for specific instructions.

ANNEX VI : Air Pollution

Ships are among the lowest sources of harmful exhaust, but need to do their part in minimizing the pollution from their airborne emissions from burning fuel to run engines and generators. Greenhouse gases like carbon dioxide contribute to climate change, and sulfur and nitrogen emissions also pollute the air. Ships operating in designated Emission Control Areas (ECAs) are required to comply with more stringent fuel, sulfur, and engine nitrogen oxides limits to avoid damage to human health and the environment.

For more detailed information on MARPOL and marine environmental conservation, please visit NAMEPA's website at www.namepa.net

BLANK ROME MARITIME

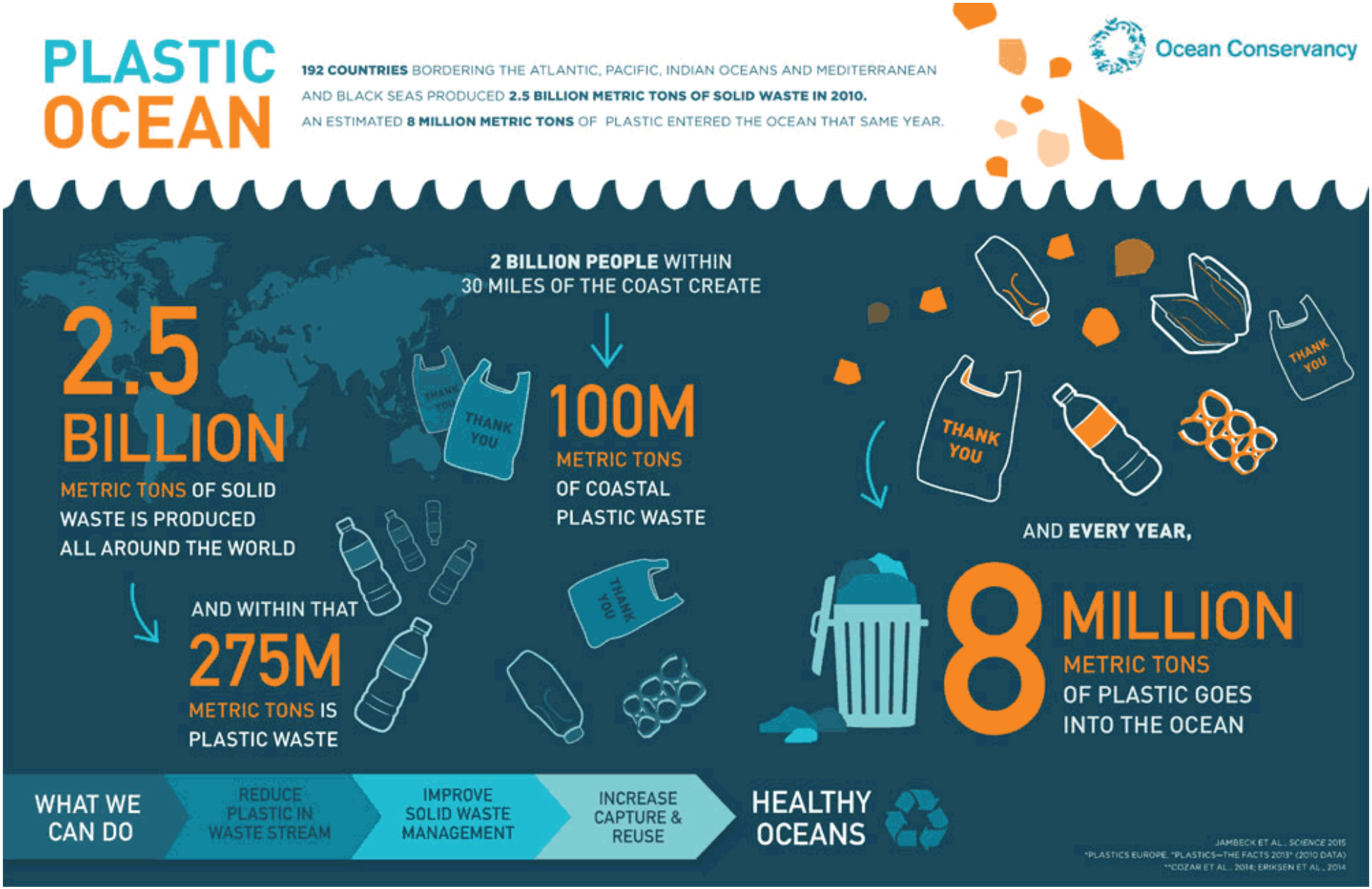
DORIAN LPG

FUTURE CARE

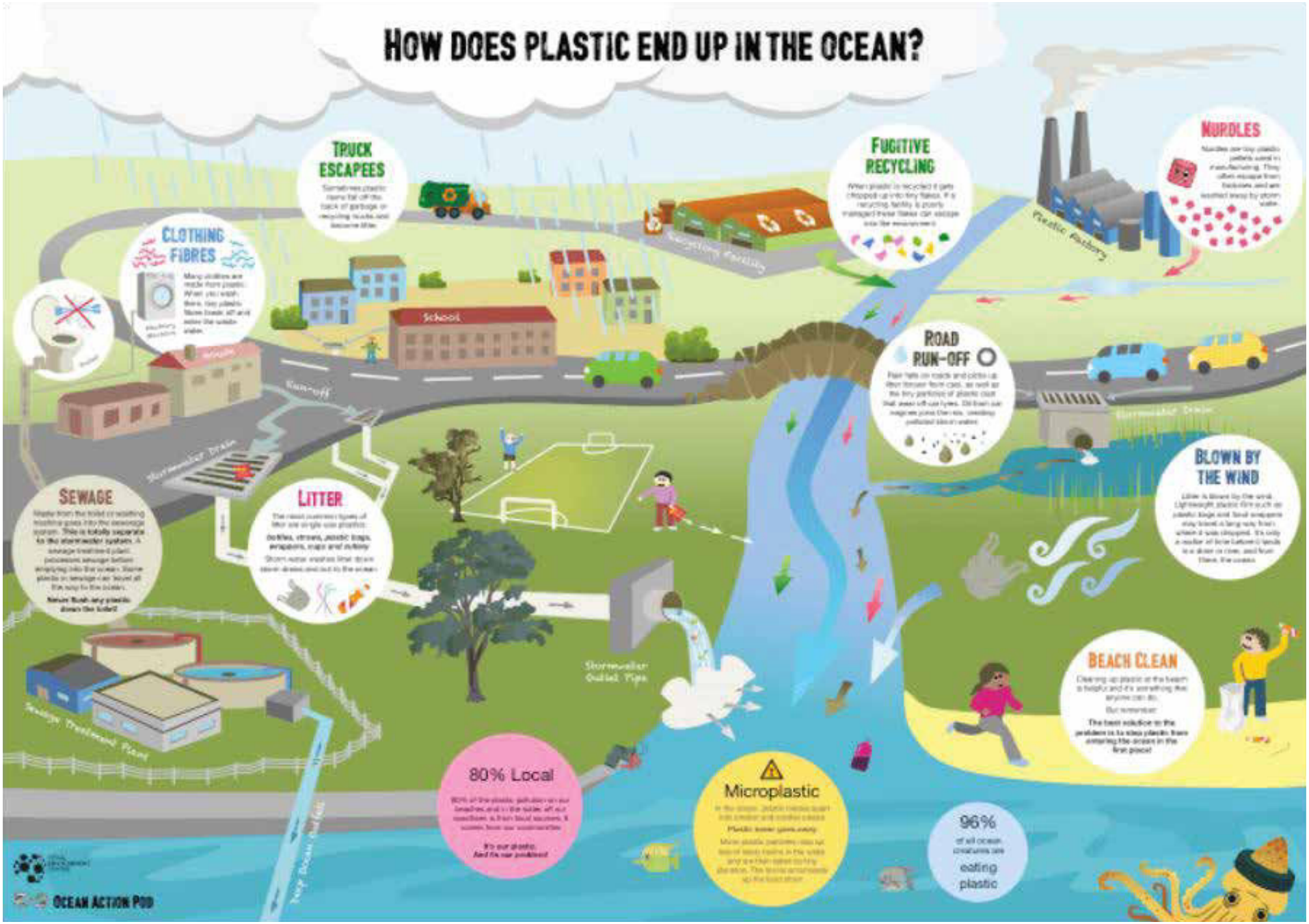
ECORPIO

10+ YEARS NAMEPA

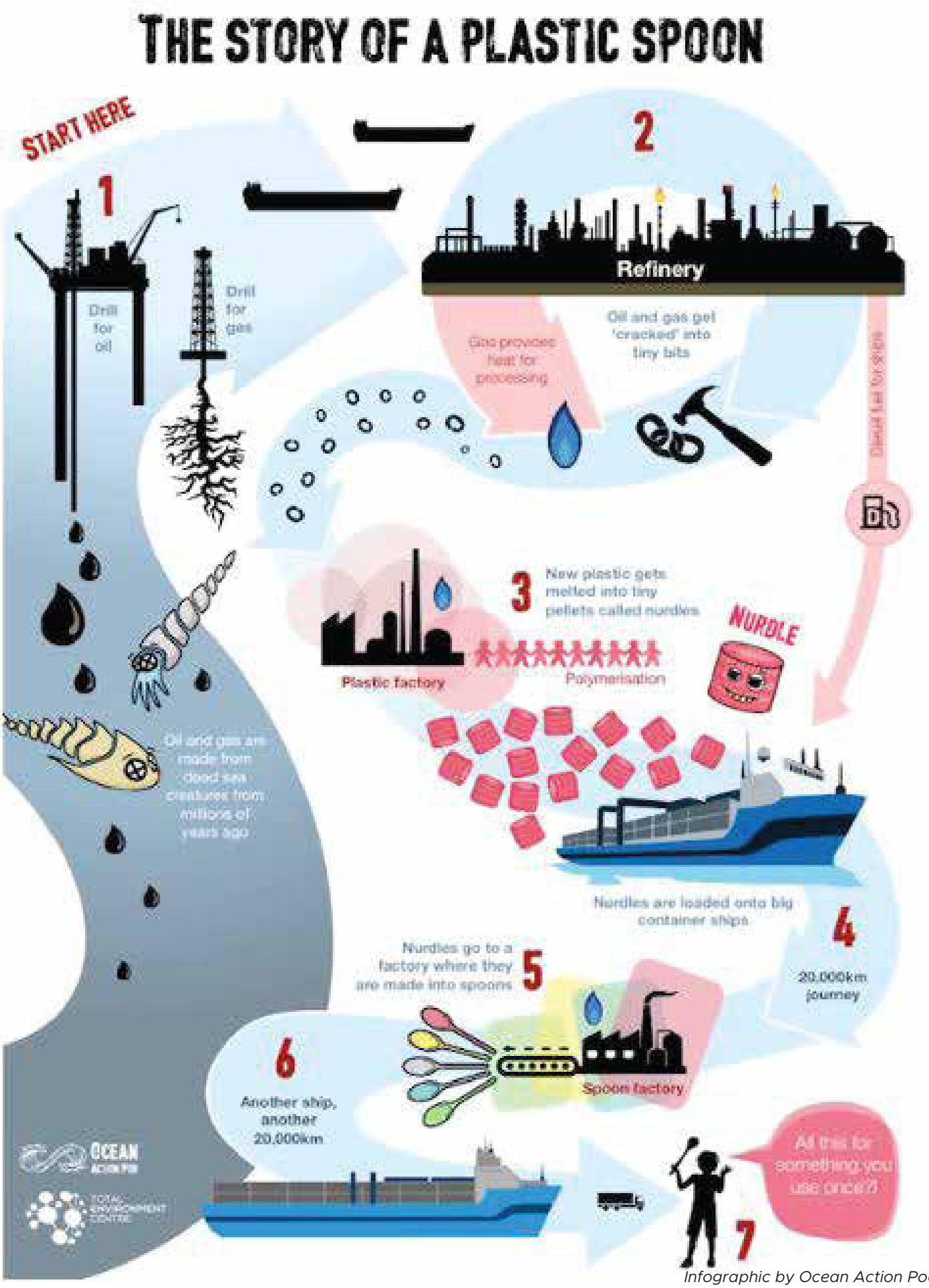
To find out how you can become a member as a company, individual, or organization, please visit www.NAMEPA.net.



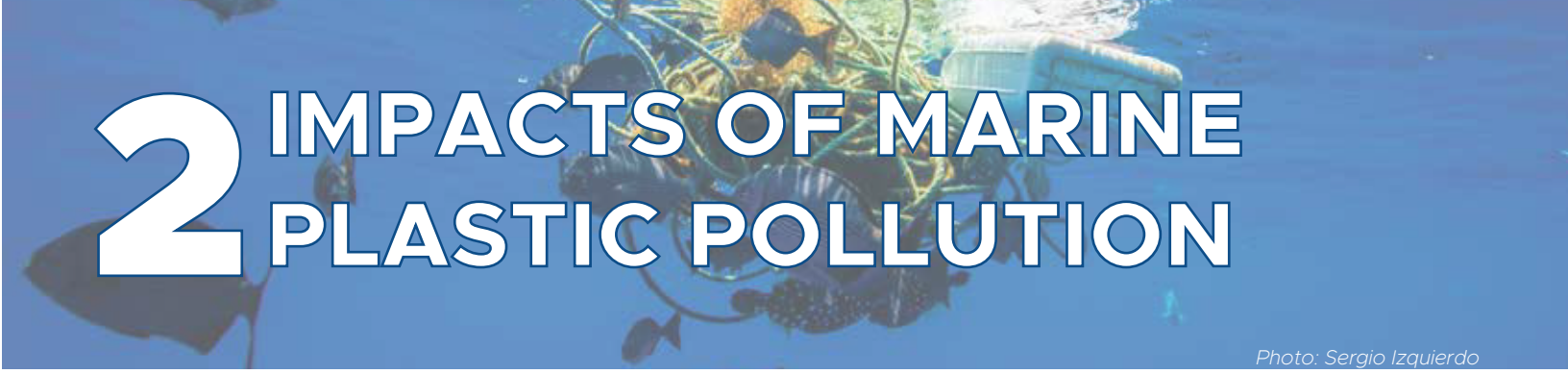
Infographic by Ocean Conservancy



Infographic by Ocean Action Pod



Infographic by Ocean Action Pod



2 IMPACTS OF MARINE PLASTIC POLLUTION

Photo: Sergio Izquierdo

OBJECTIVES

In this unit, participants will discuss how plastic pollution can impact marine animals and humans. They will think critically about how it affects different animals in different trophic levels of the marine food web. Students will have the opportunity to experience the effects of a plastic entanglement. They will then work in small groups to read a series of news reports about these impacts and work together to communicate what they have learned.

DURATION

20 minutes to 1 hour

15 - 20 mins for discussion and viewing of recommended videos
5 - 10 mins for Activity 2.1
30 - 45 mins for Activity 2.2

ALIGNMENTS

Sail Training

environment, empathy, teamwork and cooperation, creativity, communication

Ocean Literacy

5. The ocean supports a great diversity of life and ecosystems. A, E

6. The ocean and humans are inextricably interconnected. D, G

NGSS

SEP 1: Asking questions

SEP 8: Obtaining, evaluating, and communicating information

DCI - LS 2: Ecosystems: Interactions, energy and dynamics; C. Roles of water in Earth's surface processes

DCI - ESS 3: Earth and human activity

CCC 2: Cause and Effect: Mechanism and explanation

RESOURCES

Printed Materials

- Photos of animals and humans affected by marine plastic pollution
- Photo of marine microplastics
- A variety of current news articles or scientific papers about the impacts of plastic pollution on marine wildlife (See the 5 Gyres Science to Solutions Research Hub or search for current news in Science News Magazine, Science Daily, National Geographic, BBC, PBS, etc.)

Scientific Research

More information can be found on the 5 Gyres Science to Solutions Research Hub:
http://www.5gyres.org/science-research-hub

Supplies

- Medium-sized rubber bands (enough for each student to have two)
- A handful of small paperclips, washers, coins, or other small metal objects.
- Paper, pens, pencils for writing and drawing
- Optional: Sample of marine microplastics and/or plastics collected from your local beach

RECOMMENDED VIDEOS

Plastic Ocean
by United Nations (Length: 7:28)
https://youtu.be/ju_2NuK5O-E

What are the ecological impacts?
by 5 Gyres (Length: 2:14)
https://youtu.be/qlZleaYKrbQ

The Plastics Problem
by Ocean Heroes and 5 Gyres (Length: 2:17)
https://youtu.be/8BL5o7nRKtE

It's a Plastic World
by It's a Plastic World (Length: 4:39)
https://youtu.be/CWjkH7EV9lg

KEY TERMS

trophic levels, food web, biodegrade, photodegrade, microplastics, persistent organic pollutants (POPs), ingest, bioaccumulation, biomagnification

INTRODUCTION

Plastic is a flexible, durable, and versatile material which is used in countless applications in our everyday lives. From plastic food and drink packaging, electronics, and medical supplies to the carpet and furniture in our homes and even the clothing we wear, plastic is truly everywhere. The same properties that make plastic so useful to us also makes it detrimental to the natural environment. The durability of plastic allows it to endure in the ocean for hundreds of years. When plastic pollution ends up on the coast or in the ocean, it can have lasting impacts on marine wildlife.

DISCUSSION


Photo: NOAA

ASK: ***How do you think plastic pollution impacts marine animals of all sizes?***

Critical Thinking

Discuss how different types and sizes of animals might encounter and be harmed by plastic pollution.

Guide the Discussion

Suggest how animals can become entangled in plastic which can cause them to be unable to feed, possibly suffocate, or drown. Animals which ingest the plastics can slowly starve as they are unable to consume nutrients from their normal food.

Recommended Video: ***Plastic Ocean*** by United Nations (Length: 7:28) https://youtu.be/ju_2NuK5O-E


Photo: NOAA

SAY: ***More than different 1,450 species of animals have been observed being impacted by plastic pollution*** (Tekman et al., 2018)***. Birds, fish, turtles, dolphins, sharks, and even whales can be harmed or trapped by our plastic waste. Plastic can also negatively impact important habitats such as coral reefs, sea turtle nesting areas, and historic feeding grounds for filter feeders such as manta rays, whale sharks, and different species of whales.***

Look! *Photos:* Animals affected by entanglement or ingestion of marine plastic pollution (See resources, Pgs 20-23)

Recommended Videos: ***What are the ecological impacts?*** by 5 Gyres (Length: 2:14) https://youtu.be/qlZleaYKrbQ

SAY: ***Some scientists believe that plastic will never biodegrade, or breakdown into natural elements. Other scientists believe it could take hundreds, if not thousands of years. Instead, the sun photodegrades plastic, causing it to break up into thousands of smaller pieces which we call microplastics. The small size of the microplastics are easily confused as food and accidentally consumed by animals in all trophic levels (all levels of the food web/chain) of the marine environment*** (5 Gyres Institute, 2018)***.***

Recommended Videos: ***The Plastics Problem*** by Ocean Heroes and 5 Gyres (Length: 2:17) https://youtu.be/8BL5o7nRKtE

It's a Plastic World by It's a Plastic World (Length: 4:39) https://youtu.be/CWjkH7EV9Ig

Photo: 5 Gyres

SAY: ***In the ocean, a single particle of plastic can be one million times more toxic than the water around it*** (Rios et al. 2010)***. The plastic functions like small sponges, soaking up persistent organic pollutants (POPS) in the water. Marine life as small as zooplankton has been documented eating plastic. As plankton is consumed by larger animals, these pollutants can bioaccumulate, which means the toxic chemicals build up in cells and tissues as they work their way up the food chain. Increased concentration of toxic substances in the bodies of animals higher in the food chain is called biomagnification*** (5 Gyres Institute, 2018)***.***

Look! Photos: Share images of marine microplastics. (See resources, Pg 24)
Option: Share a physical sample of microplastics collected off a local beach.

SAY: ***Marine animals are exposed to toxins when they ingest microplastics, which can affect the normal functioning of their organ systems and their chances for survival. In addition to toxins entering organs, tissues, and cells via the bloodstream, plastic ingestion in the stomach can signal a "full" feeling to the brain which can lead to starvation and death of the animal*** (5 Gyres Institute, 2018)***.***

Photo: Chris Jordan

Look! Photo: Share image of deceased albatross chick with plastic stomach contents with group. (See resources, page 23)

Photo: 5 Gyres

SAY: ***Animals aren't the only ones disturbed by marine plastic pollution. Humans depend on the ocean for healthy food, oxygen, and a stable ecosystem that maintains the balance of greenhouse gases in our atmosphere*** (5 Gyres Institute, 2018)***. People around the world also enjoy the ocean for relaxation, recreation, and cultural purposes. Unsightly and toxic plastic pollution can impact us in many ways.***

Look! Photos: Share photos of people impacted by plastic pollution. (See resources, Pg 25)

ACTIVITY 2.1 - ANIMAL ENTANGLEMENT RELAY

In this activity, participants will develop a better understanding of how plastic entanglement can be detrimental to the normal activities and day-to-day lives of marine animals. It has been adapted from an activity in the Ocean Conservancy's *Talking Trash & Taking Action* (Ocean Conservancy, 2014).

Duration

5 - 10 minutes

Materials

- Medium-sized rubber bands (enough for each student to have two)
- A collection of small paperclips, washers, coins, or other small objects

1. Distribute two thick rubber bands to each participant.
2. Separate students up into groups of 3 to 10 people and have them sit together around a table or shoulder to shoulder on the deck of the ship.
3. Instruct them to place a rubber band around each of their thumbs, stretching it across the back of their hand, and then looping it over their pinky finger. The rubber bands should be snug enough to cause a little discomfort, but not pain. (NOTE: Students with any hand injuries should not participate.)
4. Give a small pile of 10 small objects such as coins, paperclips, and/or washers to the student sitting at the end of the group/line.
5. Instruct the participants to pick up the items one at a time, passing it to their neighbor, and moving the items down the line using ***only*** their "entangled" thumbs and pinky fingers. They may not slide the items along the table/deck or pass the items with any other part of their hand.

Guide

Participants will notice the difficulty and discomfort. Relate this to what marine animals experience when they're entangled in plastics and trying to go about their normal lives, searching for food, caring for and feeding their young, evading predators, etc. Optional: Instruct students to continue to wear the rubber bands on their hands while participating in Activity #2.

ACTIVITY 2.2 - COMMUNICATING THE PROBLEM OF PLASTIC

This activity will allow participants to read a recent news report or scientific journal article about the impacts of plastic polution on a marine species. Students will incorporate the information in the article into creative communication such as a sea chantey/song, poem, story, dance, physical piece of art, etc.

Duration

30 - 45 minutes

Materials

- Paper and pens, pencils, or markers for writing and drawing.
- A variety of current news articles about the impacts of plastic pollution on marine wildlife (Recommended: ScienceNews Magazine, Science Daily, National Geographic, BBC, PBS, etc.)
- Scientific literature can be used as an advanced option for this activity. Articles can can be found on the 5 Gyres Science to Solutions Research Hub: http://www.5gyres.org/science-research-hub

1. Split the participants up in to small groups of 2 to 5 people.
2. Provide each group with one or two current news reports or journal articles about how plastic pollution is impacting marine life.
3. Instruct each group to review the article and collaborate to produce a creative communication piece. Suggested options could include a piece of physical art, a song or sea chantey, poem, skit, creative storytelling, etc.
4. Students come back together to share their communication piece and teach the larger group what they learned from reading the articles.

Photos: Arkive

Photos: Arkive

Photo: Arkive

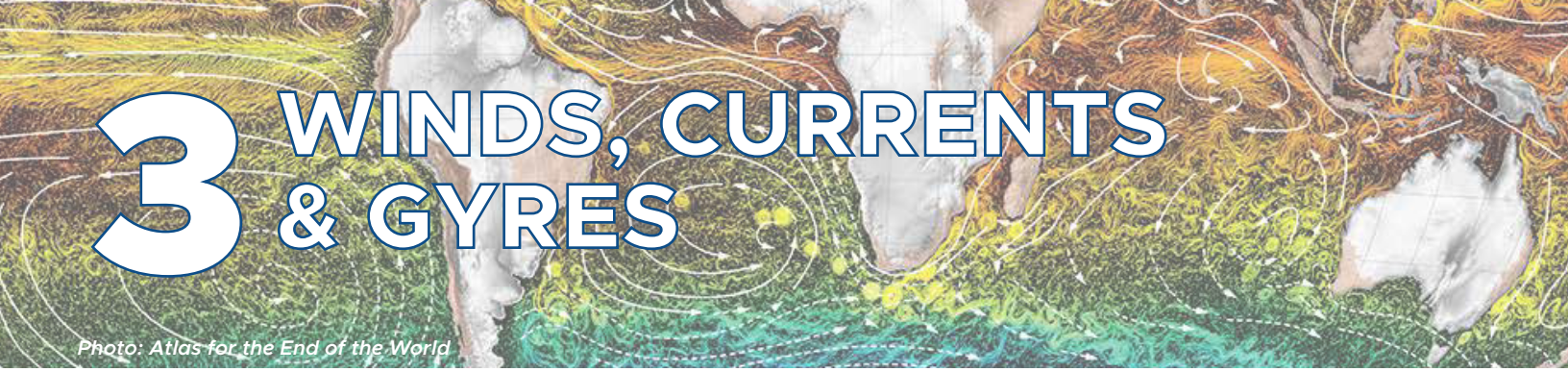
Photo: Marcus Eriksen/5 Gyres

Photo: Chris Jordan

Photos: 5 Gyres

Photo: Reuters

Photo: Zak Noyle



3 WINDS, CURRENTS & GYRES

Photo: Atlas for the End of the World

OBJECTIVES

In this unit, participants will examine how the winds and currents that affect sailing and navigation through the world's ocean also influence the movement and distribution of marine plastic pollution. They will be introduced to ocean currents and the five oceanic gyres where plastic pollution accumulates. They will also consider how floating plastics can impact vessel operations worldwide.

DURATION

30 minutes to 1 hour 15 minutes

10 - 15 mins for discussion and viewing of recommended videos
10 - 15 mins for Activity 3.1
10 mins for Activity 3.2
20 - 30 mins for Activity 3.3

ALIGNMENTS

Sail Training

awareness of environment, teamwork, observation and critical thinking, navigation, communication

Ocean Literacy

1. The Earth has one big ocean with many featuers. C, F, G

3. The ocean is a major influence on weather and climate. A

6. The ocean and humans are inextricably interconnected. A, D, G

NGSS

SEP 2: Developing and using models

DCI - PS 1: Matter and its interactions

DCI - PS 2: Motion and stability: Forces and interations

DCI - ESS 3: Earth and human activity

CCC 2: Cause and Effect: Mechanism and explanation

CCC 4: Systems and system models

RESOURCES

Printed Materials

- Several laminated world maps.
  Option: Plain paper photocopies
- World map depicting ocean currents and gyres
- World map depicting concentration of microplastics in the gyres
- World map depicting global shipping routes
- MARPOL Annex V placard (see Unit 1, Pg 10)

Supplies

- Several round, medium-sized bowls
- Enough water to fill all bowls
- Mixture of cold cereal (Suggested: A mixture of different types allowing for variation of size, shape, and color)
- One 5 to 10-meter long rope
- Several dry or wet erase markers or pens
- Paper, pens, pencils for writing and drawing

Scientific Research

More information can be found on the 5 Gyres Science to Solutions Research Hub:
http://www.5gyres.org/science-research-hub

RECOMMENDED VIDEOS

How Much Plastic is in the Ocean?
by PBS It's OK To Be Smart (Length: 5:00)
https://youtu.be/YFZS3Vh4lfI

Perpetual Ocean Current Visualization
by NASA Goddard (Length: 3:00)
https://youtu.be/CCmTY0PKGDs

What is a Gyre?
by Ocean Heroes and 5 Gyres (Length: 2:20)
https://youtu.be/h6i16CrI8ss

Garbage Patch Visualization Experiment
by NASA's Scientific Visualization Studio (Length: 1:25)
https://youtu.be/zYuvTYJ0hGk

KEY TERMS

currents, gyre, equator, atmosphere, bathymetry, Coriolis Effect

INTRODUCTION

When sailing along coastlines close to home or venturing out into the open ocean, sailors must always consider how wind and currents will impact their course and the movement of their ship. Seasonal wind patterns are often predictable but can vary widely day to day. Currents and tides can vary in strength and can affect the course of a ship as well, sometimes working with or against the vessel. These same forces also influence the movement and distribution of marine plastic pollution in the ocean, an issue that is having widespread impacts on the marine ecosystem.

Recommended Video: ***How Much Plastic is in the Ocean?*** by PBS It's OK To Be Smart (Length: 5:00) https://youtu.be/YFZS3Vh4lfI

DISCUSSION

ASK: ***What do you think drives the movement of ocean currents?***

Critical Thinking

Encourage participants to brainstorm different elements that might drive the movement and speed of ocean currents.

Guide the Discussion

Currents are driven by winds, water temperatures, and even the shape of the coast, or the local ***bathymetry*** (the shape of the sea floor). Gravity and the rotation of Earth also impact the direction of currents.

Recommended Video: ***Perpetual Ocean Current Visualization*** by NASA Goddard (Length: 3:00) https://youtu.be/CCmTY0PKGDs

Guide the Discussion

While showing this short film, read or summarize the following information outloud:

SAY: ***An ocean current is a river of water moving in the ocean; they can be at the surface, as well as deep in the ocean. Surface ocean currents are called convection currents; they form due to differences in temperature. Surface ocean currents move as wind drags on the ocean's surface. The water moves and builds up in the direction that the wind is blowing.***

Differences in air temperature cause wind. Air masses move from areas of high pressure toward areas of low pressure. In general, air masses are colder at the poles and have higher density (high pressure) than air at the equator, which is warmer and has a lower density (low pressure). These differences in temperature and pressure cause colder air masses to move toward the equator, while warmer air masses move from the equator toward the poles.

If the Earth remained still, the atmosphere would only circulate between the poles and the equator. However, the Earth spins on its axis, resulting in the Coriolis Effect, which describes the ground moving at a different speed than an object in the air. The Earth makes a complete rotation about its axis approximately once every 24 hours and has a greater circumference at the equator than at the poles—so it spins faster at the equator than at the poles (5 Gyres Institute, 2018)***.***

SAY: ***As the Earth spins, it causes the earth's air masses to curve toward the right in the Northern Hemisphere (in a clockwise motion) and to curve toward the left in the Southern Hemisphere (in a counterclockwise motion). This sets up global wind patterns that circulate air masses around the Earth and influence surface ocean currents. The air masses pull on the surface ocean water and drag it in the direction that the air is moving. This combination of factors creates the gyres.***

A gyre is a circulating system of ocean boundary currents powered by the uneven heating of air masses and the shape of the Earth's coastlines. These gyres occur north and south of the equator. There are five main gyres where plastic polluion accumulates in the ocean: The North Pacific Gyre, The South Pacific Gyre, The North Atlantic Gyre, The South Atlantic Gyre, and The Indian Oceanic Gyre (5 Gyres Institute, 2018)***.***

ACTIVITY 3.1 - CREATE YOUR OWN GYRE

In this activity, students will have the opportunity to see how wind influences the movement of the ocean and objects within it. They will also witness how floating material moves and collects within their homemade gyre. This is an adaptation of an activity designed by the Ocean Conservancy (2014).

Duration
10 - 15 minutes

Resources
- Several round, medium-sized bowls
- Mixture of cold cereal of different sizes, shapes, and colors
- Enough water to fill all bowls

Recommended Video:
What is a Gyre? by Ocean Heroes and 5 Gyres (Length: 2:20) https://youtu.be/h6i16Crl8ss

1. Split participants into small groups of 2 to 4 students.
2. Distribute a bowl and a small amount of cereal (half a handful) to each group.
3. Instruct students to fill bowls to just below the brim with water and gently drop cereal into it.
4. Instruct students to take turns gently blowing their breath across the surface of the water while the other student(s) observe the movement of the water and cereal which represents plastic pollution.

ASK:
- ***What happens to the water and cereal when you blow directly across the middle of the bowl?***
- ***What happens when you blow parallel to the brim/along the edge of the bowl? (They should notice the water and cereal circulating into a whirlpool or gyre.)***
- ***What happens when you blow straight down onto the water from above?***

5. Have two students face each other and hold the bowl between them. Direct them to blow gently across the surface of the water, parallel to the brim of the bowl at the same time, but on opposite sides of the bowl.

ASK:
- ***How does the movement of the water and cereal change with additional wind? (They should notice the water and cereal circulating into a gyre at a faster pace and they may see more mixing of the cereal beneath the surface.)***
- ***What do you notice about the movement of the cereal within the water?***
- ***Does all of the cereal stay at the surface or does it dip under or sink to the bottom?***
- ***What could these observations tell us about movement of plastic pollution in the ocean?***

ACTIVITY 3.2 - CURRENT CURRENTS

This activity will allow students to gain awareness of the wind and currents around the vessel. They will have the opportunity to consider how these forces impact the movement of the ship while it is alongside, anchored, and underway. They will also think about how these same forces would impact the movement of plastic pollution in the ocean.

Duration

10 minutes

Resources

One 5 to 10-meter long rope

Note: This activity will only work if the ship is stopped at anchor or in port. This activity is not advised while engines are running.

1. With the students on deck, instruct the students to secure the end of a 5 to 10-meter-long rope to a cleat or to the ship's rail near midships.
2. Optional: Use this as an opportunity to discuss ideal knots that could be used in this application. A clove hitch, bowline, or cleat hitch is recommended.) Double check their knot before moving to next step.
3. Once end is secured, instruct students to throw the rest of the rope out into the water.
4. Take a moment to allow the students to observe the direction and movement of the rope as it floats in the water, then guide their critical thinking by asking the following questions:

ASK:

- ***Is the rope moving? Did it move slowly or quickly into place?***
- ***Do you think its movement is caused by the wind, current, or both?***
- ***If the ship is in port or near a shoreline, could the tide be impacting the movement of the rope?***
- ***How does the direction of the rope compare to the ship's orientation with the anchor and anchor chain?***

Critical Thinking

- How would the wind and/or the current impact the ship if you were sailing?
- If a piece of plastic waste was lost overboard right now, which direction would it travel?
- If the plastic floats on the surface, do you think the wind impact its direction of movement?

Photo: Erika Delemarre

ACTIVITY 3.3 - MESSAGE IN A BOTTLE

This activity will allow participants to examine global ocean currents and consider how plastic pollution moves through the world's ocean. They'll use their creativity to communicate a message about marine plastic pollution.

Duration
20-30 minutes

Resources
- Several laminated world maps. (Option: Plain paper photocopies)
- World map depicting ocean currents and gyres
- World map depicting concentration of plastics in the gyres
- Several dry or wet erase markers or pens (one per group of students)
- Paper, pens, pencils for writing and drawing

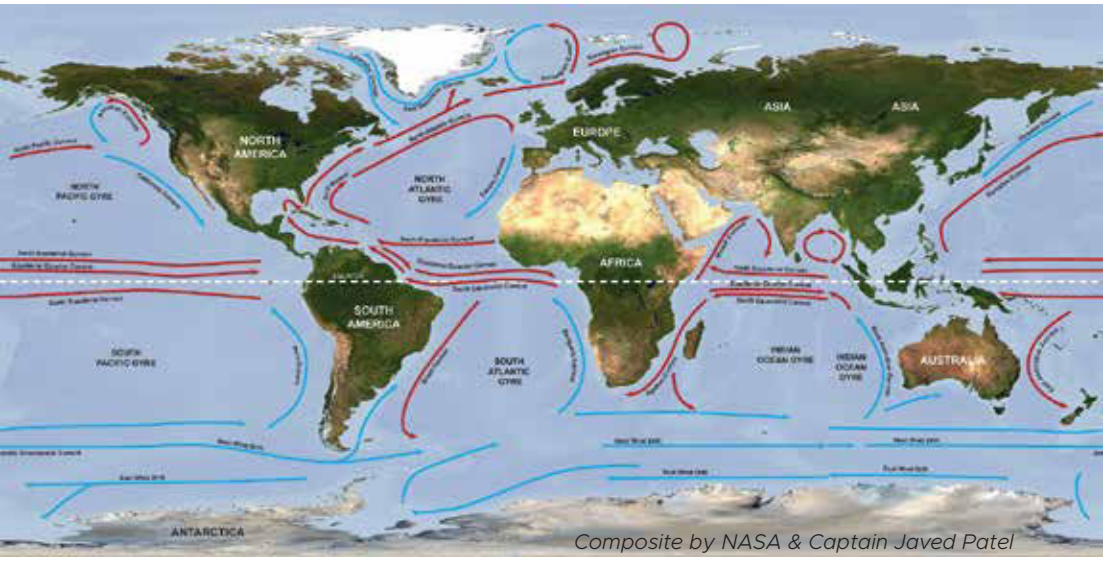
Activity 3 - Part One

1. Split large group into several smaller groups of 2 to 5 people.
2. Distribute a reusable laminated world map (or a plain photocopied map) and a wet or dry erase marker to each group.
3. Instruct students to mark a star on the map at the ship's approximate location.

SAY: ***If we lost a plastic bottle overboard right now, mark another star on the map where you think it would travel in two weeks' time. Consider where you think the winds and currents may take it. Draw a line with an arrow to show its path of travel from where we are now to the bottle's next location.***

4. Repeat the question for 2 months, 2 years, 10 years, 20 years, 50 years, 100 years, and 500 years. Give the students the option to draw an X if they believe the plastic bottle has degraded or sunk to the bottom of the ocean after a certain amount of time.
5. Have students share their maps and predictions with the rest of the group. Ask them to explain their reasoning for the direction of travel and if they marked any X's on the map, ask them what they believed happened to the plastic bottle.

Look! Infographic: Show students the world map with arrows depicting the ocean currents and gyres. (See resources, Pg 35) Depending on the ship's location, point out the arrows that mark the nearby currents on the map.



Composite by NASA & Captain Javed Patel

NOTE: A larger version of this map can be found in the resources for this unit on page 35.

ASK:

Looking at this map, which of these currents or gyres might be affecting our ship right now or which might we encounter during our voyage?

Guide

If possible, discuss your local knowledge of permanent and seasonal currents in your area and how they could impact the vessel.

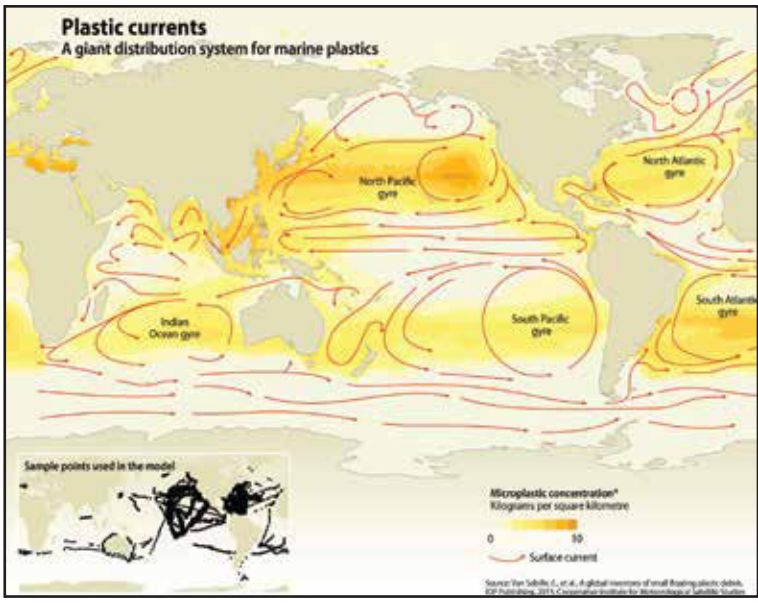
Activity 3.3 - Part One Continued...

Guide Referencing the map with the currents, point out how many of the currents connect to the five large subtropical gyers in the Pacific, Atlantic and Indian oceans.

ASK: ***Now that you have a better understanding of global currents, where do you think our plastic bottle would travel and eventually end up?***

Look! *Infographic:* Show students the world map that depicts concentrations of plastics in the ocean. (See resources, Pg 36)

Guide Point out the "hot spots" that are a brighter color in the middle of the gyres. This is where plastic pollution accumulates in the ocean. For a deeper understanding of how the movement occurs, watch the next recommended videos.



Recommended Video:

Garbage Patch Visualization Experiment by NASA's Scientific Visualization Studio (Length: 1:25) https://youtu.be/zYuvTYJ0hGk

Activity 3 - Part Two

1. Direct students to separate into their original groups again.
2. Pass out paper and pens or pencils to each group.

ASK: ***If we were going to send a message in a bottle – a GLASS bottle – out into the ocean right now, what message would you write about marine plastic pollution? Who would you want to find your message?***

3. Give students 5 - 10 minutes to work together to compose a short message.
4. Bring the students back together and have them share their messages with the whole group.

DISCUSSION

ASK: ***How do you think vessel operations could be impacted by plastic pollution?***

Critical Thinking

Brainstorm how the ship might encounter marine plastic pollution, what the hazards would be, what actions would need to be taken to solve the problems caused, etc.

Guide the Discussion

Encourage the students to consider all sizes of plastics. Suggest propeller entanglement in discarded fishing line or nets; overheating of the engine due to plastic being sucked over the grate of the seawater intake for its cooling system; ship collisions with larger marine debris items, etc. How could these events impact your ship and what would be the repercussions of the ship losing its maneuverability (lost time, reduced safety, etc.)? How would your crew respond if any of these instances occurred?

SAY: ***Shipping routes can be impacted by permanent and seasonal currents. A deep understanding of currents allows for planning by commercial shipping agencies, cruise lines, fishing fleets, and private vessels. The Coast Guard also relies on knowledge of currents when planning search and rescue operations at sea.***

Look! Infographics: Show students the map of vessel traffic through the world's ocean alongside the map of the marine debris hot spots in the ocean basins and the Mediterranean Sea. (See resources, Pg 36-37)

ASK: ***Can you see any overlap on the movement of vessels and the areas where there are high concentrations of marine debris? What could this mean for vessels moving through these hot spots?***

Critical Thinking

Brainstorm the big-picture impacts of marine plastic pollutionon global shipping and transportation.

Guide the Discussion

Encourage students to consider loss of time, revenue, supplies, human safety, etc. to ships impacted by plastic pollution.

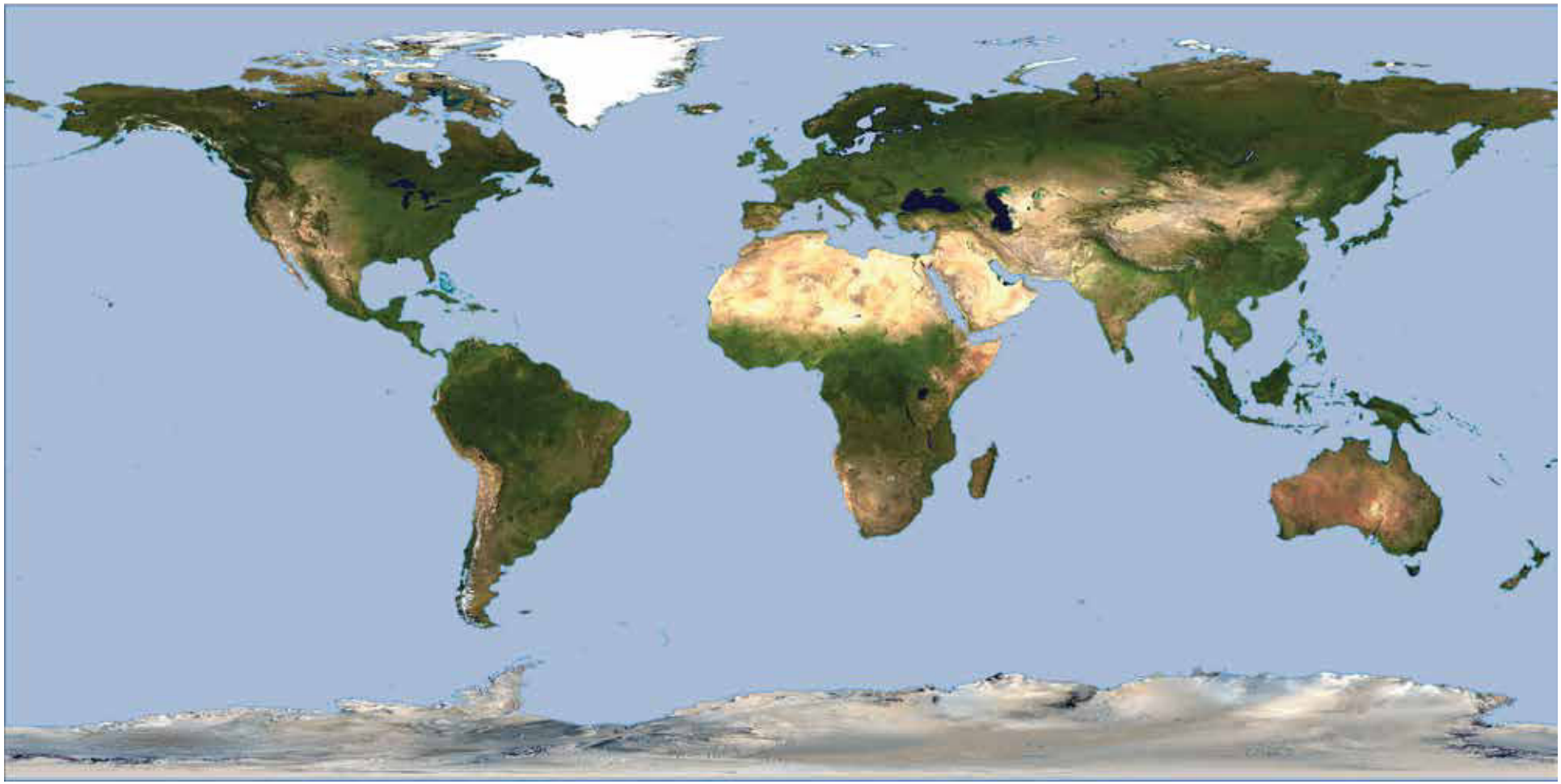
ASK: ***How might these vessels also be contributing to marine plastic pollution?***

Critical Thinking

What kind of materials might different ships lose or intentionally discard of overboard?

Guide the Discussion

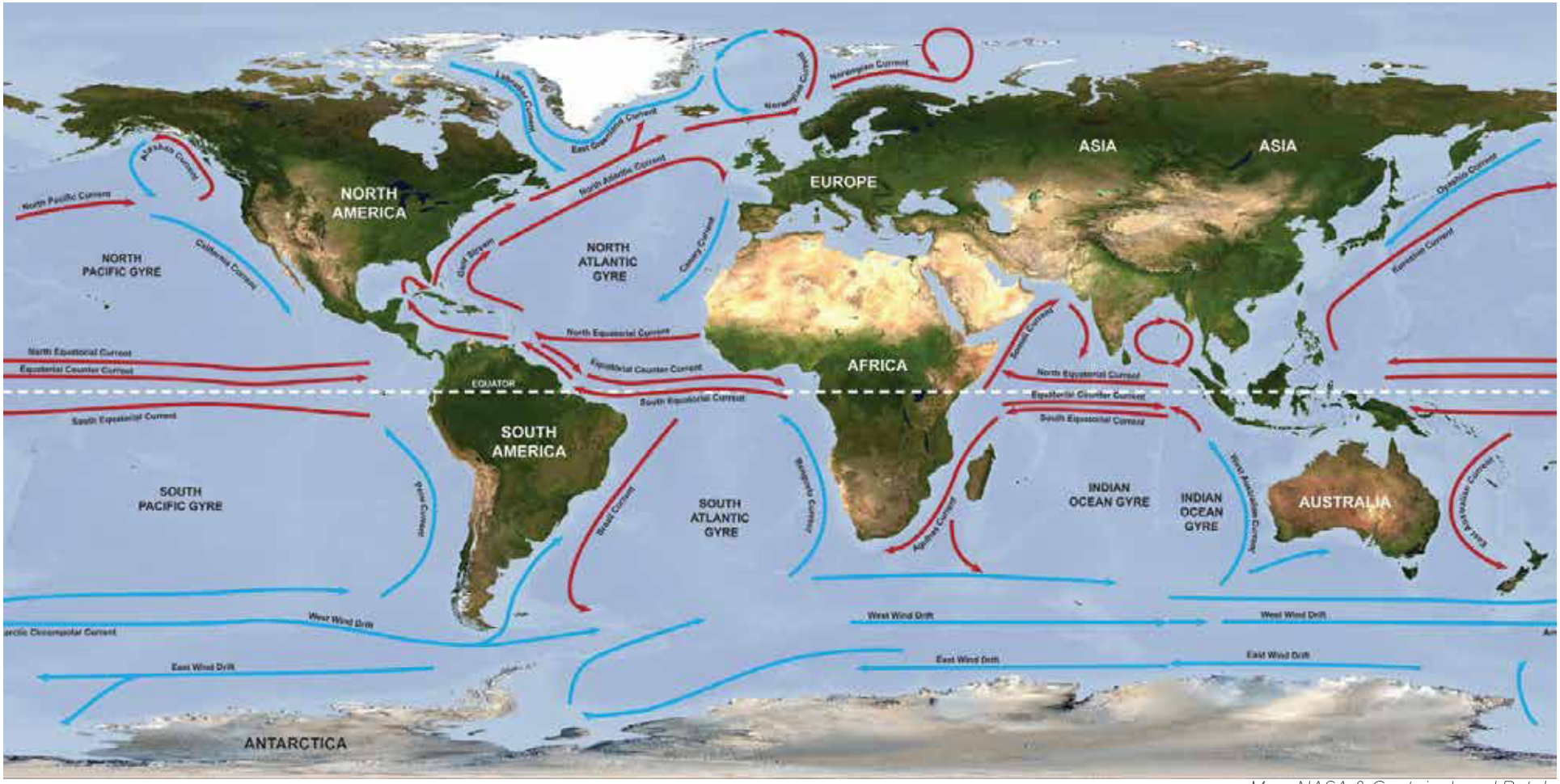
Consider intentionally discarded or lost fishing gear, general waste, toxic waste, etc. Sometimes ships will illegally throw these materials overboard in order to avoid paying for their disposal when they're in port. Optional: Reference MARPOL Annex V placard in the Unit 1 resources on pages 10-12.



Map: NASA

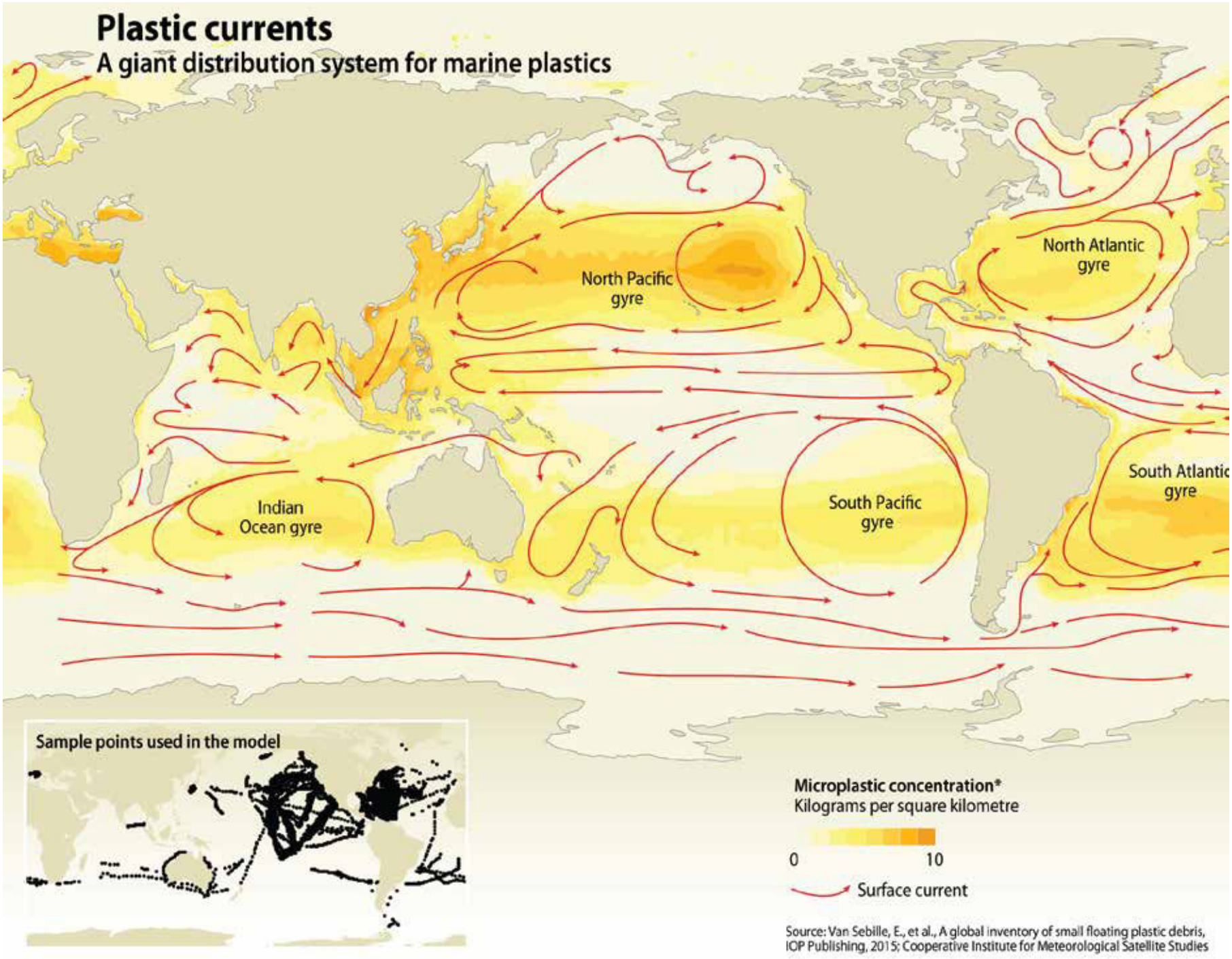
Map: Wikimedia Commons

Ocean Currents and Gyres



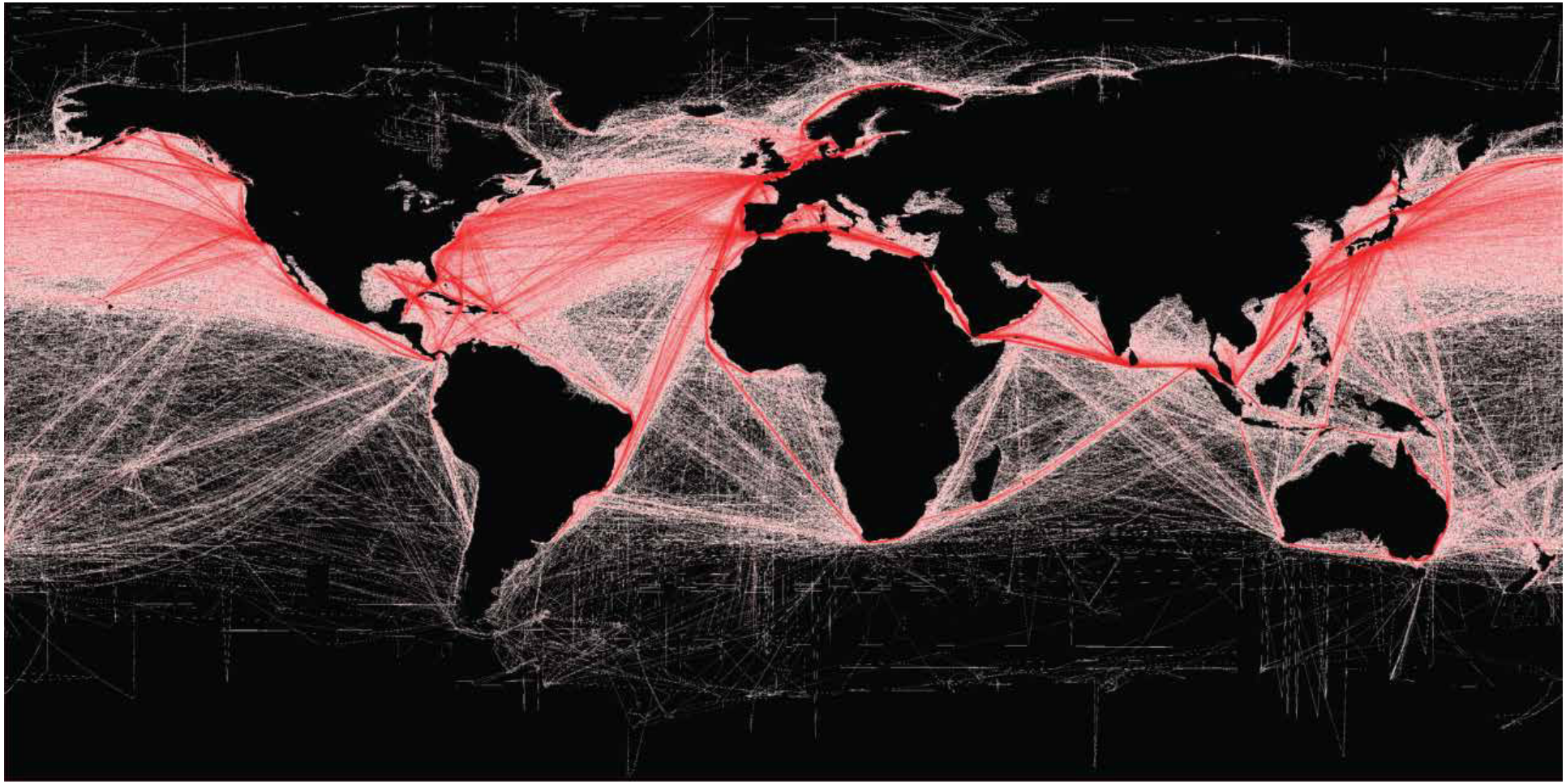
Map: NASA & Captain Javed Patel

Concentration of Microplastics in Gyres



Map: GRID-Arendal

Global Commercial Shipping Routes



Commercial Shipping Routes Map by B.S. Halpern

4 PLASTICS IN OUR LIVES & INNOVATING SOLUTIONS

Photo: Wikimedia Commons

OBJECTIVES

In this unit, students will have the chance to become more aware of the plastics they use in their daily lives. They will think critically about the waste they generate on board the ship and at home every day. They will explore how plastic behaves in saltwater. This unit will finish with an activity that will encourage students to think creatively about innovative solutions to marine plastic pollution.

DURATION

35 minutes to 1 hour 30 minutes
6 mins for introduction
25 mins for Activity 4.1
10 mins for Activity 4.2
30 - 45 mins for Activity 4.3

ALIGNMENTS

Sail Training

critical thinking, awareness of self and actions, creative problem solving, teamwork, effective communication

Ocean Literacy

6. The ocean and humans are inextricably interconnected. D, G

NGSS

SEP 6: Constructing explanations for science and designing solutions for engineering

DCI - ETAS 1: Engineering design

DCI - ETAS 2: Links among engineering, tech, science, and society

CCC 5: Energy and matter: Flows, cycles, and conservation

KEY TERMS

composition, fossil fuels, entangle, ingest, compostable, biodegradable. bioplastics, circular economy

RESOURCES

Printed Materials

- B.A.N. (Better Alternatives Now) List 2.0 (See pg 89)
- MARPOL Annex V placard (see Unit 1, Pg 10)

Supplies

- Paper, pens, pencils for writing and drawing
- Miscellaneous plastic items such as a plastic bag, toothbrush, fork, straw, bottle cap, ruler, pen, candy wrapper, clothes pin/peg, etc.
- Extra-large bucket or bowl filled with seawater

Scientific Research

More information can be found on the 5 Gyres Science to Solutions Research Hub:
http://www.5gyres.org/science-research-hub

RECOMMENDED VIDEOS

How Much Plastic is in the Ocean?
by PBS It's OK To Be Smart (Length: 5:00)
https://youtu.be/YFZS3Vh4lfI

How We Can Keep Plastics Our of Our Oceans
by National Geographic (Length: 3:00)
https://youtu.be/HQTUWK7CM-Y

Why I Live a Zero Waste Life
by Lauren Singer at TEDx Teen (Length: 13:30)
https://youtu.be/pF72px2R3Hg

Gyrecraft - Transforming Ocean Trash into Beautiful Art by Studio Swine on National Geographic (Length: 5:00)
https://youtu.be/wDrKlByGEsA

Plastic Kiln Innovation by 5 Gyres (Length: 2:00) https://vimeo.com/173068317

How to Repurpose Plastic Bottles into Eco-Bricks by Rappler and the Plastic Solution (Length: 3:00) https://youtu.be/vaJrkzQ43m4

Lush Uses Social Plastic by The Plastic Bank (Length: 2:25) https://youtu.be/MlzknllOjTI

The Solution to Plastic Waste Pollution
by UPROXX & Full Cycle Bioplastics
(Length 2:20) https://youtu.be/o_STBEU7ykI

INTRODUCTION

We all use and interact with plastic in our everyday lives. It has become so abundant we often don't even notice how much we rely on it. There's a problem with plastic because it's being used more and more for "disposable" applications which is causing excessive amounts of plastic waste to be generated by populations around the world. Marine plastic pollution is becoming a large problem in our ocean, but we have the ability to slow the flow by being aware, creative, and innovative.

SAY: ***Let's take a moment to brainstorm all the plastic items we have used today, from the minute we rolled out of our bunks until this very moment. Call out the plastic items that you have touched today.***

Guide the Discussion

Suggest plastic items such as toothbrushes, toothpaste and shampoo bottles, hair brushes or combs, deodorant sticks, water bottles, cereal bowls, cups or mugs, sponges, sunscreen bottles, lip balm tubes, eyeglasses or sunglasses, elastic hairbands, shoes, hats, the casing for electronics, and even anything made with synthetic fibers such as pillows, clothing, curtains, wet weather gear, or harnesses. (And quite possibly the lines on your ship as well!)

Recommended Videos:

How Much Plastic is in the Ocean? by PBS It's OK To Be Smart (Length: 5:00)
https://youtu.be/YFZS3Vh4lfI

How We Can Keep Plastics Our of Our Oceans by National Geographic (Length: 3:00)
https://youtu.be/HQTUWK7CM-Y

ACTIVITY 4.1 - PLASTIC IS EVERYWHERE

In this activity, participants will see examples of how plastics exist in nearly every part of their everyday lives. With their new awareness, they will experiment with how these different plastics would behave if they escaped into the ocean to become marine plastic pollution.

Duration

25 minutes

Resources

- MARPOL Annex V placard

1. Instruct participants to go to their cabin/bunks and retrieve one plastic item from their personal belongings. Whichever item they choose, it should not match any other plastic item from any other person in their cabin or watch group.
2. Students have three minutes to retrieve the item and gather together again, preferably around a table or in a circle sitting on deck.

ASK: ***What are your items used for? Can we categorize the items into groups by use?***

Guide the Discussion

Have students place items out on the table or deck and categorize them. Examples: Food wrappers, leisure activities, personal hygiene, clothing items, etc.

Photo: Mandy Barker

Activity 4.1 Continued...

3. Instruct the students to now reorder the plastics into groups of "single-use" plastics (i.e. food wrappers, drink bottles, plastic bags, etc.), "disposable" plastics (toothbrushes, razors, etc.), and "reusable/long-life" plastics (eyeglasses, reusable water bottles, clothing made from polyester, etc.)

DISCUSSION

ASK: ***What is this difference between the "single-use" plastic items and the ones we use longer periods of time?***

Critical Thinking

Encourage students explore the difference in the items' ***composition***. How thick is the plastic? Is it flexible or rigid? Does it seem strong or weak? Would it stand up to applied heat or being frozen?

ASK: ***How does the strength and durability of the plastic align with its purpose and intended length of use?***

Critical Thinking

Direct students to compare the item's composition with its use. (i.e. How does the durability of a soda bottle which is used for 30 minutes compare to that of a toothbrush which is used for several months? What about dental floss versus the sole of a shoe?)

ASK: ***How do you think the durability and strength of these items would impact the length of time they would persist as pollution if they were to end up the ocean?***

SAY: ***Some plastics will break up into smaller pieces faster than others (for example Styrofoam), but most may take hundreds, if not thousands, of years to truly break down into a natural state. Scientists don't know for sure how long plastics will persist in the environment since the material has only been around since the early 1900's.***

ASK: ***Where do these items go when they reach the end of their lifespan or when you're finished using them? How would you dispose of them on the ship? On land?***

Critical Thinking

Have students consider where their trash/rubbish goes while aboard the ship. Could their item be repurposed for something new? Could it be recycled?

Guide the Discussion

Discuss waste management on board the ship and share MARPOL Annex V placard (pg 10) which outlines the international regulations for dumping at sea. Is recycling available in the ship's home port and/or the ports it will be visiting during this voyage?

ASK: ***How can we reduce the amount of plastic waste we generate on board? What about at home or at school?***

Critical Thinking

Encourage students consider the plastic items they ***need*** versus the ones that they ***want***. What are the alternatives to using different plastic items? Can they be replaced with something biodegradable or reusable?

Guide the Discussion

Some suggestions include reusable water bottles, refillable containers, bar soap without packaging, cloth shopping bags, reusable food containers, homemade snacks or fresh produce without plastic packaging, etc.

Recommended Video: ***Why I Live a Zero Waste Life*** by Lauren Singer at TEDx Teen (Length: 13:30) https://youtu.be/pF72px2R3Hg

Photo: 5 Gyres

SAY: ***A lot of fossil fuels are used and fortunes are spent on making and transporting single-use, "disposable" plastics only for them to be thrown away minutes after use. Even items that are labeled for recycling often end up in landfills or into the environment.***

ASK: ***Is it worth harming the environment just for our convenience?***

Critical Thinking

Have students weigh the pros and cons of the conveniences and benefits that plastics provide to us.

THE FOUR R's

Refuse

Refuse plastic waste when it's automatically given to you. Order a drink at a restaurant, but say to the waiter: "No straw, please." When you got to a shop to buy groceries, don't take a plastic shopping bag if it is offered to you.

Reduce

Reduce the amount of plastic waste that you allow to enter your life. Purchase products that have minimal or no plastic wrapping or packaging. You can also stop purchasing single-use items like disposable sandwich bags, plastic cutlery, or Styrofoam cups.

Reuse

Have reusable items on hand such as a stainless-steel water bottle, strong cloth shopping bags, ceramic or metal coffee mugs, durable take-away food containers, reusable utensils, etc. You can also repurpose plastic items for new uses like building something new or incorporating them into artwork.

Recycle

This should always be your last choice. If you must dispose of plastic, do your best to responsibly recycle it. Recyling makes sense in theory, but is limited in reality becuase it can be restricted by local facilities and regulations.

ACTIVITY 4.2 - SINK OR FLOAT?

In this activity, participants will get to explore how different plastic items behave in sea water. They will think critically about where different items may end up in the ocean and how it could affect marine life. (Note: This activity is best done following Activity 4.1.)

Duration

1o minutes

Resources

- Extra-large bucket or bowl filled with seawater
- Miscellaneous plastic items such as a plastic bag, toothbrush, fork, straw, bottle cap, ruler, pen, candy wrapper, clothes pin/peg, hair comb (Optional: Use students' plastic items from Activity 1)

SAY: ***What do you think each of these items will do when they are dropped into sea water?***

1. Ask students to show by a raise of hands whether they think each item will sink or float.
3. Students take turns placing a single item into the bucket one at a time, allowing it to float at the surface at first.
4. If the item is filled with air, after a few moments, instruct the student to push it below the surface to ensure all the air is removed.
5. Encourage students to make observations about how the items act in the water.
6. Offer students the opportunity to try out their plastic items from Activity 4.1, but only if it won't cause damage to their personal belongings.

ASK: ***What could this mean for the marine life living at the surface of our ocean? What about on the sea floor? And how about somewhere in between?***

Critical Thinking

Consider marine animals of all sizes from plankton and fish to turtles, sharks, and whales. Some live near the surface while others like crabs, lobster, and shellfish are typically on the sea floor.

Guide the Discussion

Marine plastic pollution can be found throughout our ocean, on the coastlines and out in the open ocean, at the surface and in the deep sea, thousands of meters deep, and everywhere in between! Plastic can ***entangle*** or become accidentally ***ingested*** by marine life impacting their ability to swim, breath, eat, reproduce, and care for their young.

Photo: Arkive

Photo: Nels Israelson

Photo: Arkive

Look! Share the photos of how marine plastic pollution can impact wildlife and humans. (Unit 1 resources, pages 20-25.

SAY: ***There are many ways we can prevent the ocean and marine wildlife from being harmed by our plastics. We need to take responsibility for our actions by reducing the amount of plastic waste we produce, seeking out innovative alternatives to plastics, and ensuring that the plastic we must throw away is recycled or disposed of correctly.***

ARE BIOPLASTICS THE ANSWER?

SAY:

Different forms of bioplastics have become widely available to consumers in recent years. These products are often made from materials derived from feedstocks such as corn, soybean, or sugar cane. To capture our attention, companies market these plastics with words such as "eco-friendly," "compostable," "natural," or "biodegradable" written in blue or green and accompanied by a small leaf or tree. At first glance, bioplastics may seem like an earth-friendly solution to marine plastic pollution, but they're not.

Bioplastics are composed of a variety of materials and some are even partially derived from fossil fuels. Some bioplastics can be recycled, while some are only intended for disposal in industrial composting facilities. Because the materials used in production are not uniform and the labeling is confusing, consumers often don't know how to dispose of bioplastics correctly. This can lead to contamination of recycling and composting facilities, or even worse: more plastics littered into the environment by consumers who think they're "all natural."

For more information on bioplastics and alternatives to plastic, have a look at the B.A.N. List 2.0 in page 89.

ACTIVITY 4.3 - CREATE & INNOVATE

This activity will allow participants to think creatively to come up with innovative solutions to reduce plastic waste and/or reduce marine plastic pollution.

Duration
30 - 45 mins

Resources
- B.A.N. List 2.0 (See Appendix) and product chart (See resources, Pg 44)
- Miscellaneous plastic items such as a plastic bag, toothbrush, fork, straw, bottle cap, ruler, pen, candy wrapper, clothes pin/peg, hair comb (Optional: Use students' plastic items from Activity 4.1)
- Paper and pencils, pens, and/or markers for writing and drawing

Look!
Review the chart from the B.A.N. List 2.0 on the next page. This chart outlines the plastic materials and sustainable alternatives that could be used for the production of the top 20 products which have been identified as plastic pollution in the natural environment.

Recommended Videos:

Gyrecraft - Transforming Ocean Trash into Beautiful Art
by Studio Swine on National Geographic (Length: 5:00) https://youtu.be/wDrKlByGEsA

Plastic Kiln Innovation
by 5 Gyres (Length: 2:00) https://vimeo.com/173068317

How to Repurpose Plastic Bottles into EcoBricks
by Rappler and the Plastic Solution (Length: 3:00) https://youtu.be/vaJrkzQ43m4

Lush Uses Social Plastic
by The Plastic Bank (Length: 2:25) https://youtu.be/MIzknllOjTI

The Solution to Plastic Waste Pollution
by UPROXX & Full Cycle Bioplastics (Length 2:20) https://youtu.be/o_STBEU7ykI

1. Split group into small groups of 3 to 5 students and distribute writing materials to each group.

SAY:

For the next 20 minutes you are going to be engineers. You are going to redesign a plastic item of your choice using materials that are natural and biodegradable.

You can also redesign your item so it can be part of the circular economy, meaning its parts can be returned directly to the manufacturer to be refurbished or recycled into new products. Another option is to engineer a way that you can reduce the amount of plastic pollution in the ocean.

You can use your paper and pens to brainstorm and sketch out your ideas. Ask yourself the following questions:

- ***What is the problem? How can the design be improved?***
- ***What are the different approaches we can take to find a solution?***
- ***Should we redesign it or create something completely new?***
- ***Can we repurpose existing plastic waste in our design?***

2. Allow students to spread out a little bit so they can talk and share ideas.
3. After 20 - 30 minutes, bring the small groups back together to discuss present their innovation and explain why it is the best solution to the problem they identified.

Alternatives for Materials Used in the Top 20 Plastic Products Identified as Environmental Contaminants

MATERIALS IN THE TOP 20 PRODUCTS

PLASTIC PRODUCT	IN ENVIRONMENT COUNT	IN ENVIRONMENT %	LIKELY PLASTIC-TYPE (POLYMER)	BETTER ALTERNATIVES NOW	BEST ALTERNATIVES NOW
1 Food Wrappers (candy, chips, etc.)	350818.0	18.6	Several different plastics**	More work needed on bio-benign alternatives	Bulk purchasing of food in reusable containers
2 Bottle Caps (Plastic)	315488.1	16.7	Polypropylene (PP #5)	"Connect the Cap" technical fix available	Functional replacement with reusable bottles
3 Beverage Bottles (Plastic)	227018.0	12.0	Polyethylene terephthalate (PET #1)	Increase deposit to increase collection rates	Functional replacement with reusables
4 Bags (Plastic)	178144.0	9.4	Primarily Low-Density polyethylene (LDPE #4)	Natural, bio-based shopping bags (paper)	Functional replacement with reusable bags
5 Straws, Stirrers	142745.0	7.5	Polypropylene (PP #5)	Paper or wood straws/stirrers	Functional replacement with reusable straws/stirrers
6 Lids (Plastic)	97751.2	5.1	Polystyrene (PS #6)	More work needed on bio-benign alternatives	Functional replacement with reusable cups
7 Utensils	93829.0	4.9	Polystyrene (PS #6)	Natural, bio-based biodegradable utensils (bamboo/wood)	Functional replacement with reusable utensils
8 Cigarette Butts*	61341.7	3.2	Cellulose Acetate Fiber	Filter-less cigarettes	Plant-based biodegradable cigarette filters
9 Take Out/Away Containers (Foam)	60697.8	3.2	Polystyrene (PS #6)	Plant-based biodegradable take-out containers	Functional replacement with reusable take-out containers; work to change health codes to enable this change
10 Take Out/Away Containers (Plastic)	56788.6	3.0	Several different plastics**	Plant-based biodegradable take-out containers	Functional replacement with reusable containers ***
11 Cups, Plates (Plastic)	52943.9	2.8	(PS #6) & (PET #1)	Plant-based biodegradable cups	Functional replacement with reusable cups
12 Cigar Tips	50196.0	2.6	Polystyrene (PS #6)	Functional replacement with reusable cigar tips	Ban of smoking in public space
13 Cups, Plates (Foam)	49274.5	2.6	Polystyrene (PS #6)	Plant-based biodegradable cups	Functional replacement with reusable cups ***
14 Tobacco Packaging/Wrap	35185.8	1.8	Polypropylene or Polyethylene (#5 or #2)	Plant-based biodegradable alternatives	Natural bio-based materials, like cellulose
15 Balloons	30709.3	1.6	Latex or Mylar	Plant-based biodegradable alternatives	Cultural alternatives to balloon releases
16 Other Plastic Bottles	25395.6	1.3	Several different plastics**	Increase deposit to increase collection rates	Functional replacement with reusable bottles
17 Cigarette Lighters	22608.5	1.2	Polycarbonate (PC - #7)	See best alternative	Functional replacement with matches or refillable non-plastic lighters
18 Personal Care Products (condoms & tampon applicators)	16522.2	0.8	Several different plastics**	See best alternative	Natural bio-based materials
19 6-Pack Holders	9188.0	0.4	Low density polyethylene (LDPE #4)	Plant-based biodegradable alternatives	Paper box beverage holders
20 Diapers	6466.9	0.3	Several different plastics**	Plant-based biodegradable alternatives	Cloth diaper services when available

** Counts of cigarette butts were divided by 20 to represent packs rather than individual cigarettes.*
*** These products are made from several different types of plastic, and a full analysis for each product is not included here.*
**** In many cities, this will require new health codes to permit reusable containers in this context.*

Chart from B.A.N. (Better Alternatives Now) List 2.0

5 WATER SAMPLING & PLASTICS MONITORING

Photo: 5 Gyres

OBJECTIVES

In this unit, students will have the opportunity to use equipment on deck to deploy a scientific research device called a manta trawl. During the 30 minutes to an hour that a sample is being taken, instructors may choose to run an activity from one of the other units in this program or show several of the recommended videos.

NOTE: *Apart from Activity 5.2 which can be done independently, most of this unit relies on your ship having a 5 Gyres TrawlShare manta trawl on board.* Some instructions in this unit have been adapted from the original 5 Gyres TrawlShare Protocol.

DURATION

1 hour 30 minutes to 2 hours

15 - 45 mins to view primer videos
10 - 15 mins to prepare & launch trawl
30 mins - 1 hour for Activity 5.1
45 mins to collect & analyze sample
3o mins for Activity 5.2

ALIGNMENTS

Sail Training

teamwork, communication, critical thinking, environmental awareness, deploying and retrieving equipment using pulleys, lines, and davits/spinnaker boom

Ocean Literacy

5. The ocean supports a great diversity of life and ecosystems. A, E

6. The ocean and humans are inextricably interconnected. A, D, G

NGSS

SEP 3: Planning and carrying out investigations

SEP 4: Analyzing and interpreting data
SEP 5: Using mathematics and computational data

DCI - LS 2: Ecosystems: Interactions, energy, and dynamics

DCI - ESS 3: Earth and human activity

CCC 3: Scale, proportion, and quantity

KEY TERMS

zooplankton, microplastics, Beaufort Scale of Sea State, macroplastics, pelagic

RESOURCES

Printed Materials

- Beaufort Scale of Sea State
- Printed TrawlShare data sheet
- Printed TrawlShare graph paper
- Printed Plastic Observe data sheet

Supplies

- Operational davit or spinnaker boom
- 5 Gyres manta trawl with net
- Fitted PVC tube (included with trawl)
- Two hose clamps (included with trawl)
- Trawl “cod end” (mesh bag that fits onto the PVC tube at the end of the trawl net)
- Saltwater or freshwater hose ***or*** sea bucket
- Adjustable wrench/spanner
- Flathead screwdriver
- Baling wire
- 1mm mesh sieve/strainer
- Large metal or glass bowl
- Metal spoon
- Metal tweezers
- Wash bottle
- Handheld magnifying glass
- Ruler
- Clipboard
- Envelope
- Time keeping device
- Digital camera to record activities and sample
- *Optional:* Flow meter, binoculars, small scale

More information can be found at http://www.5gyres.org/trawlshare


Photo: 5 Gyres

INTRODUCTION

If possible, before beginning this unit and deploying manta trawl, have the students watch one or both of the recommended videos of the 5 Gyres research expeditions. An longer alternative is ***Smog of the Sea*** and could be shown the evening before the trawl sample activity.

TRAWL ASSEMBLY

Before using the 5 Gyres manta trawl for the first time you will need to assemble it. We recommend watching the TrawlShare Instructional Video (https://vimeo.com/210996851) and/or following these instructions carefully:

Attach the two "wings" to the body of the trawl using the bolts provided. Attach the fitted PVC tube and the cod end to the end of the net. One hose clamp connects the large net that's attached to the manta to the PVC tube. The other hose clamp connects the PVC tube to the cod end.

Best Practice: The seams of the cod end should be facing outwards, making the cod end appear to be "inside-out."

Make sure all bolts and screws throughout the trawl assembly are VERY tight because they can slip off easily when deployed. Plan to tighten them again before each deployment. Attach the bridle to the body of the manta using the two small shackles provided. It is recommended that you "lock" the shackles in place with baling wire. Connect the bridle to a line running from a davit or boom on the side of the ship.

Option: This is a good opportunity to practice knot tying with students. A bowline or figure 8 follow through knot to connect the bridle to the line should be sufficient.

RECOMMENDED VIDEOS

TrawlShare Instructional Video
by 5 Gyres Institute (Length 3:20)
https://vimeo.com/210996851

5 Gyres North Atlantic Gyre Expedition
by 5 Gyres Institute (Length 6:00)
https://www.youtube.com/watch?v=O9QJvMntn0I

5 Gyres South Atlantic Research Voyage
by 5 Gyres Institute (Length 8:00)
https://www.youtube.com/watch?v=i9Nz3vy6XjY

Smog of the Sea
by Ian Cheney (Length 30:00)
https://www.thesmogofthesea.com/watch-film/

How Much Plastic Do You Eat?
by BBC Earth Lab (Length 12:16)
https://www.youtube.com/watch?v=veMdowmPSbw

Ocean Drifters
by Plymouth University (Length 16:30)
https://www.youtube.com/watch?v=ziGtmjiUlJQ

Scientific Research

More information can be found on the 5 Gyres Science to Solutions Research Hub:
http://www.5gyres.org/science-research-hub


Photo: Erika Delemarre

DATA RECORDING

Before deploying the trawl, instruct several students to work together to use the TrawlShare data sheet to ***record all information*** for the "Start Data" and "Sea and Boat Conditions." Latitute and longitute, sea state, boat speed and direction, wind direction and speed ***must*** be recorded at deployment ***and*** recovery. The data sheet and Beaufort Scale can be found on pages 49 and 50. If possible, use the onboard knot meter to determine boat speed. If you are using an optional flow meter, attach the flow meter to the manta trawl so that it falls in the center of the mouth of the trawl (not below the trawl). If taking sequential samples, please number each sample separately and use separate data sheets.

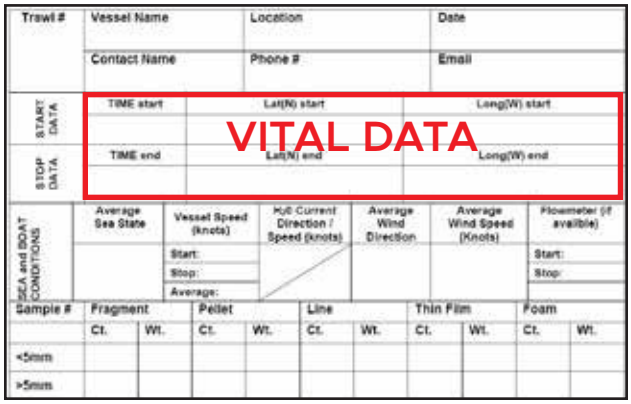


Photo: Erika Delemarre

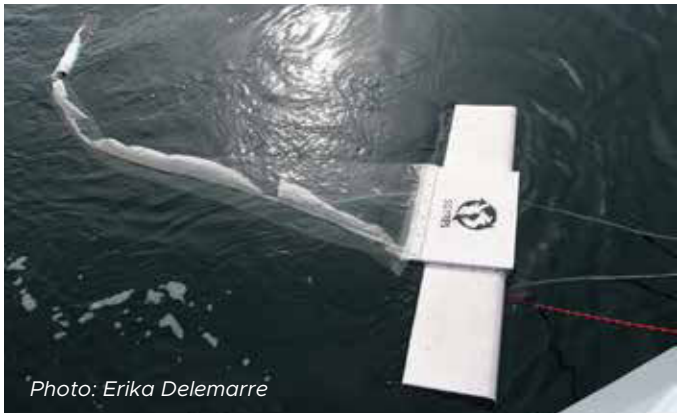


Photo: Erika Delemarre

TRAWL DEPLOYMENT

Deploying the trawl outside of the wake zone will create the most ideal conditions for taking a sample. Turbulence inside the wake zone can push floating plastic deep underwater. A spinnaker pole or a davit can be used to position the trawl tow line away from the side of the boat. This will also allow students to observe the trawl and net performance while it's in the water.

Two crew members should be on hand: one controlling the tow line and preparing it for a controlled run. The other crew member should be holding the body of the trawl with the assistance of a student. Another student can gather the net and the cod end. The crew member and two students should stand along the rail, aft of the davit to deploy the trawl. Ensure that the bridle and lines are untangled from any equipment on deck and ready to be released in a controlled run. Request permission from the captain or deck officer before deployment.

Under direction of the crew member, the student holding the net and cod end will toss it out, away from the ship and into the water first, followed shortly by the crew member and assisting student who will launch the trawl by gently tossing it out and away from the ship into the water. The manta trawl needs to land correctly "belly down" in the water with the 5 Gyres logo visible on the top. The student(s) recording the trawl data should mark the time the trawl enters the water.

Once in the water, if the trawl is bouncing off the surface or diving below water, adjust the length of the tow line which will change the angle of the front of the trawl in the water. Adjustments to vessel speed can also help the trawl sit correctly in the water while taking the sample.

TRAWL SPEED & DIRECTION

It is best to maintain a steady linear course while towing the manta trawl to avoid the tow line coming under the vessel. Keep this in mind if your planned course requires any tacking or wearing/jibing. The vessel should be sailing at < 3 knots while towing the manta trawl. Again, if the trawl is leaping out of the water or plowing beneath the waves, then you're going too fast. Watch the trawl and adjust accordingly. Remember not to trawl in Sea State 4 or above. You need to watch the sea state and should consider recovering the trawl if winds increase above 16 knots. The trawl should not bounce or dip below the surface. It should travel smoothly across the water surface to capture the ideal sample.

TRAWL SAMPLE DURATION

The manta trawl should be deployed for 30 – 60 minutes, ideally in a straight transect. While the trawl is deployed frequently check it visually to monitor the trawl performance, entanglement with large debris, quantity of debris, and security of the tow lines. You want to avoid letting the cod end on the back of the trawl fill with zooplankton, which can happen when trawling at dusk when zooplankton migrate to the surface.

ACTIVITY 5.1 - MIX & MATCH

During the 30 - 60 minutes the trawl is deployed, you can opt for the participants do an activity from another unit or watch several of the recommended videos. If so, please ensure a dedicated crew member is on deck, monitoring the trawl. The short film ***Smog of the Sea*** is 30 minutes long and would fill this time block perfectly. It would also be ideal to show the students the short films about the 5 Gyres expeditions if they haven't already.

Photo: Erika Delemarre

RECOMMENDED VIDEOS

5 Gyres North Atlantic Gyre Expedition
by 5 Gyres Institute (Length 6:00)

5 Gyres South Atlantic Research Voyage
by 5 Gyres Institute (Length 8:00)

Smog of the Sea
by Ian Cheney (Length 30:00)

RECOVERING THE TRAWL

Two crew members and several assisting students are required to recover and secure trawl. One crew on the tow line at the davit, and another crew member with assisting students to catch the trawl and bring it back on board. The moment the trawl exits the water, the students recording the trawl data should record the time again and the other "Stop Data" on the data sheet. ***It is very important to record the most accurate latitude and longitude at this point and ensure the entire data sheet is completed.*** Once the trawl is back on deck, students can work together to process the sample.

Beaufort Scale of Sea State					
Beaufort Number or Force	Wind Speed			Description	Effects on Ocean Surface
	mph	km/hr	knots		
0	< 1	< 1	< 1	**Calm**	Water is mirror-like.
1	1 - 3 mph	1 - 5 kph	1 - 3 knots	**Light Air**	Small ripples appear on water surface.
2	4 - 7 mph	6 - 11 kph	4 - 6 knots	**Light Breeze**	Small wavelets develop, crests are glassy.
3	8 - 12 mph	12 - 19 kph	7 - 10 knots	**Gentle Breeze**	Large wavelets, crests start to break, some whitecaps.
4	13 - 18 mph	20 - 28 kph	11 - 16 knots	**Moderate Breeze**	Small waves develop, becoming longer, whitecaps.
5	19 - 24 mph	29 - 38 kph	17 - 21 knots	**Fresh Breeze**	White crested wavelets (whitecaps) form, some spray.
6	25 - 31 mph	39 - 49 kph	22 - 27 knots	**Strong Breeze**	Larger waves form, whitecaps prevalent, spray.
7	32 - 38 mph	50 - 61 kph	28 - 33 knots	**Moderate or Near Gale**	Larger waves develop, white foam from breaking waves begins to be blown.
8	39 - 46 mph	62 - 74 kph	34 - 40 knots	**Gale or Fresh Gale**	Moderately large waves with blown foam.
9	47 - 54 mph	75 - 88 kph	41 - 47 knots	**Strong Gale**	High waves (6 meters), rolling seas, dense foam, Blowing spray reduces visibility.
10	55 - 63 mph	89 - 102 kph	48 - 55 knots	**Whole Gale or Storm**	Large waves (6-9 meters), overhanging crests, sea becomes white with foam, heavy rolling, reduced visibility.
11	64 - 72 mph	103 - 117 kph	56 - 63 knots	**Violent Storm**	Large waves (9-14 meters), white foam, visibility further reduced.
12	73+ mph	118+ kph	64+ knots	**Hurricane**	Large waves over 14 meters, air filled with foam, sea white with foam and driving spray, little visibility.

Chart Design: Erika Delemarre

5 Gyres TrawlShare Data Sheet

ORGANIZATION: EMAIL:

CONTACT NAME: PHONE:

Trawl #	Vessel Name	Location	Date
	Contact Name	Phone #	Email

START DATA	TIME start	Lat(N) start	Long(W) start
STOP DATA	TIME end	Lat(N) end	Long(W) end

SEA and BOAT CONDITIONS	Average Sea State	Vessel Speed (knots)	H_20 Current Direction / Speed (knots)	Average Wind Direction	Average Wind Speed (Knots)	Flowmeter (if availble)
		Start:				Start:
		Stop:				Stop:
		Average:				

Sample #	Fragment		Pellet		Line		Thin Film		Foam	
	Ct.	Wt.	Ct.	Wt.	Ct.	Wt.	Ct.	Wt.	Ct.	Wt.
<5mm										
>5mm										

NOTES:

ORGANIZATION: EMAIL:

CONTACT NAME: PHONE:

1. Write Trawl number here _____.
2. Place all plastic particles on this paper and photograph it.
3. Count the particles bigger than a box, and those smaller.
4. Dry sample on the paper and fold the whole thing into an envelope.

ANALYZING THE SAMPLE

RESOURCES

See list at beginning of this unit.

Sample Preparation

1. Instruct students to move the manta trawl to an area that can be reached by a water hose. (Option: Use sea bucket to collect water.) One student holds the manta trawl up at shoulder height while two students stretch the net down the length of the deck.

2. Another student takes a hose and starting at the manta trawl, sprays the ***OUTSIDE*** of the net, working their way all the way down to the cod end. This is meant to dislodge any material that may be caught inside the large net. Spraying from the ***OUTSIDE*** of the net, wash all material down through the PVC tube and into mesh cod end.

3. Using a flat head screw driver, loosen the hose clamp that secures the cod end onto the PVC tube.

4. Turning the cod end inside out, dump the contents of the sample into the 1mm sieve.

5. Use the spoon and wash bottle to clean the cod end entirely to get the entire sample into the sieve. A thorough rinse will ensure all plastic particles are included.

Sample Sorting

1. Instruct the students to use tweezers to remove all recognizable pieces of plastic from the 1mm sieve and transfer all plastic materials into a glass bowl or directly onto the provided graph paper.

2. Encourage students to use the magnifying glass to look closely at the surface of the particles to make sure they are plastic. You may also use the tweezers to see if they are solid (plastic) or soft (usually not plastic).

3. Lay all plastic pieces on graph paper (if time allows, let it dry someplace undisturbed). Using the ruler or lines on the graph paper, separate plastic pieces into size and type categories:

a. Size categories:
   (particles > 5mm), (particles < 5mm)
b. Type categories:
   Fragment, Film, Foam, Pellet, Line

4. Count number of plastics for each category and record on data sheet.

5. If available, prepare scale for weighing sample. Tare the scale with the container you are using. Take weight in grams. Record weight next to the count on the data sheet.

6. Using a digital camera, photograph the sample spread out on the graph paper. Make sure the sample number is clear in photograph. This is a very important step for later identification of shape, size, color, and type of plastic.

7. Using a digital camera, photograph the completed data sheet.

8. Enter all data into the Microsoft Excel sheet provided by 5 Gryes.

Photo: Erika Delemarre

DISCUSSION


Photo: 5 Gyres

ASK: ***What types of items are in the sample? Are they animals, plants, algae, plastic, or unidentifiable?***

Critical Thinking

Encourage students to pay attention to shape, size, color, and texture. What might these items be doing on the surface of the ocean, far from shore?

Guide the Discussion

Trawl samples often contain a lot of ***zooplankton***, small pelagic animals which play a crucial role in the marine food web. ***Micro-*** and ***macroplastic*** items can come in all shapes, sizes and colors. Small, spongy, white balls or irregular-shaped specks are often expanded polystyrene, or more commonly known as Styrofoam. Clear, gelatinous material is often plankton while clearer, crunchy material can be plastic film or plant fiber.


Photo: Max Planet

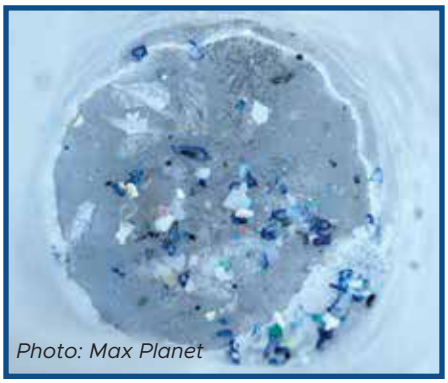


Photo: Max Planet


Photo: 5 Gyres

ASK: ***If there is plastic present, is it identifiable? What could this plastic have been used for before it became marine plastic pollution?***

Critical Thinking

If only microplastics are present, look at the color and thickness. Could these items have been a bottle cap or a food wrapper? The sole of a shoe or pen cap? A cup lid or a fishing float?

Guide the Discussion

Instruct students to carefully sort through the sample for plastic film and fibers, fishing line, white or colorful microplastics, white or yellowish polystyrene (Styrofoam), and/or different colored nurdles which are the small lentil-shaped “raw” plastic material that is used in the manufacturing of plastic items.


Photo: 5 Gyres

DISCUSSION

ASK: ***How might these plastics be impacting the plankton floating around it?***

Critical Thinking

Could they be living on it? Could they be ingesting it?

Guide the Discussion

Floating plastic can become habitat for everything from the tiniest microbes to small fish, crustaceans, and more! Many ***pelagic*** (open ocean) species including plankton have been observed feeding on plastic, but it is definitely not a natural or nutritious food!

ASK: ***How might these plastics impact larger animals like fish, whales, or humans?***

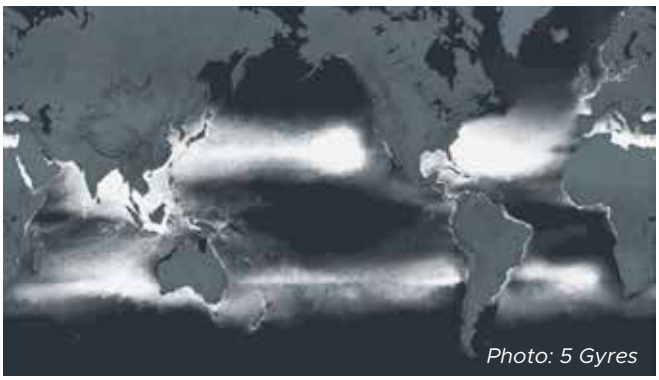
Critical Thinking

Encourage students to consider how consumption of plastic could impact the health and well-being of animals. What would it do to their digestive tracts? Is plastic nutricious?

ASK: ***What could this sample tell us about plastic distribution in the ocean? Do you think this could be a good representation of how much is out here?***

Critical Thinking

Depending on the amount of plastic that comes up in the sample, have students think about whether or not it is representative to the plastic distribution in different areas of the ocean.



White areas depict higher concentrations of plastic.

Guide the Discussion

The amount of plastic pollution in the ocean varies by location. More has been documented near coastlines and in the oceanic gyres. In 2014, international scientists collaborated with 5 Gyres to publish the first ***Global Estimate of Marine Plastic Pollution, determining that 5.25 trillion particles of "plastic smog" surface plastic pollution—weighing in at 269,000 tons—pollute our oceans worldwide*** (Eriksen et al., 2014). The estimate was informed in part by TrawlShare research samples like the one we just did!

ASK: ***How do you think the data we collected today could help solve the problem of marine plastic pollution? Do you think it will make a difference?***

Critical Thinking

Who do they think should know about our findings? How can scientific data make a difference in the way the world works?

Guide the Discussion

The TrawlShare data collected by "citizen scientists" around the world is used by 5 Gyres Institute to educate and inform international policymakers, gobal corporations, and the general public around the world. Our contribution will help 5 Gyres solve the problem of marine plastic pollution by providing vital data from our big, blue backyard.

Recommended Videos:

How Much Plastic Do You Eat? by BBC Earth Lab (Length 12:16)

Ocean Drifters by Plymouth University (Length 16:30)

CONTRIBUTING YOUR DATA TO 5 GYRES RESEARCH

The most important part of taking a sample with the 5 Gyres manta trawl is ensuring that the data you and your students collect gets back to 5 Gyres Institute. The data you provide will directly contribute to our research and the global estimate of plastic pollution in the ocean. Please follow the instructions below to ensure that the sample and all data are documented and returned.

Storing the Sample

1. Allow the sample to air dry in a protected area below deck before storing it.

2. Once it is dry, fold the sample inside of its graph paper and put it in an envelope with the sample data sheet.

3. Label the envelope with the sample number, date, time, latitude and longitude, and ship name. It is very important to keep the samples separate. You will need one envelope, one piece of graph paper, and one data sheet for each sample.

Sending the Sample to 5 Gyres

4. Email the following information to carolynn@5gyres.org:

   a. Send a digital photograph of plastic pieces on graph paper labeled with the sample number.
   b. Send a digital photograph of the data sheet.
   c. Send Microsoft Excel sheet with your data filled in.
   d. Send any interesting photographs of trawl deployment, ship, recovery, and anything else you would like to share with 5 Gyres. Make sure to explain where the photograph was taken. 5 Gyres may feature your photos on our web site, social media, or printed materials.

5. Once you have several samples collected, gather the envelopes into a larger envelope or package and mail it to 5 Gyres Institute. If your sailing vessel is based outside of the United States, please try to send your samples in at least every three or four months.

   a. Each sample should have a complete data sheet, graph paper, and the plastic sample. Please make sure you include your contact information at the top of all of the data sheets. We want to keep in touch in case we have questions about the samples and to highlight you on 5 Gyres TrawlShare social media.

   b. Send your envelopes of samples to:

5 Gyres Institute
c/o TrawlShare Program
5792 West Jefferson Blvd
Los Angeles, CA 90016
USA

ACTIVITY 5.2 - MONITORING MACROPLASTICS

This activity can be completed without a 5 Gyres manta trawl and can easily be used to fill free time between other sailing activities. It is recommended that this activity is done during calm seas below a Beaufort Force 4 (0-16 knot winds). Participants will collect visual data on microplastic pollution while the ship is sailing. This program empowers volunteers to collect important data that 5 Gyres will use to monitor global and regional trends in plastic pollution.

Duration

30 minutes

Resources

- Printed 5 Gyres Plastic Observe data sheet
- Pencil and clipboard (or something rigid to write on)
- Time keeping device
- Optional: Binoculars
- Recommended: Sun protection and/or appropriate weather gear for being on deck for 30 minutes.

1. Select a group of 2 to 5 students to work on this together. One or two student(s) should act as the recorder and be in charge of the data sheet while the other student(s) are observers. Option: Organize two separate groups of students to observe from each side of the ship.

2. Instruct students to record all required data about the voyage, ship, current location, Beaufort Scale sea state, etc. ***before*** beginning the observation activity. (See Beaufort Scale on the next page.)

3. After they have collected the necessary information from the chart house, station the group at the railing at midships. Optional: Provide them with binoculars.

4. Instruct students to focus their gaze 20 meters out to sea, perpendicular to the ship. They will scan an arc of 90 degrees from midships to the bow and back.

5. Students should record everything larger than a bottle cap that they observe. More distant objects may be recorded if detected.

6. Use the coded letters and numbers from the key on the data sheet to record observations of each object in the appropriate column on the data sheet.

DISCUSSION

ASK:

- ***What types of items were observed?***
- ***If there was plastic present, is it clearly identifiable?***
- ***What could this plastic have been used for before it turned into ocean pollution?***
- ***How might these plastics be impacting the marine life that lives in the pelagic (open ocean) environment?***

Critical Thinking

Could the animals be ingesting it? Could they be living on it? Could they be entangled by it?

Guide the Discussion

Encourage students to consider marine animals of all sizes at all trophic levels, from microscopic plankton and small fish to sea birds, sharks, and large marine mammals. Plastic pollution impacts the health and wellbeing of different types of animals generally through ingestion and entanglement. Ingestion of plastic items can distrupt and block the digestive track, causing an animal to slowly starve. Entanglement can restrict animals from being able to breathe, feed, reproduce, care for their young, and more.

5 Gyres Plastic Observe Data Sheet

ORGANIZATION: EMAIL:

CONTACT NAME: PHONE:

VESSEL NAME & EXPEDITION LOCATION			DATE
OBSERVER HEIGHT FROM SURFACE	WEATHER	BOAT SPEED	WIND SPEED
HEADING in DEGREES	SEA STATE (BEAUFORT SCALE)	NUMBER OF OBSERVERS	

	TIME start	Lat(N) start	Long(W) start
START DATA			
	TIME end	**Lat(N) end**	**Long(W) end**
STOP DATA			

Sea State	Current Speed	Current Direction	Distance by knot meter	Wind Speed

SIZE	a=<5 cm	DISTANCE FROM SHIP	0=0-5 m	COLOR	W = WHITE/TRANSLUCENT
	b=5-15 cm		1=5-10 m		R = RED/ORANGE
	c=15-30 cm		2=10-20 m		Y = YELLOW
	d=30-60 cm		3=20-30 m		G = GREEN
BUOYANCY	1 = protruding above surface		4=30-50 m		B = BLUE
	0 = at the surface		5=50-100 m		T = TAN/BROWN
	-1 = below the surface		6=>100 m		BK = BLACK/GREY

NOTES:

5 Gyres Plastic Observe Data Sheet

ORGANIZATION: ______________________ EMAIL: ______________________

CONTACT NAME: ______________________ PHONE: ______________________

	Sheeting and Tarps	Plastic Bags	Bottles (Beverage)	Bucket	Styrofoam	Other plastic items	Glass bottle	Glass light bulbs and fluorescent tubes	Other (Describe)	Buoys/Floats	Misc. Line	Misc. Nets	Other Fishing Gear	Plastic Fragment
SIZE														
DISTANCE														
BUOYANCY														
COLOR														
SIZE														
DISTANCE														
BUOYANCY														
COLOR														
SIZE														
DISTANCE														
BUOYANCY														
COLOR														
SIZE														
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BUOYANCY														
COLOR														
SIZE														
DISTANCE														
BUOYANCY														
COLOR														

6 LEADERSHIP: BE THE CHANGE

Photo: Wikimedia Commons

OBJECTIVES

In this unit, students will have the opportunity to apply what they have learned in the 5 Gyres TrawlShare STEM to Stern program and take action. They will be given the opportunity to design a communications campaign about marine plastic pollutions to deliver in their schools or communities following their voyage. An additional activity will guide them in writing a letter to a corporation or policymaker to share what they have learned and request change in procedures or policies.

NOTE: This unit relies on the students having a general understanding of marine plastic pollution. It is suggested that you deliver this unit following one of the other units in the program.

DURATION

30 minutes to 2 hours
30 mins - 1 hour for Activity 6.1
30 mins - 1 hour for Activity 6.2

ALIGNMENTS

Sail Training

sense of responsibility and purpose, leadership, effective communication, community

Ocean Literacy

6. The ocean and humans are inextricably interconnected. D, G

NGSS

SEP 8: Obtaining, evaluating, and communicating information

DCI - ESS 3: Earth and human activity

CCC 2: Cause and effect, mechanism and explanation

RESOURCES

Printed Materials

- (2) Infographics from Break Free From Plastic
- ***Outline of a Circular Economy*** (Ellen MacArthur Foundation)
- ***B.A.N. List 2.0*** (See Appendix)

Supplies

- Paper, pens, pencils for writing and drawing
- Optional: Envelopes and postage stamps

Scientific Research

More information can be found on the 5 Gyres Science to Solutions Research Hub: http://www.5gyres.org/science-research-hub

RECOMMENDED VIDEOS

How Much Plastic is in the Ocean?
by PBS It's OK To Be Smart (Length: 5:00)
https://youtu.be/YFZS3Vh4lfI

What Can We Do About Marine Debris
by NOAA's Ocean Today (Length 2:00)
https://youtu.be/XuhdmDc4L1Y

Our campaign to ban plastic bags in Bali
by Melati and Isabel Wijsen on TED
(Length 11:00) https://youtu.be/P8GCjrDWWUM

Fueling Plastics
by Center for Environmental Law (Length 2:15)
https://youtu.be/U0EmJ6wsyo4

Most Polluting Brands
by Break Free From Plastic (Length 2:00)
https://www.breakfreefromplastic.org/wp-content/uploads/2018/01/bfffp.mp4

A brilliant solution to clean up our environment
by Boomerang Alliance (Length 2:30)
https://youtu.be/58rvQ60ae2s

Plastics in the Pacific - KQED QUEST
by KQED Science (Length 10:00)
https://youtu.be/g9fEbqxyNl0

KEY TERMS

corporate responsibility, policy, target audience

ACTIVITY 6.1 - RISE UP!

In this activity, students will work in small groups to apply their knowledge about marine plastic pollution to create an action plan or communications campaign to deliver in their schools or communities at home. It is recommended that you prepare a short list of names and titles of local or regional government officials/policy makers to make this activity truly effective.

Duration

30 mins - 1 hr.

Resources

- Infographics from Break Free From Plastic (Pgs 63-64)
- Outline of a Circular Economy (Pg 65)
- Paper, pens, pencils

Photo: Break Free From Plastic

Recommended Primer Videos:

How Much Plastic is in the Ocean?
by PBS It's OK To Be Smart (Length: 5:00)
https://youtu.be/YFZS3Vh4lfI

What Can We Do About Marine Debris
by NOAA's Ocean Today (Length 2:00)
https://youtu.be/XuhdmDc4L1Y

Our campaign to ban plastic bags in Bali
by Melati and Isabel Wijsen on TED
(Length 11:00) https://youtu.be/P8GCjrDWWUM

SAY:

We have learned about the problems posed by marine plastic pollution and how it can negatively impact our ocean, marine wildlife, and us. Now we're going to turn our knowledge into action by working together to spread awareness in our schools and communities.

1. Split students into small groups of 2 to 5 people. Distribute writing materials.
2. Take a few minutes to review the three diagrams (see resources, Pgs 63-65) with students.
3. Instruct students to spend 5 minutes brainstorms and sketching out ideas for projects or a messaging campaign that could help reduce plastic waste in their communities. At the end of the 5 minutes they will need to have chosen their favorite idea.
4. Once students have picked their project, slowly read the following questions one by one, providing a few minutes after each question to allow them time to discuss and take note of their answers on paper:
   a. ***What is your core message? Is it clear and direct?***
   b. ***What materials, supplies, or tools do you need to execute your project?***
   c. ***Who is your target audience for your project or campaign?***
   d. ***Do your want to inspire your target audience to change their behavior? To volunteer? To donate time or money? Be specific.***
   e. ***What obstacles stand in the way of you achieving your goals? (ie. Do your need to find funding? Do you need to get special approval from school officials or community leaders?)***
   f. ***What is your timeline? (i.e. When is your deadline to achieve your goal? Are there any clear milestones along the way?)***
   g. ***How will you measure your success? (i.e. How do you know your program worked?)***
5. Allow the groups an additional 5 minutes to discuss and refine their answers.
6. Finish this activity by allowing groups to take turns presenting their project ideas with each other.

ACTIVITY 6.2 - LOUD & CLEAR!

This activity will allow students to work independently and practice communicating through writing. They will express what they have learned about marine plastic pollution to either: 1. The head of a corporation that produces plastic items; or 2. A local community leader or policymaker who can influence the laws governing the sale or distribution, the use, and the waste management of plastics. This activity is inspired by portions of Algalita's Integrated Plastic Pollution Curriculum (Ballent et al., 2018).

Duration

30 mins - 1 hr.

Resources

- Infographics from Break Free From Plastic (Pgs 63-64)
- Outline of a Circular Economy (Pg 65)
- Paper and pencils, pens, and/or markers for writing and drawing
- Envelopes and postage stamps

Recommended Primer Videos:

Fueling Plastics
by Center for Environmental Law
(Length 2:15)
https://youtu.be/U0EmJ6wsyo4

A brilliant solution to clean up our environment
by Boomerang Alliance
(Length 2:30)
https://youtu.be/58rvQ60ae2s

Most Polluting Brands
by Break Free From Plastic
(Length 2:00)
https://www.breakfreefromplastic.org/wp-content/uploads/2018/01/bfffp.mp4

INTRODUCTION

We have learned about the problems posed by marine plastic pollution and how it can negatively impact our ocean, marine wildlife, and us. We can solve this problem in many ways through the individual actions we take and choices we make. It's also important to recognize that government ***policy*** change can have widespread impacts in our local communities and in nations around the world. Local companies and international corporations must be held accountable for producing wasteful plastic products that are becoming marine plastic pollution. As consumers, we can demand this ***corporate responsibility***.

Photo: Erika Delemarre

SAY: ***We are going to take a few minutes to independently write letters to a government or business leader of our choice. Maybe it is the mayor or council member of your city or town, your governor or member of parliament, or maybe it's your president or prime minister. You could also choose to write a letter to the leader of a corporation that you feel is producing plastic products that turn into marine plastic pollution or even a local restaurant owner whose business creates unneccessary amounts of waste. It is OK if you don't know the individual's names; you can open your letter with a general greeting such as "Dear community leader," or "Dear business leader."***

Activity 6.2 Continued...

1. Distribute two sheets of paper and pens or pencils to the students.

2. Encourage students to use one piece of paper to outline their ideas and what they would like to say in their letter before writing a final draft on the second sheet.

3. Suggest the students include:

   a. An introduction of themselves, including their name, age, and where they are from.

   b. Briefly describe why they are personally concerned about marine plastic pollution.

   c. Include a clear and definitive "Ask" to the community leader or business person including what they want them to do and why taking action is so important.

   d. Think about their perspective and give them good reason to consider your request.

   e. Thank recipient for taking the time to read the letter and consider this request.

   f. Their printed name and a signature.

4. Participants can also express their ideas artistically through a drawing, poem, or diagram.

3. If envelopes and postage stamps are available to the students, have them fold their letters and place them in the envelopes. On the envelope, make note in pencil for which policymaker or business leader the letter should go to.

   a. Students can take the letters home with them where they can later look up the correct address and post the letter.

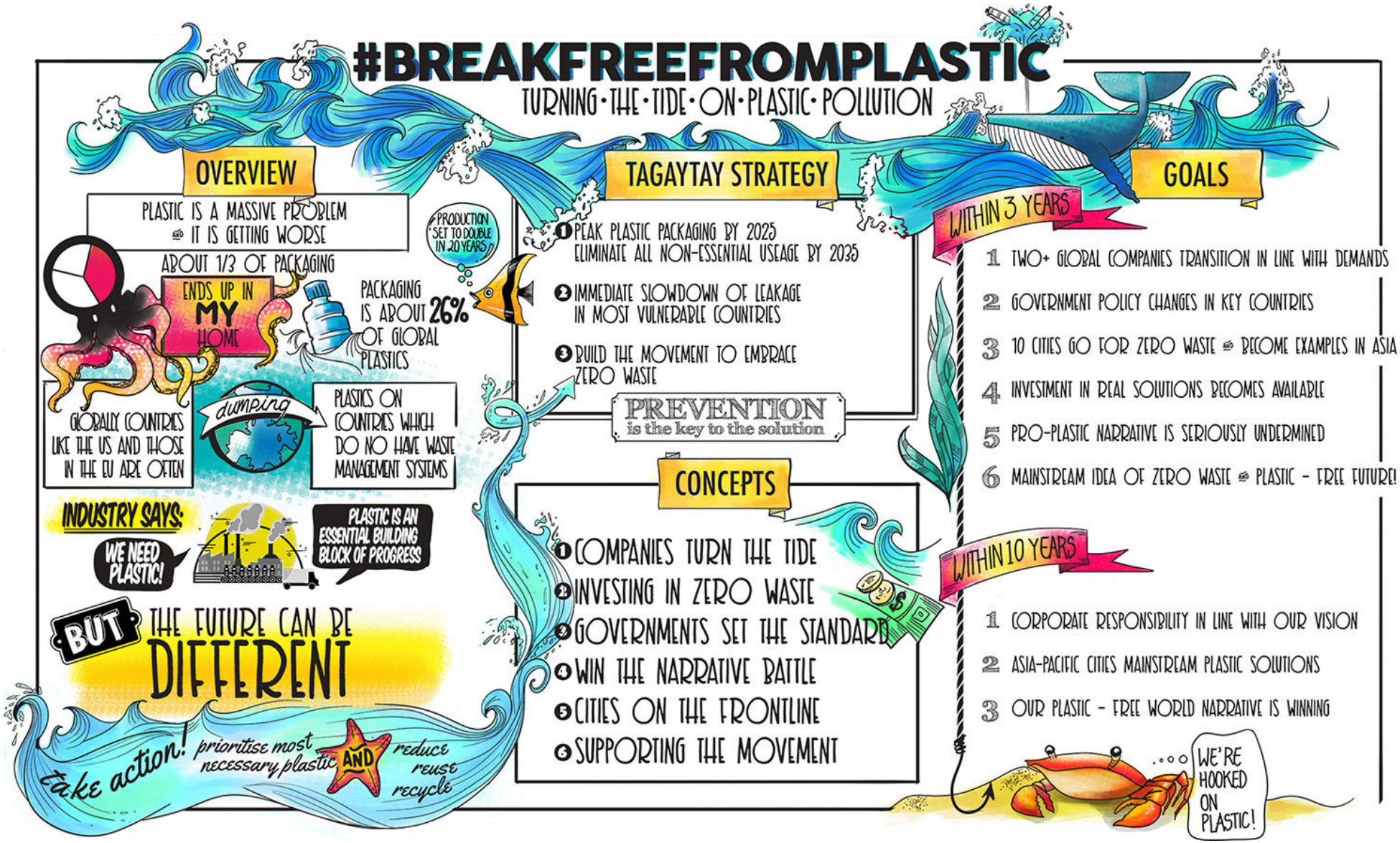
   b. Crew or support staff can collect the envelopes then look up the addresses and post the letters once back in port.

Recommended Video:

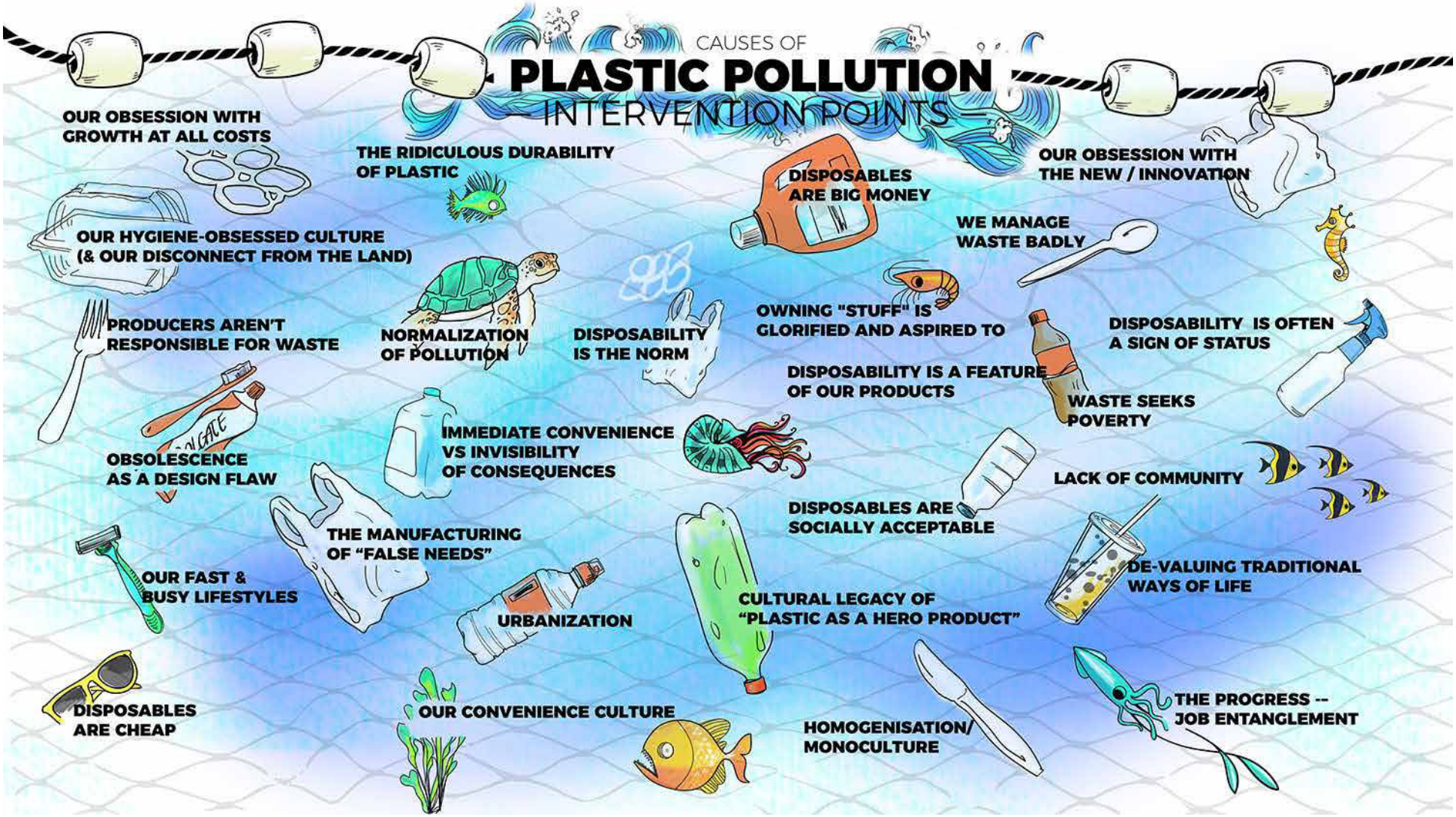
Plastics in the Pacific - KQED QUEST
by KQED Science (Length 10:00)
https://youtu.be/g9fEbqxyNl0

Teenagers from around the world convened for Algalita's 2018 Plastic Ocean Pollution Solutions youth conference.

Photo: Erika Delemarre



Infographic: Break Free From Plastic



Infographic: Break Free From Plastic

OUTLINE OF A CIRCULAR ECONOMY

PRINCIPLE 1

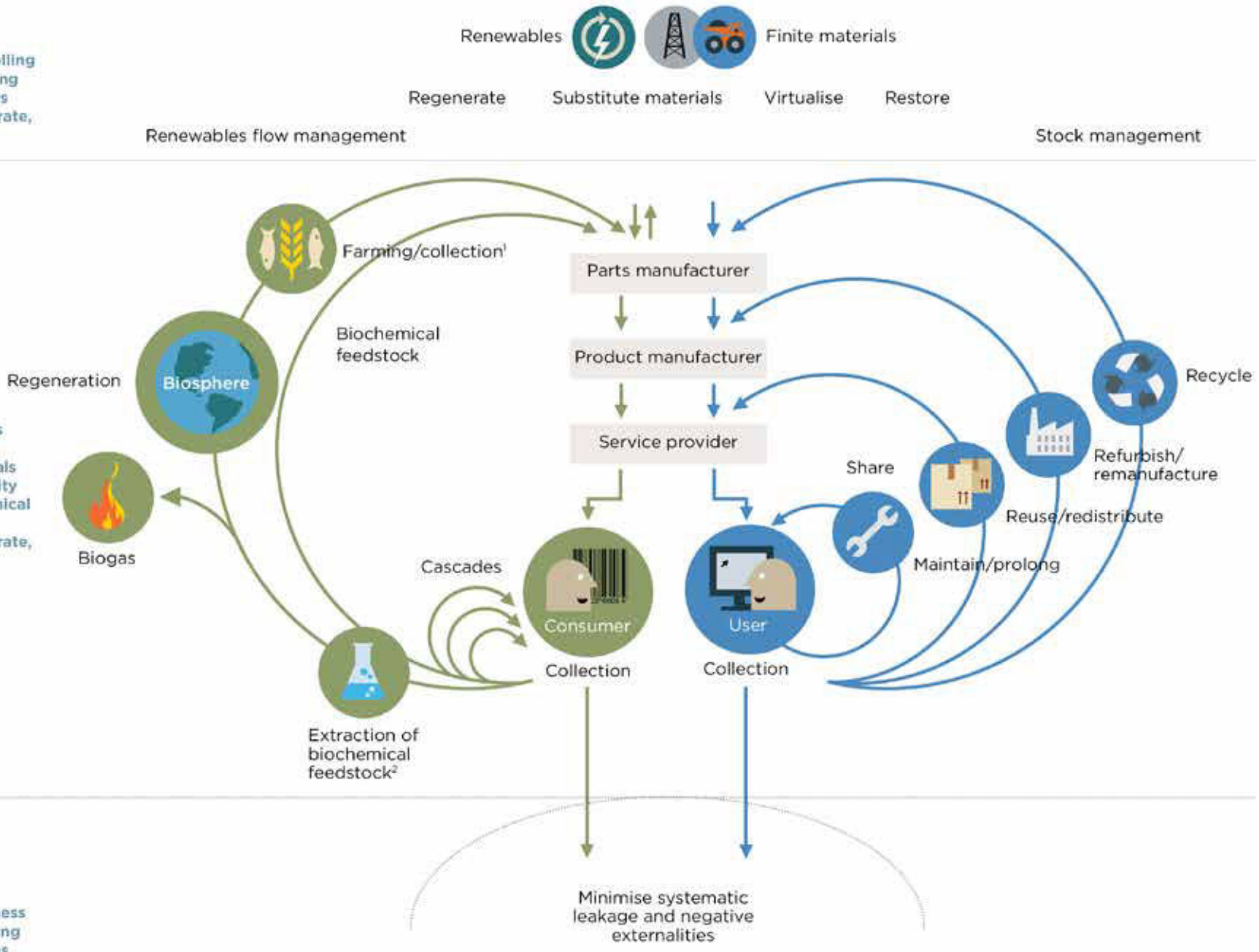
Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows
ReSOLVE levers: regenerate, virtualise, exchange

PRINCIPLE 2

Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles
ReSOLVE levers: regenerate, share, optimise, loop

PRINCIPLE 3

Foster system effectiveness by revealing and designing out negative externalities
All ReSOLVE levers



1. Hunting and fishing
2. Can take both post-harvest and post-consumer waste as an input

Source: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C).

APPENDICES

Photo: 5 Gyres

GLOSSARY OF KEY TERMS


Photo: NOAA

atmosphere* [at-muh s-feer] *noun* - The envelope of gases surrounding the earth or another planet.

bathymetry [buh-thim-i-tree] *noun* - The measurement of depth of water in oceans, seas, or lakes; the data derived from such measurement, especially as compiled in a topographic map

Beaufort Scale of Sea State [boh-fert skeyl] *noun* - A scale of wind speed based on a visual estimation of the wind's effects, ranging from force 0 (less than 1 knot or 1 km/h, 'calm') to force 12 (64 knots or 118 km/h and above, 'hurricane'); a scale of the states of sea created by winds of these various forces up to and including force 10.

bioaccumulation [bahy-oh-uh-kyoo-myuh-ley-shuh n] *noun* - (of a substance) become concentrated inside the bodies of living things.

biodegrade [bahy-oh-di-greyd] *verb* - (of a substance or object) be decomposed by bacteria or other living organisms.

biomagnification [bahy-oh-mag-nuh-fi-key-shuh n] *noun* - The concentration of toxins in an organism as a result of its ingesting other plants or animals in which the toxins are more widely disbursed.

bioplastic [bahy-oh-plas-tik] *noun* - A type of biodegradable plastic derived from biological substances rather than from petroleum.

circular economy [sur-kyuh-ler ih-kon-uh-mee] *noun* - A circular economy should see a departure from the current "take, make and dispose" approach that underlines much of modern civilization. Instead, in the circular economy model, durable goods would be designed so that they could be repaired rather than replaced and biological materials would be managed so that they could be returned to the biosphere without contamination *(Financial Times, 2018).*

composition [kom-puh-zish-uh n] *noun* - The nature of something's ingredients or constituents; the way in which a whole or mixture is made up.

compostable/compost [kom-pohst] *adjective/noun* - The ability to decay into natural organic material.

Coriolis Effect [kawr-ee-oh-lis ih-fekt] *noun* - An effect whereby a mass moving in a rotating system experiences a force (the Coriolis force) acting perpendicular to the direction of motion and to the axis of rotation. On the earth, the effect tends to deflect moving objects to the right in the northern hemisphere and to the left in the southern and is important in the formation of cyclonic weather systems.

corporate responsibility [kawr-per-it ri-spon-suh-bil-i-tee] *noun* - Corporations have a responsibility to those groups and individuals that they can affect, i.e., its stakeholders, and to society at large. Stakeholders are usually defined as customers, suppliers, employees, communities and shareholders or other financiers. The responsibility to society at large may well be identical with the responsibility to its various communities. Many have suggested that corporations have a special "social responsibility" over and above its business purpose. In any case corporate responsibility consists of earning a license to operate by creating value for stakeholders, including shareholders, and society. Corporate responsibility includes being consistent with

**All definitions from English Oxford Dictionary unless otherwise noted.*

ethical principles and conduct such as honesty, integrity and respect for others. By voluntarily accepting responsibility for its actions corporations earn their license to operate in society *(Financial Times, 2018).*

current
[kur-uh nt] *noun* - Coherent streams of water moving through the ocean and include both long, permanent features such as the Gulf Stream, as well as smaller, episodic flows in both coastal waters and the open ocean. They are formed primarily by wind blowing across the surface of the ocean and by differences in the temperature, density and pressure of water and are steered by Earth's rotation as well as the location of the continents and topography of the ocean bottom. *(Woods Hole Oceanographic Institution)*

decomposition
[dee-kom-puh-zish-uh n] *noun* - The state or process of decay.

entangle/entanglement
[en-tang-guh l] *verb/noun* - Cause to become twisted together with or caught in.

Equator
[ih-kwey-ter] *noun* - An imaginary line drawn around the earth equally distant from both poles, dividing the earth into northern and southern hemispheres and constituting the parallel of latitude 0°.

food web
[food web] *noun* - An ecological term for a system of interlocking and interdependent food chains.

fossil fuel
[fos-uh l fyoo-uh l] *noun* - A natural fuel such as coal or gas, formed in the geological past from the remains of living organisms.

gravity
[grav-i-tee] *noun* - The force that attracts a body toward the center of the earth, or toward any other physical body having mass.

gyre
[jahyuh r] *noun* spiraling circulations thousands of miles in diameter and rimmed by large, permanent ocean currents *(Woods Hole Oceanographic Institution, 2018).*

ingest /ingestion
[in-jest] *verb/noun* - Take (food, drink, or another substance) into the body by swallowing or absorbing it.

latitude
[lat-i-tood] *noun* - The angular distance of a place north or south of the earth's equator, or of a celestial object north or south of the celestial equator, usually expressed in degrees and minutes.

longitude
[lon-ji-tood] *noun* - The angular distance of a place east or west of the meridian at Greenwich, England, or west of the standard meridian of a celestial object, usually expressed in degrees and minutes.

marine debris [duh-bree]
marine litter [lit-er]
marine plastic pollution [puh-loo-shuh n] *noun* - Rubbish, trash, or garbage; 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 lakes. It is a global problem, and it is an everyday problem. There is no part of the world left untouched by debris and its impacts. Marine debris is a threat to our environment, navigation safety, the economy, and human health *(NOAA Marine Debris Program, 2018).*

microplastic
[mahy-kroh plas-tik] *noun* - Extremely small (less than 5mm in size) pieces of plastic debris in the environment resulting from the disposal and breakdown of consumer products and industrial waste.

macroplastic
[mak-roh plas-tik] *noun* - Marine plastic pollution that is 5mm or greater in size. *(5 Gyres Institute)*

pelagic
[puh-laj-ik] *adjective* - Relating to the open sea; inhabiting the upper layers of the open sea.

persistent organic pollutants (POPs)
[per-sis-tuh nt awr-gan-ik puh-loot-nt] *noun* - A hazardous organic chemical compound that is

resistant to biodegradation and thus remains in the environment for a long time.

photodegrade
[foh-toh-dih-greyd] *verb* - (of a substance or object) be decomposed by the action of light, especially sunlight.

plankton
[plangk-tuh n] *noun* - The small and microscopic organisms drifting or floating in the sea or fresh water, consisting chiefly of diatoms, protozoans, small crustaceans, and the eggs and larval stages of larger animals. Many animals are adapted to feed on plankton, especially by filtering the water.

policy
[pol-uh-see] *noun* - A course or principle of action adopted or proposed by a government, party, business, or individual.

precipitation
[pri-sip-i-tey-shuh n] *noun* - Rain, snow, sleet, or hail that falls to the ground.

target audience
[tahr-git aw-dee-uh ns] *noun* - A particular group of people at which a film, book, campaign, message, etc., is aimed.

topography
[tuh-pog-ruh-fee] *noun* - The arrangement of the natural and artificial physical features of an area.

trophic level
[trof-ik lev-uh l] *noun* - Each of several hierarchical levels in an ecosystem, comprising organisms that share the same function in the food chain and the same nutritional relationship to the primary sources of energy.

watershed
[waw-ter-shed] *noun* - An area or ridge of land that separates waters flowing to different rivers, basins, or seas; An area or region drained by a river, river system, or other body of water.

zooplankton
[zoh-uh-plangk-tuh n] *noun* - Plankton consisting of small animals and the immature stages of larger animals.

Photo: Sergio Izquierdo

Photo: Erika Delemarre

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Photo: Wolfram Burner

5 GYRES SCIENCE TO SOLUTIONS RESEARCH HUB

For instructors or students looking to dive deeper into the science of marine plastic pollution, the 5 Gyres Science to Solutions Research Hub is a clear and concise support platform to help you easily navigate plastic pollution research. We've collected what we believe are the studies most relevant to understanding the problem today, with synopses provided by our science team to help readers digest key points.

The information collected may not encompass every publication on the subject, but rather serves as a guide to understand general themes and emerging topics. It also includes our seminal studies: 5 Gyres was first American organization to identify plastic microbeads in 2012, first to estimate the quantity of surface marine plastic pollution in 2014, and first to assess plastics simultaneously on toxicity, recyclability and more through the 2016 and 2018 5 Gyres Plastics BAN List studies.

How does it work? Use the keyword drop-down list and/or search by region to navigate, then read our synopsis before clicking the link to access the abstract. Check back often as we will be continually updating as new studies come in.

Additionally, our series of 5 Gyres Policy Briefs on some of the worst plastic pollution items—such as plastic bags, polystyrene, straws, and microbeads—will expand over time. We hope that the 5 Gyres Science Hub will be a valuable resource for those new to understanding plastic pollution as well as those who want to go deeper into this issue.

http://www.5gyres.org/science-research-hub

Keywords

Bacteria
Bioaccumulation
BPA - Bisphenol-A
Debris - Marine Debris
Emerging Topics
Garbage Patch - Gyres
Human Health
Microfibers
Microplastics
PBDEs
Persistent Organic Pollutants
Plastic Pollution
Polychlorinaded Bromides
Polyethylene
Polystyrene - Styrofoam
Reproductive Toxicity
Solutions
Trawl
Waste Management
Wildlife - Animals

Regions

Global
Continental
North Pacific
South Pacific
Eastern Pacific
North Atlantic
South Atlantic
Arctic/Southern Ocean
Indian Ocean

Congratulations for completing the
5 Gyres TrawlShare STEM to Stern
Marine Plastic Pollution Program!

To access the materials shared in this program and learn more about how you can battle marine plastic pollution visit
www.5gyres.org/stem-to-stern

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Photo: Erika Delemarre

ADDITIONAL EDUCATIONAL CURRICULUM & RESOURCES

5 Gyres Catch the Wave NGSS Curriculum
Lessons cover a variety of science subjects through the lens of plastic pollution, including: plastic pollution sources and solutions, food chains, body systems, waste management, cause and effect, human impact, identifying plastics, watersheds, the water cycle, understanding currents, and packaging engineering solutions. https://catchthewave.blue/courses/5gyres

A Sea Without Waste / Un Mar Sin Desperdicio
A Spanish educational curriculum and materials for primary school students.
https://www.estrategiasmarinas.info/un-mar-sin-desperdicio-contenidos

Algalita Integrated Plastic Pollution Curriculum
A teaching resource designed around problem-driven learning to help students and their communities address environmental challenges. Curriculum available by contacting Anika@algalita.org.

California Coastal Commission Resources for California Educators
Resources, activities, and programs available for download covering coastal areas, wetlands, and watersheds. https://www.coastal.ca.gov/publiced/directory/educate.html

Earth Day Network Climate Education Week Toolkit – End Plastic Pollution – Earth Day 2018
A variety of age appropriate activities provides a broad overview of the environmental issues surrounding the production, use, and disposal of plastic products. By understanding the complete life cycle of plastic products we use every day, we can begin to understand the impacts those products have on our climate, our environment, and our bodies.
http://www.earthday.org/wp-content/uploads/Education-Toolkit-022718.pdf

Los Angeles Maritime Institute Top Sail Youth Program
Educational programs hosted aboard the twin brigantines, *Irving Johnson* and *Exy Johnson* expose youth to a world beyond their communities where they are provided with real-life challenges and hands-on learning opportunities not available in the traditional classroom.
https://lamitopsail.org/programs/

Ocean Conservancy and NOAA Marine Debris Program Talking Trash and Taking Action
A kit containing games, quizzes, advice on organizing cleanups and post-cleanup engagement prevention, conscious consumer action, proper product disposal and improved environmental citizenship. https://marinedebris.noaa.gov/partnerships/talking-trash-and-taking-action-marine-debris

NOAA Marine Debris Toolkit for Educators
The Toolkit is designed to assist teachers in educating their students about marine debris and involving them in marine debris research and outreach. Using the Toolkit, students conduct marine debris surveys, which can help to provide valuable information on where, when, and what kind of debris is showing up. Students can enter their data into a national database, analyze monitoring results, and become involved in marine debris stewardship within their communities.
https://marinedebris.noaa.gov/curricula/marine-debris-monitoring-toolkit-educators

MARLISCO – Marine Litter in European Seas
Downloadable social awareness and education materials. http://www.marlisco.eu/education.en.html

Next Generation Science Standards (NGSS)
An American Educational format designed with three distinct and equally important dimensions to learning science. These dimensions are combined to form each standard—or performance expectation—and each dimension works with the other two to help students build a cohesive understanding of science over time. https://www.nextgenscience.org/

Ocean Action Pod
Classroom activities, printable props, and accompanying teachers notes covering plastic pollution and solutions. Designed in Australia. https://www.oceanactionpod.org/for-schools

Ocean Action Project (Spanish Language)
Coordinated by CIIMAR (Interdisciplinary Center for Marine and Environmental Research - University of Porto), this program increases knowledge about the essential principles of Ocean Literacy and the impact of pollution at sea, as well as promoting good conservation practices for the marine ecosystem. http://oceanaction.pt/projeto

Ocean Literacy: Essential Principles and Fundamental Concepts of Ocean Sciences for Learners of All Ages – The result of a two-week workshop on ocean literacy by National Geographic Society, National Oceanic and Atmospheric Administration, Centers for Ocean Sciences Education Excellence, National Marine Educators Association, and College of Exploration in June 2005. To learn more about promoting an ocean literate world, visit http://www.oceanliteracy.net.

Sea Change: Our Ocean Our Health - Teaching Module: Marine Pollution & Human Health
An EU H2020 funded project that aims to establish a fundamental "Sea Change" in the way European citizens view their relationship with the sea, by empowering them, as Ocean Literate citizens, to take direct and sustainable action towards a healthy ocean, healthy communities and ultimately a healthy planet. http://seachangeproject.eu/resources

Sea Education Association SEA Semester
A leader in ocean education for college students. Since 1971, SEA has equipped students with the tools to become environmentally literate leaders prepared to address the defining issue of the twenty-first century: the human impact on the environment. http://www.sea.edu

SEA Semester Environmental Studies in Woods Hole & at Sea
Marine pollution has been a focus of SEA Semester student research since the early 1980s. Tar balls and plastic particles have been collected and counted in routine, twice-daily surface plankton net tows, resulting in long-term records of contamination in the North Atlantic Ocean, Caribbean Sea, and North and South Pacific Oceans. During this time the occurrence of floating tar balls has substantially declined, in contrast to floating plastic debris, which continues to persist. Ocean plastics are the focus of multiple avenues of research by SEA faculty and SEA Semester students to better understand their sources, distribution, transport, and fate in the ocean.
https://www.sea.edu/sea_research/ocean_plastics_marine_pollution

Surfers Against Sewage Educational Programmes
A variety of programs designed for students of all ages studying ocean health from different perspectives. https://www.sas.org.uk/our-work/education

The Smog of the Sea for Educators
A resource page for individuals and community groups to take action including a vast database of online campaigns, toolkits, and organizing strategies to reduce single-use plastic bags, water bottles, straws, styrofoam and more. https://www.thesmogofthesea.com/for-educators

Tangaroa Blue - Australian Marine Debris Initiative Education Kit
Creating awareness about marine environmental and conservation issues through exploration of: 'What is marine debris?', 'Why is marine debris a problem?' and 'What can we do about it?'. Concepts of consumption, pollution, and resolution are investigated with students developing an understanding that there is an interrelationship between the Earth's environment and human activities.
https://www.tangaroablue.org/resources/education-kit.html


Photo: 5 Gyres

ORGANIZATIONS & INITIATIVES

5 Gyres Institute
The 5 Gyre Institute is a 501(c)(3) nonprofit organization in special consultative status with the United Nations Economic and Social Council since 2017. Our mission is to empower action against the global health crisis of plastic pollution through science, education, and adventure. http://www.5gyres.org

5 Gyres' Nix the 6
A campaign to eliminate single-use polystyrene and expanded polystyrene foam ("Styrofoam") plastics. Pledge to "nix the 6" at: http://www.5gyres.org/polystyrene

5 Gyres Ambassador Program
Educating and empowering 5 Gyres' global network of supporters to take action against plastic pollution in their own communities. https://www.5gyres.org/ambassadors

Algalita
Educates and equips local and global influencers with the knowledge and resources needed to prevent plastic pollution. http://www.algalita.org

European Environment Association (EAA) – Our Ocean Our Future
Promoting action in Spain and the Mediterranean region aimed at creating the necessary social awareness to help reduce the amount of waste that reaches the sea. https://ambienteeuropeo.org

The Big Blue & You
An organization dedicated to inspiring and educating youth about ocean conservation through arts and media. https://bigblueandyou.org

Boomerang Alliance
An Australian organization empowering local communities in their struggle to stem the massive waste of discarded resources polluting our playgrounds, parks, rivers and beaches.
https://www.boomerangalliance.org.au

Break Free From Plastic
A global movement envisioning a future free from plastic pollution. www.breakfreefromplastic.org

Bye Bye Plastic Bags
Two young sisters lobbying to ban the use of shopping bags in Bali, Indonesia.
http://www.byebyeplasticbags.org

European Commission – Our Oceans, Seas and Coasts: Marine Litter
Overview of EU policies and actions to reduce and prevent marine plastic pollution.
http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/index_en.htm

Clean Coasts
An organization working to protect Ireland's beaches, seas and marine life.
http://cleancoasts.org/

COARE – The Center for Oceanic Awareness, Research, & Education
An organization working to enlighten people, young and old, to the plight of the oceans, to change the way they think and act, and encouraging them to create positive and lasting change.
http://www.coare.org

Healthy Seas
Organization which brings together different stakeholders with a common goal to remove plastic pollution from the ocean. http://healthyseas.org

The Last Plastic Straw
Helping influence people to shift away from single-use plastic straws.
http://www.thelastplasticstraw.org

Lonely Whale
An organization facilitating the creation of innovative ideas that push the boundary on current trends in technology, media and advocacy that positively impact the health of our ocean.
https://www.lonelywhale.org

MARLISCO Project - Marine Litter in European Seas: Social Awareness and Co-Responsibility
Raising public awareness, facilitating dialogue and promoting co-responsibility among the different actors towards a joint vision for the sustainable management of marine litter across all European seas.
http://www.marlisco.eu/index.en.html

NOAA Marine Debris Program
Overview of marine plastic pollution problem, current efforts to solve it, and multimedia resources for educators. https://marinedebris.noaa.gov/info/faqs.html

North American Marine Environment Protection Association
Working to preserve the marine environment by promoting marine industry best practices.
http://www.namepa.net

Surfrider Foundation's Ocean Friendly Restaurants
Reducing single-use plastics and raising customer awareness at restaurants around the world.
https://www.surfrider.org/programs/ocean-friendly-restaurants

Ocean Conservancy - Trash Free Seas International Coastal Cleanup
Annual international beach clean-up ending marine plastic pollution at its source.
https://oceanconservancy.org/trash-free-seas

Ocean Wise – The Great Canadian Shoreline Cleanup
Inspiring the global community to become Ocean Wise by increasing its understanding, wonder and appreciation for our oceans. https://www.shorelinecleanup.ca

Oceana
An international organization focused solely on oceans, dedicated to achieving measurable change by conducting specific, science-based campaigns with fixed deadlines and articulated goals.
http://www.oceana.org

PADI Project Aware
Inspiring, informing, and providing the tools needed to engage and connect individuals, governments, NGOs, and businesses who share the values and vision for a clean, healthy ocean.
http://www.projectaware.org

Plastic Bag Laws
A resource for legislative bodies considering laws limiting the use of plastic bags.
http://www.plasticbaglaws.org

Plastic Pollution Coalition
A global alliance of individuals, organizations, businesses, and policymakers working toward a world free of plastic pollution and its toxic impacts on humans, animals, waterways and oceans, and the environment. http://www.plasticpollutioncoalition.org

Rozalia Project
Through expeditions on the sailing research vessel, American Promise, Rozalia Project protects and cleans the ocean using technology, innovation, solutions-based research and engaging STEM programs. http://rozaliaproject.org

Sail Training International
Global organization of sail training ships dedicated to the development and education of young people through the sail training experience, regardless of nationality, culture, religion, gender or social background. https://sailtraininginternational.org

Sailors for the Sea - Green Boating Guide
Keeping waters blue by boating green. Eco-friendly, boat maintenance tips for people interested in protecting the ocean and their local waterways.
https://www.sailorsforthesea.org/programs/green-boating-guide

Scripps Institution of Oceanography at University of California San Diego
The Scripps mission is to seek, teach, and communicate scientific understanding of the oceans, atmosphere, Earth, and other planets for the benefit of society and the environment.
https://scripps.ucsd.edu

Surfrider Foundation Europe Ocean Initiative
Organization tackling the marine litter issue through education, citizen science, and lobbying in Europe.
http://www.initiativesoceanes.org/en

Take 3
An initiative asking citizens to take 3 pieces of rubbish with you when you leave the beach, waterway or anywhere. http://www.take3.org/

United Nations Environment Programme (UNEP) Marine Litter
Overview of topic and links to different global initiatives.
https://www.unenvironment.org/explore-topics/oceans-seas/what-we-do/working-regional-seas/marine-litter

Woods Hole Oceanographic Institute
Information on a broad range of topics ranging from ocean currents and gyres to marine biology.
http://www.whoi.edu/main/ocean-topics

Photo: Erika Delemarre


Photo: 5 Gyres

RECOMMENDED VIDEOS & FILMS

Unit 1 - Sources of Marine Plastic Pollution

What is Marine Debris?
by NOAA (Length: 2:00)
https://www.youtube.com/watch?v=FfSFKEM5Psc

What is a Watershed?
by Caring for Our Watersheds (Length: 1:00)
https://www.youtube.com/watch?v=QOrVotzBNto

Where Does Marine Debris Come From?
by NOAA (Length: 2:00)
https://www.youtube.com/watch?v=FN9FF7VH4ig

The Majestic Plastic Bag – A Mockumentary
by Heal The Bay (Length: 4:00)
https://www.youtube.com/watch?v=GLgh9h2ePYw

The Story of Three Plastic Bottles
by Emma Bryce on TED-Ed (Length: 4:00)
https://www.youtube.com/watch?v=_6xlNyWPpB8

Unit 2 - Impacts of Marine Plastic Pollution

Plastic Ocean
by United Nations (Length: 7:28)
https://youtu.be/ju_2NuK5O-E

What are the ecological impacts?
by 5 Gyres (Length: 2:14)
https://youtu.be/qlZleaYKrbQ

The Plastics Problem
by Ocean Heroes and 5 Gyres (Length: 2:17)
https://youtu.be/8BL5o7nRKtE

It's a Plastic World
by It's a Plastic World (Length: 4:39)
https://youtu.be/CWjkH7EV9lg

Unit 3 - Winds, Currents & Gyres

How Much Plastic is in the Ocean?
by PBS It's OK To Be Smart (Length: 5:00)
https://youtu.be/YFZS3Vh4lfI

Perpetual Ocean Current Visualization
by NASA Goddard (Length: 3:00)
https://youtu.be/CCmTY0PKGDs

What is a Gyre?
by Ocean Heroes and 5 Gyres (Length: 2:20)
https://youtu.be/h6i16CrI8ss

Garbage Patch Visualization Experiment
by NASA's Scientific Visualization Studio
(Length: 1:25)
https://youtu.be/zYuvTYJ0hGk

Unit 4 - Plastics In Our Lives & Innovating Solutions

How Much Plastic is in the Ocean?
by PBS It's OK To Be Smart (Length: 5:00)
https://youtu.be/YFZS3Vh4lfI

How We Can Keep Plastics Our of Our Oceans
by National Geographic (Length: 3:00)
https://youtu.be/HQTUWK7CM-Y

Why I Live a Zero Waste Life
by Lauren Singer at TEDx Teen (Length: 13:30)
https://youtu.be/pF72px2R3Hg

Gyrecraft - Transforming Ocean Trash into Beautiful Art by Studio Swine on National Geographic (Length: 5:00)
https://youtu.be/wDrKlByGEsA

Plastic Kiln Innovation by 5 Gyres
(Length: 2:00) https://vimeo.com/173068317

How to Repurpose Plastic Bottles into Eco-Bricks by Rappler and the Plastic Solution
(Length: 3:00) https://youtu.be/vaJrkzQ43m4

Lush Uses Social Plastic by The Plastic Bank
(Length: 2:25) https://youtu.be/MlzknllOjTI

The Solution to Plastic Waste Pollution
by UPROXX & Full Cycle Bioplastics
(Length 2:20) https://youtu.be/o_STBEU7ykI

Unit 5 - Water Sampling & Plastics Monitoring

TrawlShare Instructional Video
by 5 Gyres Institute (Length 3:20)
https://vimeo.com/210996851

5 Gyres North Atlantic Gyre Expedition
by 5 Gyres Institute (Length 6:00)
https://www.youtube.com/watch?v=O9QJvMntn0I

5 Gyres South Atlantic Research Voyage
by 5 Gyres Institute (Length 8:00)
https://www.youtube.com/watch?v=i9Nz3vy6XjY

Smog of the Sea
by Ian Cheney (Length 30:00)
https://www.thesmogofthesea.com/watch-film/

How Much Plastic Do You Eat?
by BBC Earth Lab (Length 12:16)
https://www.youtube.com/watch?v=veMdowmPSbw

Ocean Drifters
by Plymouth University (Length 16:30)
https://www.youtube.com/watch?v=ziGtmjiUlJQ

Unit 6 - Leadership: Be the Change

How Much Plastic is in the Ocean?
by PBS It's OK To Be Smart (Length: 5:00)
https://youtu.be/YFZS3Vh4lfI

What Can We Do About Marine Debris
by NOAA's Ocean Today (Length 2:00)
https://youtu.be/XuhdmDc4L1Y

Our campaign to ban plastic bags in Bali
by Melati and Isabel Wijsen on TED
(Length 11:00) https://youtu.be/P8GCjrDWWUM

Fueling Plastics
by Center for Environmental Law (Length 2:15)
https://youtu.be/U0EmJ6wsyo4

Most Polluting Brands
by Break Free From Plastic (Length 2:00)
https://www.breakfreefromplastic.org/wp-content/uploads/2018/01/bfffp.mp4

A brilliant solution to clean up our environment
by Boomerang Alliance (Length 2:30)
https://youtu.be/58rvQ60ae2s

Plastics in the Pacific - KQED QUEST
by KQED Science (Length 10:00)
https://youtu.be/g9fEbqxyNl0

ADDITIONAL FILMS

Plasticized
"Plasticized is an intimate account of a first-hand journey aboard the Sea Dragon with the 5 Gyres Institute on the very first scientific expedition, focused on plastic waste, through the centre of the South Atlantic Ocean. An eye-opening story about the institute's global mission to study the effects, reality, and scale of plastic pollution around the world."

https://youtu.be/dfcRW7slrPI

A Plastic Ocean
"A Plastic Ocean documents the newest science, proving how plastics, once they enter the oceans, break up into small particulates that enter the food chain where they attract toxins like a magnet. These toxins are stored in seafood's fatty tissues, and eventually consumed by us."

https://plasticoceans.org

BLUE
"BLUE is the story our generation need to hear. The industrialization that has occurred in the oceans over the last century, mirrors the events that triggered mass extinctions on land. Industrial scale fishing, habitat destruction, species loss and pollution have placed the ocean in peril. The very nature of the sea is being irretrievably altered. BLUE is a provocative journey into the ocean realm, witnessing this critical moment in time when the marine world is on a precipice."

https://bluethefilm.org

STRAWS
"STRAWS leaves audiences with a clear understanding of the problems caused by plastic pollution and empowers individuals to be part of the solution." http://www.strawsfilm.com

Bag It: Is your life too plastic?
One man takes a look at the plastic in his life, how he uses it and the impacts it has on the envrionment and human health.

http://www.bagitmovie.com

Plastic Is Forever Documentary
"What happens when you throw plastic away? Dylan D'Haeze, a 13-year-old filmmaker from the San Juan Islands decided to find out. He followed plastic trash to where it ends up - with some surprising results."

http://www.kidscansavetheplanet.com/plasticisforever.html

OCEAN LITERACY

Essential Principles and Fundamental Concepts

FURTHER INFORMATION

Please visit www.oceanliteracy.net to find an online version of this document as well as obtain updates, correlations to education standards, and links to related educational resources.

Literature Cited

How People Learn: Brain, Mind, Experience and School (National Academy of Sciences, Washington, DC, 2000). • *Taking Science to School* (National Academy of Sciences, Washington, DC, 2007) • *Learning Science in Informal Environments: People, Places and Pursuits* (National Academy of Sciences, Washington, DC, 2009). • *A Framework for K-12 Science Education, Practices, Crosscutting Concepts and Core Ideas* (National Academy of Sciences, Washington, DC, 2012). • Steel, B. S., Lovrich, N., Lach, D., & Fomenko, V. Correlates and consequences of public knowledge concerning ocean fisheries management. Coastal Management, 33, 37-51 (2005). • The Ocean Project, America, the Ocean, and Climate Change (2009, theoceanproject.org/download-reports/) • Tran, L. U., "Children and adults' understanding of ocean and climate sciences" (National Oceanic and Atmospheric Administration, Washington, DC, 2009).

1 The Earth has one big ocean with many features.

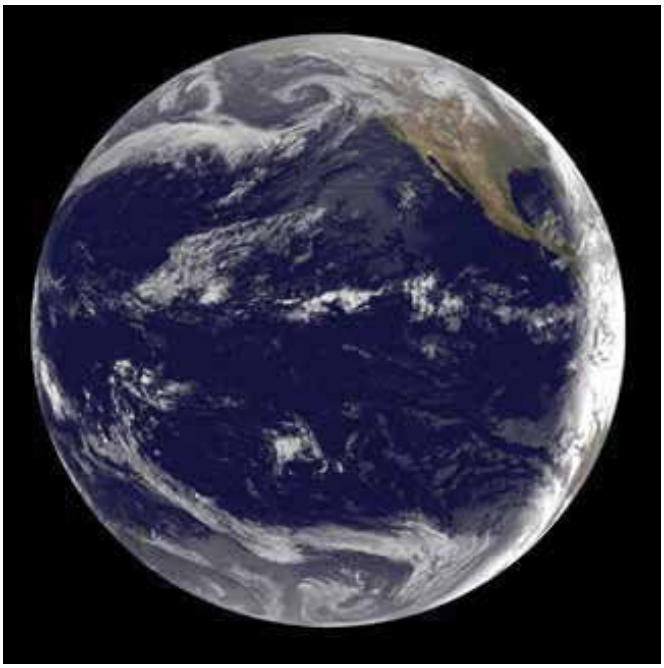
A The ocean is the defining physical feature on our planet Earth—covering approximately 70% of the planet's surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian, Southern, and Arctic.

B Ocean basins are composed of the seafloor and all of its geological features (such as islands, trenches, mid-ocean ridges, and rift valleys) and vary in size, shape and features due to the movement of Earth's crust (lithosphere). Earth's highest peaks, deepest valleys and flattest plains are all in the ocean.

C Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of Earth's rotation (Coriolis effect), the Sun and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation. This "global ocean conveyor belt" moves water throughout all of the ocean basins, transporting energy (heat), matter, and organisms around the ocean. Changes in ocean circulation have a large impact on the climate and cause changes in ecosystems.

D Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides. Sea level changes as plate tectonics cause the volume of ocean basins and the height of the land to change. It changes as ice caps on land melt or grow. It also changes as sea water expands and contracts when ocean water warms and cools.

E Most of Earth's water (97%) is in the ocean. Seawater has unique properties. It is salty, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. Balance of pH is vital for the health of marine ecosystems, and important in controlling the rate at which the ocean will absorb and buffer changes in atmospheric carbon dioxide.



THE OCEAN FROM SPACE. This infrared image from the GOES-11 satellite shows the Pacific Ocean. *Photo: NASA*

F The ocean is an integral part of the water cycle and is connected to all of Earth's water reservoirs via evaporation and precipitation processes.

G The ocean is connected to major lakes, watersheds, and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments, and pollutants from watersheds to coastal estuaries and to the ocean.

H Although the ocean is large, it is finite, and resources are limited.

2 The ocean and life in the ocean shape the features of Earth.

A Many earth materials and biogeochemical cycles originate in the ocean. Many of the sedimentary rocks now exposed on land were formed in the ocean. Ocean life laid down the vast volume of siliceous and carbonate rocks.

B Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.

C Erosion—the wearing away of rock, soil and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean, and the processes associated with plate tectonics move sediments. Most beach sand (tiny bits of animals, plants, rocks, and minerals) is eroded from land sources and carried to the coast by rivers; sand is also eroded from coastal sources by surf. Sand is redistributed seasonally by waves and coastal currents.

D The ocean is the largest reservoir of rapidly cycling carbon on Earth. Many organisms use carbon dissolved in the ocean to form shells, other skeletal parts, and coral reefs.

E Tectonic activity, sea level changes, and the force of waves influence the physical structure and landforms of the coast.

COASTAL CARVINGS. Waves crashing on the coast of Big Sur, California near the site of the *F/V Bono* crash. *Photo: Steve Lonhart/NOAA Monterey Bay National Marine Sanctuary*

3 The ocean is a major influence on weather and climate.

A The interaction of oceanic and atmospheric processes controls weather and climate by dominating the Earth's energy, water, and carbon systems.

B The ocean moderates global weather and climate by absorbing most of the solar radiation reaching Earth. Heat exchange between the ocean and atmosphere drives the water cycle and oceanic and atmospheric circulation.

C Heat exchange between the ocean and atmosphere can result in dramatic global and regional weather phenomena, impacting patterns of rain and drought. Significant examples include the El Niño Southern Oscillation and La Niña, which cause important changes in global weather patterns because they alter the sea surface temperature patterns in the Pacific.

D Condensation of water that evaporated from warm seas provides the energy for hurricanes and cyclones. Most rain that falls on land originally evaporated from the tropical ocean.

E The ocean dominates Earth's carbon cycle. Half of the primary productivity on Earth takes place in the sunlit layers of the ocean. The ocean absorbs roughly half of all carbon dioxide and methane that are added to the atmosphere.

F The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon, and water. Changes in the ocean's circulation have produced large, abrupt changes in climate during the last 50,000 years.

G Changes in the ocean-atmosphere system can result in changes to the climate that in turn, cause further changes to the ocean and atmosphere. These interactions have dramatic physical, chemical, biological, economic, and social consequences.

NATURAL PHENOMENON. A GOES-12 satellite image of Hurricane Katrina shortly after landfall on August 29, 2005. *Image: NOAA*

4 The ocean made Earth habitable.

A Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean. This accumulation of oxygen in Earth's atmosphere was necessary for life to develop and be sustained on land.

B The ocean is the cradle of life; the earliest evidence of life is found in the ocean. The millions of different species of organisms on Earth today are related by descent from common ancestors that evolved in the ocean and continue to evolve today.

C The ocean provided and continues to provide water, oxygen, and nutrients, and moderates the climate needed for life to exist on Earth (Essential Principles 1, 3, and 5).

CORAL REEF HABITAT. A fisherman tries his luck with a net in American Samoa.

5 The ocean supports a great diversity of life and ecosystems.

A Ocean life ranges in size from the smallest living things, microbes, to the largest animal on Earth, blue whales.

B Most of the organisms and biomass in the ocean are microbes, which are the basis of all ocean food webs. Microbes are the most important primary producers in the ocean. They have extremely fast growth rates and life cycles, and produce a huge amount of the carbon and oxygen on Earth.

C Most of the major groups that exist on Earth are found exclusively in the ocean and the diversity of major groups of organisms is much greater in the ocean than on land.

D Ocean biology provides many unique examples of life cycles, adaptations, and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land.

E The ocean provides a vast living space with diverse and unique ecosystems from the surface through the water column and down to, and below, the seafloor. Most of the living space on Earth is in the ocean.

F Ocean ecosystems are defined by environmental factors and the community of organisms living there. Ocean life is not evenly distributed through time or space due to differences in abiotic factors such as oxygen, salinity, temperature, pH, light, nutrients, pressure, substrate, and circulation. A few regions of the ocean support the most abundant life on Earth, while most of the ocean does not support much life.

G There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, and methane cold seeps, rely only on chemical energy and chemosynthetic organisms to support life.

H Tides, waves, predation, substrate, and/or other factors cause vertical zonation patterns along the coast; density, pressure, and light levels cause vertical zonation patterns in the open ocean. Zonation patterns influence organisms' distribution and diversity.

I Estuaries provide important and productive nursery areas for many marine and aquatic species.

PACIFIC ECOSYSTEM. A kelp forest is home to an ochre sea star in Monterey Bay, California.

6 The ocean and humans are inextricably interconnected.

A The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth's oxygen. The ocean moderates the Earth's climate, influences our weather, and affects human health.

B The ocean provides food, medicines, and mineral and energy resources. It supports jobs and national economies, serves as a highway for transportation of goods and people, and plays a role in national security.

C The ocean is a source of inspiration, recreation, rejuvenation, and discovery. It is also an important element in the heritage of many cultures.

D Humans affect the ocean in a variety of ways. Laws, regulations, and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution), changes to ocean chemistry (ocean acidification), and physical modifications (changes to beaches, shores, and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

E Changes in ocean temperature and pH due to human activities can affect the survival of some organisms and impact biological diversity (coral bleaching due to increased temperature and inhibition of shell formation due to ocean acidification).

F Much of the world's population lives in coastal areas. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges).

G Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

THE DAY'S CATCH. A commercial fishing vessel off the coast of Santa Cruz, California returns to port.

7 The ocean is largely unexplored.

A The ocean is the largest unexplored place on Earth—less than 5% of it has been explored. The next generation of explorers and researchers will find great opportunities for discovery, innovation, and investigation.

B Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes. Our very survival hinges upon it.

C Over the last 50 years, use of ocean resources has increased significantly; the future sustainability of ocean resources depends on our understanding of those resources and their potential.

D New technologies, sensors, and tools are expanding our ability to explore the ocean. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories, and unmanned submersibles.

E Use of mathematical models is an essential part of understanding the ocean system. Models help us understand the complexity of the ocean and its interactions with Earth's interior, atmosphere, climate, and land masses.

F Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, physicists, animators, and illustrators. And these interactions foster new ideas and new perspectives for inquiries.

UNDERWATER EXPLORATION. *Deep Worker* submersibles explore the Flower Garden Banks National Marine Sanctuary in the Gulf of Mexico.

The initial document containing the Ocean Literacy Essential Principles and Fundamental Concepts represented a significant grassroots effort on the part of the ocean sciences and education communities and started with a 2-week online workshop involving some 100 members of those communities. The event was planned and coordinated by Francesca Cava, National Geographic Society; Sarah Schoedinger, National Oceanic and Atmospheric Administration (NOAA); Craig Strang, Lawrence Hall of Science, University of California, Berkeley; and Peter Tuddenham, College of Exploration, with sponsorship from the National Geographic Society (NGS) and NOAA. The workshop was hosted by the College of Exploration, endorsed by the Association of Zoos and Aquariums (AZA) and The Ocean Project, and promoted by the National Marine Educators Association (NMEA). In addition, the following people made significant contributions to the development and review of the initial guide published in 2005:

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The 2013 revision of this guide has been supported by NOAA's Office of Education and the National Marine Sanctuary Foundation. The following individuals contributed to this revised version:

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For a complete listing of all the individuals who have contributed to the development of the Ocean Literacy Framework, please visit our honor roll at www.oceanliteracy.net

National Marine Educators Association

COSEE CENTERS FOR OCEAN SCIENCES EDUCATION EXCELLENCE

Sea Grant

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

ONEWORLD ONEOCEAN FOUNDATION

NATIONAL MARINE SANCTUARIES

COLLEGE OF EXPLORATION

NATIONAL GEOGRAPHIC

Scientific and Engineering Practices (SEP)

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information.

Crosscutting Concepts (CCC)

1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change

Disciplinary Core Ideas (DCI)

Physical Sciences

PS1: Matter and its interactions

PS2: Motion and stability: Forces and interactions

PS3: Energy

PS4: Waves and their applications in technologies for information transfer

Life Sciences

LS1: From molecules to organisms: Structures and processes

LS2: Ecosystems: Interactions, energy, and dynamics

LS3: Heredity: Inheritance and variation of traits

LS4: Biological evolution: Unity and diversity

Earth and Space Science

ESS1: Earth's place in the universe

ESS2: Earth's systems

ESS3: Earth and human activity

Engineering, Technology, and Applications of Science

ETS1: Engineering design

ETS2: Links among engineering, technology, science, and society

Design by Erika Delemarre

BETTER ALTERNATIVES NOW

B.A.N. LIST 2.0

An analysis and call-to-action to phase out the most polluting plastic products used in the United States

GOALS OF THIS REPORT

Identify the Top 20 plastic products and packaging that pollute U.S. watersheds

Provide the public, policymakers and environmental advocates with valuable data to drive campaigns

Share available data on brands associated with products on the B.A.N. List

Unravel the misinformation surrounding bioplastics

Discuss alternatives to the most common polluting products and packaging

TABLE OF CONTENTS

THE NATIONAL DATASET

INTRODUCTION

Over the last fifty years, plastic has become the packaging material of choice for many of the goods we consume. It's durable, lightweight, easily molded into different shapes and applications for marketing choices, and readily seals out oxygen and other contaminants. And plastic is artificially cheap. It dominates single-serve food and beverage packaging, carry-out shopping bags, and to-go containers and cutlery from restaurants and cafeterias. With Americans leading busier lives and eating on-the-go more than ever, all of that plastic is piling up.

This growing reliance on plastic to fuel our "culture of convenience" is not without cost. Globally, an average of eight million tons of plastic escapes collection systems, winding up in the environment and eventually the ocean[1]. Once there, sunlight and currents shred plastic debris into smaller particles called microplastics[2], which absorb and concentrate toxic chemicals up the marine food chain and into our bodies.[3] From plankton to fish, and to humans that eat seafood, plastic pollution is changing the very chemistry of life.[4]

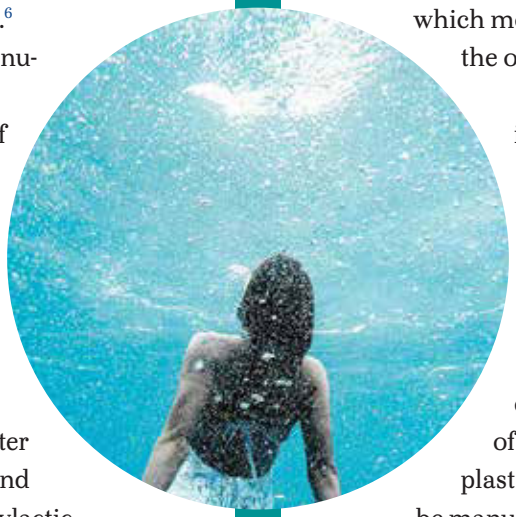
"Plastic—a material invented to last forever—can no longer be used to make products intended to be thrown away. There is no away."

The true cost to the environment is mirrored by the impacts of plastic pollution on people. In our current linear economy, whereby the unregulated design of single-use, throw away products are ultimately buried or burned, the economic and human health effects are costly. Lower income communities typically become the neighborhoods where trash is collected the least, and in many cases where waste management systems are designated, including incinerator plants, new landfills, and material recovery facilities.

Plastic production is estimated to increase four-fold by 2050[5]. It is essential that the single-use, throw away culture end. Plastic—a material invented to last forever—can no longer be used to make products intended to be thrown away. There is no away.

TOXICITY

Research on microplastics and human health is an emerging field. Evidence of toxicity has raised concern about the chemistry of plastic polymers and common additives in the products we eat and drink from. In the marine environment, plastic pollution increases its toxicity over time through the absorption of persistent organic pollutants.[6]



Far upstream, where product manufacturing begins, different polymers were ranked based on the number of chemicals used. A chemical analysis showed that those polymers most commonly found in packaging, Polystyrene (PS), Polycarbonate (PC), and Polyvinyl Chloride (PVC) were of greatest concern to human health.[7] The polymer Polyethylene Terephalate (PET) scored slightly better in comparison to Polyethylene (PE) and Polypropylene (PP). The polymer Polylactic Acid (PLA) scored as least hazardous but this ranking does not take into account additives. Mixed into polymers to make products, many additives are known to be hazardous and increase the toxicity profile of individual plastic products.

Human contact with plastic products and packaging can cause some chemical toxicity due to the localized leaching of component monomers, endogenous additives, and adsorbed environmental pollutants. Chronic exposure is anticipated to be of greater concern due to the accumulative effect that can occur. This is expected to be dose-dependent, and robust evidence-base of exposure levels is greatly needed to better understand the potential mechanisms of toxicity and possible health effects.[8]

Research shows that plastic debris can be a vector for toxic chemicals in the marine environment. A study of floating plastic pollution found particularly high levels of polycyclic aromatic hydrocarbons (PAHs) on both PS foam packaging material and PS foam marine debris.[9] PAHs are known pollutants that are generated by incomplete combustion and used in many plastic manufacturing processes. This study demonstrates both the inherent toxicity of PS foam and its ability to accumulate pollutants in the marine environment. Another study that measured the accumulation of polychlorinated biphenyls (PCBs) and PAHs on different types of marine plastic pollution found that HDPE, LDPE, and PP contained higher concentrations of PAHs and PCBs than other polymers which more readily sank to the bottom of the ocean.[10]

The combination of toxic chemicals in manufacturing, plastic's persistence in the environment, and the increasing understanding that marine plastics hold the potential to deliver greater doses of toxic chemicals to marine life, all point to the need to dramatically reduce and redesign the use of plastics. Where it remains in use, plastic products and packaging should be manufactured using safer chemicals and designed with a circular economic model in mind. All additives must be available in full disclosure on the item, similar to the ingredient list required on food and beverage containers.

HOW IS B.A.N. LIST 2.0 DIFFERENT THAN B.A.N. LIST 1.0?

In B.A.N. List 1.0 we took a close look at the extent of plastic pollution on the California coastline. Quantity and type of plastics were measured on the ground by phone apps and beach surveys, resulting in a list of the top 15 most common products or packaging materials. We reported the kinds of polymers and additives used in those products and what we considered the best alternatives, ranging from reusables to paper or bioplastic alternatives. B.A.N. List 2.0 is much different.

B.A.N. List 2.0 analyzes data from the entire United States using the same sources to find the top 20 polluting products or packaging. Utilizing Litterati, a mobile app that allows users to document corporate logos or names on polluting plastics, we can assign some brand names to those items. B.A.N. List 2.0 can be used to encourage companies to

address their part of the plastic pollution problem.

In B.A.N. List 2.0, we also present a case study of bioplastic degradation as it relates to consumer expectations to answer the question, "Are bioplastics the answer?" We tested 20 bioplastic and biopolymer-based products that made claims about their environmental performance. Our results show that what products advertise, what consumers think, and how products perform are generally inconsistent, exposing potential "greenwashing" and a need for public education and truth in advertising.

METHODOLOGY AND ANALYSIS

In order to identify the products and packaging that are causing the most harm in the environment and for human health, 10 organizations partnered to create the B.A.N. List 2.0 (Better-Alternatives-Now). We examined publicly available data sources to determine which plastic applications perform the worst from a pollution standpoint (e.g. what's found in the environment). We expanded our analysis to include datasets from across the United States.

There are multiple sets of data collected by different organizations that document environmental contamination by product types and/or brand identification. For the B.A.N. List 2.0, datasets from Ocean Conservancy's International Coastal Cleanup Day, NOAA's Marine Debris Tracker, Clean Ocean Action, Project Aware, and Heal the Bay were referenced. Available data on the top 20 items by count were combined, resulting in a hierarchy beginning with the most common contaminant (food wrappers).

With this list of the top 20 items, we worked with the mobile app Litterati to share the top 5 brands identified for each product/packaging item category. Nine of those 20 categories had brand data.

Our analysis adds to a growing body of data highlighting the urgent need for action. We're demanding that policy makers and business leaders take immediate action to phase out these harmful plastics, and build systems of circularity into the design of their products. Better alternatives are needed now, either through government regulatory action, voluntary efforts by industry, or both.

BREAK FREE FROM PLASTIC—A SNEAK PEAK AT B.A.N. LIST 3.0

HUNDREDS OF NONGOVERNMENTAL organizations (NGOs) worldwide have come together to stop plastic pollution. We are building a movement with common values of environmental protection and social justice, and these shared values guide our work in building the world in which we wish to live.

In September 2017 in Manila, Philippines, several member groups under the global #breakfreefromplastic movement spent 8 days on Freedom Island to conduct a brand audit. The results revealed that six international brands are responsible for 53.8% of plastic packaging pollution found in the designated ecotourism area, which has been declared as a critical habitat for migratory birds.

International brands are among the worst oceans polluters—and the global #breakfreefromplastic movement is holding them accountable.

In 2018 B.A.N. List 3.0 will compare the U.S. plastic trash audit to datasets from Southeast Asia, with a focus on brand accountability.

MERGED NATIONAL DATASETS: THE TOP 20 PRODUCTS

PLASTIC PRODUCT	COUNT							
	ICC	NOAA	MDT	Heal The Bay	COA	Project AWARE	TOTAL	%
1 Food Wrappers (candy, chips, etc.)	318880.0	272.0	16315.0	307.0	14827.0	217.0	**350818.0**	**18.6**
2 Bottle Caps (Plastic)	273089.0	779.0	11735.0	27352.0	2328.0	205.1	**315488.1**	**16.7**
3 Beverage Bottles (Plastic)	206993.0	122.0	7809.0	6297.0	5508.0	289.0	**227018.0**	**12.0**
4 Bags (Plastic)	157702.0	39.0	6970.0	5249.0	7871.0	313.0	**178144.0**	**9.4**
5 Straws, Stirrers	125635.0	172.0	4645.0	4026.0	8102.0	165.0	**142745.0**	**7.5**
6 Lids (Plastic)	75921.0	186.9	409.0	5829.5	15347.0	57.9	**97751.2**	**5.1**
7 Utensils	42599.0	33.0	1848.0	47133.0	1864.0	352.0	**93829.0**	**4.9**
8 Cigarette Butts*	51550.5	25.3	2337.9	6775.9	643.0	9.1	**61341.7**	**3.2**
9 Take Out/Away Containers (Foam)	41805.0	102.9	537.7	17696.0	548.0	8.3	**60697.8**	**3.2**
10 Take Out/Away Containers (Plastic)	49973.0	123.0	37.0	5624.0	1021.7	9.9	**56788.6**	**3.0**
11 Cups, Plates (Plastic)	48559.0	14.6	732.6	1862.2	1766.0	9.6	**52943.9**	**2.8**
12 Cigar Tips	41211.0	47.0	328.0	6243.0	2351.0	16.0	**50196.0**	**2.6**
13 Cups, Plates (Foam)	42047.0	12.4	4495.7	690.0	2021.0	8.3	**49274.5**	**2.6**
14 Tobacco Packaging/Wrap	33434.0	82.3	604.5	352.0	694.0	19.0	**35185.8**	**1.8**
15 Balloons	23492.0	19.0	1442.0	5263.0	480.3	13.0	**30709.3**	**1.6**
16 Other Plastic Bottles	17548.0	62.0	1578.0	4769.6	1429.0	9.0	**25395.6**	**1.3**
17 Cigarette Lighters	10750.0	24.0	676.5	10750.0	405.0	3.0	**22608.5**	**1.2**
18 Personal Care Products (condoms & tampon applicators)	11555.0	37.4	827.5	2213.2	1875.1	14.0	**16522.2**	**0.8**
19 6-Pack Holders	8224.0	3.0	180.0	641.0	130.0	10.0	**9188.0**	**0.4**
20 Diapers	3938.0	12.5	276.8	2150.6	82.0	7.0	**6466.9**	**0.3**
Sum Total	**1584905.5**	**2169.3**	**63785.2**	**161223.9**	**69293.0**	**1735.1**	**1883112.0**	**100.0**

** Counts of cigarette butts were divided by 20 to represent packs rather than individual cigarettes.*

MERGED NATIONAL DATASETS

To create common categories of plastic products and packaging among these six datasets, we made assumptions to split or lump numbers together, such as counting cigarette butts as packs (20 butts per pack) rather than individually, or lumping personal care products, like ear buds or tampon applicators, into one category. These assumptions made sense and made datasets more comparable. This exercise also uncovered challenges and opportunities in how to mitigate specific types of pollution.

MATERIALS IN THE TOP 20 PRODUCTS

PLASTIC PRODUCT	IN ENVIRONMENT COUNT	IN ENVIRONMENT %	LIKELY PLASTIC-TYPE (POLYMER)	BETTER ALTERNATIVES NOW	BEST ALTERNATIVES NOW
1 Food Wrappers (candy, chips, etc.)	350818.0	18.6	Several different plastics**	More work needed on bio-benign alternatives	Bulk purchasing of food in reusable containers
2 Bottle Caps (Plastic)	315488.1	16.7	Polypropylene (PP #5)	"Connect the Cap" technical fix available	Functional replacement with reusable bottles
3 Beverage Bottles (Plastic)	227018.0	12.0	Polyethylene terephthalate (PET #1)	Increase deposit to increase collection rates	Functional replacement with reusables
4 Bags (Plastic)	178144.0	9.4	Primarily Low-Density polyethylene (LDPE #4)	Natural, bio-based shopping bags (paper)	Functional replacement with reusable bags
5 Straws, Stirrers	142745.0	7.5	Polypropylene (PP #5)	Paper or wood straws/stirrers	Functional replacement with reusable straws/stirrers
6 Lids (Plastic)	97751.2	5.1	Polystyrene (PS #6)	More work needed on bio-benign alternatives	Functional replacement with reusable cups
7 Utensils	93829.0	4.9	Polystyrene (PS #6)	Natural, bio-based biodegradable utensils (bamboo/wood)	Functional replacement with reusable utensils
8 Cigarette Butts*	61341.7	3.2	Cellulose Acetate Fiber	Filter-less cigarettes	Plant-based biodegradable cigarette filters
9 Take Out/Away Containers (Foam)	60697.8	3.2	Polystyrene (PS #6)	Plant-based biodegradable take-out containers	Functional replacement with reusable take-out containers; work to change health codes to enable this change
10 Take Out/Away Containers (Plastic)	56788.6	3.0	Several different plastics**	Plant-based biodegradable take-out containers	Functional replacement with reusable containers ***
11 Cups, Plates (Plastic)	52943.9	2.8	(PS #6) & (PET #1)	Plant-based biodegradable cups	Functional replacement with reusable cups
12 Cigar Tips	50196.0	2.6	Polystyrene (PS #6)	Functional replacement with reusable cigar tips	Ban of smoking in public space
13 Cups, Plates (Foam)	49274.5	2.6	Polystyrene (PS #6)	Plant-based biodegradable cups	Functional replacement with reusable cups ***
14 Tobacco Packaging/Wrap	35185.8	1.8	Polypropylene or Polyethylene (#5 or #2)	Plant-based biodegradable alternatives	Natural bio-based materials, like cellulose
15 Balloons	30709.3	1.6	Latex or Mylar	Plant-based biodegradable alternatives	Cultural alternatives to balloon releases
16 Other Plastic Bottles	25395.6	1.3	Several different plastics**	Increase deposit to increase collection rates	Functional replacement with reusable bottles
17 Cigarette Lighters	22608.5	1.2	Polycarbonate (PC - #7)	See best alternative	Functional replacement with matches or refillable non-plastic lighters
18 Personal Care Products (condoms & tampon applicators)	16522.2	0.8	Several different plastics**	See best alternative	Natural bio-based materials
19 6-Pack Holders	9188.0	0.4	Low density polyethylene (LDPE #4)	Plant-based biodegradable alternatives	Paper box beverage holders
20 Diapers	6466.9	0.3	Several different plastics**	Plant-based biodegradable alternatives	Cloth diaper services when available

** Counts of cigarette butts were divided by 20 to represent packs rather than individual cigarettes.*
*** These products are made from several different types of plastic, and a full analysis for each product is not included here.*
**** In many cities, this will require new health codes to permit reusable containers in this context.*

TOP 5 BRANDS IN EACH PRODUCT CATEGORY

PLASTIC PRODUCT	#1 BRAND / # OF ITEMS**	#2 BRAND / # OF ITEMS**	#3 BRAND / # OF ITEMS**	#4 BRAND / # OF ITEMS**	#5 BRAND / # OF ITEMS**
1 Food Wrappers (candy, chips, etc.)	Wrigley's / 394	Trident / 344	Starburst / 169	Snickers / 166	- / -
2 Bottle Caps (Plastic)	Coke / 20	Gatorade / 15	Naked / 3	Snapple / 2	Crystal Geyser / 2
3 Beverage Bottles (Plastic)	Poland Springs / 106	Gatorade / 82	Coke / 37	Crystal Geyser / 36	Arrowhead / 27
4 Bags (Plastic)	Starbucks / 50	McDonalds / 49	Taco Bell / 9	- / -	- / -
5 Straws, Stirrers	Starbucks / 133	McDonalds / 132	Dunkin Donuts / 25	Burger King / 16	Subway / 12
6 Lids (Plastic)	- / -	- / -	- / -	- / -	- / -
7 Utensils	- / -	- / -	- / -	- / -	- / -
8 Cigarette Butts*	Marlboro 2099	Camel / 791	Parliament / 688	Newport / 472	Pall Mall / 247
9 Take Out/Away Containers (Foam)	- / -	- / -	- / -	- / -	- / -
10 Take Out/Away Containers (Plastic)	- / -	- / -	- / -	- / -	- / -
11 Cups, Plates (Plastic)	Starbucks / 315	McDonalds / 187	Taco Bell / 56	Dunkin Donuts / 54	Peets / 43
12 Cigar Tips	- / -	- / -	- / -	- / -	- / -
13 Cups, Plates (Foam)	- / -	- / -	- / -	- / -	- / -
14 Tobacco Packaging/Wrap	Swisher Sweets / 249	Dutch / 76	Backwoods / 49	- / -	- / -
15 Balloons	- / -	- / -	- / -	- / -	- / -
16 Other Plastic Bottles	- / -	- / -	- / -	- / -	- / -
17 Cigarette Lighters	- / -	- / -	- / -	- / -	- / -
18 Personal Care Products (condoms & tampon applicators)	Trojan / 5	Lifestyles / 2	Pleasure Plus / 1	- / -	- / -
19 6-Pack Holders	- / -	- / -	- / -	- / -	- / -
20 Diapers	- / -	- / -	- / -	- / -	- / -

** Counts of cigarette butts were divided by 20 to represent packs rather than individual cigarettes.*
*** The # of items represents the total number of products identified as that specific brand in 2016.*

TOP 5 BRANDS IN EACH PRODUCT CATEGORY

Brands were identified by the company's logo, its font style of any text, and/or the shape of the product or its packaging. The task was complicated by items being fragmented, and degraded or faded by sunlight. In one recent analysis of 1200 items collected by volunteers in the San Francisco Bay area, only 19% of items had recognizable brand information.[11] This data is hard to get.

In this analysis, we relied on information available from the mobile app "Litterati", whereby users photograph trash and have an option to write in brand information. Litterati utilizes brand data to share with brand owners, encouraging them to find more sustainable

solutions. Our study gathered data on 9 of the 20 categories we had created. However, since many of the brand categories are generic, like utensils and foam cups, brand identification can be challenging.

Our data is also influenced by a brand's market share. For example, Marlboro is the dominant cigarette brand for U.S. consumers, with 32% market share, which may explain its dominance as litter. Regardless of whether the brand tops the B.A.N. List because of high consumer purchasing or littering, alternatives are critical to protect public and environmental health.

Given these caveats, the table "Top Brands in Each Category" presents the best available top five brands identified in eight categories.

ARE BIOPLASTICS THE ANSWER?

AN OVERVIEW

WHAT ARE BIOPLASTICS?

There is much confusion surrounding terms such as biodegradable and compostable, as well as bioplastic, bio-based, bio-polymer, etc. While all of these terms have specific meanings, they are confusing to consumers. This confusion is often created by misleading, suggestive, and unclear marketing claims—statements, words, images and even packaging color and design. Terms such as "compostable", "biodegradable" or "ecofriendly" are used frequently on packaging in ways that confuse the public. This problem is compounded by the use of similar images and terms on plastics derived from fossil fuels in an attempt to gain customers who are seeking environmental attributes they believe bioplastics have.

Bioplastics and bio-based plastics are made from renewable feed stocks (biomass), like the leftover pulp from harvesting sugarcane. The feedstock however doesn't determine its compostability or biodegradability, the molecular structure does. Therefore using the word "Bioplastic" doesn't tell you anything about its performance in the environment, or its recyclability. Let's break it down.

Bio-based plastics are produced from monomers derived from biomass, like fermenting plant carbohydrates into ethylene, which can then be polymerized into polyethylene (PE). You can also make PET the same way. PET is the plastic polymer that water bottles, for instance, are commonly made of, and while nearly all PET water bottles are made from fossil fuel-derived plastic, PET can also be made from biomass, and is called bio-PET. Bio-PET, bio-PP, or bio-PE are no different than PET, PP or PE, the feedstock is just different—and none of them are compostable or biodegradable.

Bio-derived plastic is a mixture of plastics derived from both feedstocks, modern plants and fossil fuels. Having some of the feedstock come from modern plants allows companies to advertise with ambiguous words like "green" and "natural", and depicting green leaves and trees in their graphics. One example is the "Plant Bottle", a product from Coca Cola. Derived from up to 30% plant material and 70% or more other feedstocks, it is still 100% polyethylene. While the plant bottle is recyclable, it is not biodegradable or compostable, though the leaf in its design suggests otherwise.

Biopolymers, the truly biodegradable plastics, are made from a natural substance, such as chitin or cellulose, polylactic acid (PLA) made from plants,

or the polymer polyhydroxyalkanoate (PHA), which is naturally produced by bacteria. Producing bioplastics is a matter of extracting the polymer from the biomass directly. Although in some cases, like the textile rayon or cellulose acetate used for cigarette butts, the polymer is chemically modified to give it more durable properties for commercial use, so they resist biodegradation. PHA and PLA are the most common commercially used bioplastics for consumer goods. But these biopolymers, while considered compostable, are designed to be composted in industrial compost facilities, not backyard compost bins or the environment. This leads to further public confusion about which bin those products go in, or what happens if they become litter or enter the marine environment.

So, which ones are biodegradable or compostable? Bio-based and bio-derived plastics are neither, so they need to enter the recycle stream, and must be labeled in a way that doesn't mislead the public. When we talk about biodegradation, we mean that the polymer breaks down into smaller molecules, such as CO2, CH4 and H2O by microbial digestion. Biopolymers like PHA and PLA are biodegradable, but have very specific conditions where degradation happens. These conditions are not found in soil, home compost bins or the marine environment. According to most of the companies that use PHA or PLA, the ocean or a backyard compost bin is not considered an acceptable disposal environment for their product, although terms like "compostable" and "biodegradable" are still commonly used on packaging.

In summary, there's too much confusion. There is a need for consistent labeling on *all* products and packaging, using industrial standards (ASTM, ISO, EN) and more "truth in advertising" so the public understands how to be responsible with their bioplastics, and what happens if they become litter.

MAKING SENSE OF TERMS & STANDARDS: READING BETWEEN THE LINES

The difference between *biodegradability* and *compostability*, two terms commonly used interchangeably on products and packaging, are unclear to consumers and may lead to misconceptions and uninformed purchasing. As consumers demand more "green products," advertisers make claims that are easily misinterpreted.

"There's too much confusion. There is a need for consistent labeling on *all* products & packaging, using industrial standards... so the public understands how to be responsible with their bioplastics."

The Federal Trade Commission (FTC) has produced "Green Guides" to give producers some guidance. For example, the term *degradable* must only be used for materials that return to nature in a reasonable time frame, stating that "marketers must not make unqualified degradable claims for items destined for landfills, incinerators, or recycling facilities because complete biodegradation in those specific environments will not occur within one year."[12] The FTC states that to claim a product is compostable there must be reliable scientific evidence that all materials in the product or package will break down into usable compost in a safe and timely manner in an appropriate composting facility; "timely" meaning that it breaks down with other natural composting materials.[13]

In most cases, products and packaging refer to industrial standards that back up their claims, such as the "fine print" for numbers that begin with ASTM (American Society for Testing and Materials), EN (European Standard or literally "European Norms") or ISO (International Organization for Standardization). These are objective tests that define how a material behaves. So when a package label reads, "We conform to ASTM 6400" it means that bacteria can break down the packaging in a setting over 50°C, which may be achievable in a municipal composting facilities, but not typically in your backyard compost bin. These tests are used by companies to abide by FTC rules to

clarify compostability or degradability.

California has some of the most strict "truth in advertising" guides in the country,[14] recently passing SB 567 that expands the current scope of labeling requirements from bags and food packaging to all plastic products. The term biodegradable cannot be used on any plastic product whatsoever. Unless a product or packaging is truly compostable or marine degradable by established standards, like the European Vincotte OK Compost HOME Certification, then those terms cannot be legally used.

To better identify and certify that industrially compostable plastics really do meet applicable ASTM standards (ASTM D6400 and ASTM D6868), and are not suitable for backyard composting, BPI (Biodegradable Products Institute) provides a review and certification of testing results that allows a product to be labeled as certified compostable using the BPI Compostable Label.[15] Even with this certification, there are sometimes mixed results at compost facilities due to the wide range of parameters and technologies used at these facilities. That is why some cities, such as the City of Seattle, also require "field testing" at local compost facilities. Cedar Grove Composting has long been known for field testing compostable packaging, which can use the Cedar Grove Compostable label if shown to successfully compost. To address that there are a number of different industrial compost facility technologies in use, the Compost Manufacturing Alliance now provides field testing services using a variety of compost technologies.[16]

The Biodegradable Products Institute seal.

There is an additional category of materials that are particularly problematic and confusing. These blend plant based materials, such as starch, with fossil fuel based plastic, such as polypropylene. These materials are not biodegradable, compostable or recyclable, but are claimed to be superior because they reduce their fossil fuel use through using some renewable materials in their make up.

LET'S DEFINE SOME OF THESE COMMON STANDARDS:

ASTM D6400 tests whether the material is compostable in a municipal composting facility. This test lasts a minimum of 90 days, but up to 180, testing microbial degradation at consistent temperatures greater than 50°C. Exposed to an inoculum derived from a municipal waste stream, the material should biodegrade completely.

ASTM D5338 is a standard biodegradation test that measures aerobic biodegradation of plastic materials under controlled composting conditions for a minimum of 90 days. ASTM D5338 is a core component of ASTM 6400 Compostability Test Method, which is recognized by many regulatory agencies and municipalities, and the FTC as a requirement for making biodegradability claims about a product or material. It's primarily used for materials that have not made it to the waste stream yet, often being used for materials intended to test food and beverage containers.

ASTM D5511 tests anaerobic biodegradation of plastic materials under high-solids anaerobic-digestion conditions. This procedure has been developed to permit the determination of the rate and degree of anaerobic biodegradability of plastic products when placed in a high-solids anaerobic digester for producing compost from municipal solid waste. The test measures degradation under accelerated conditions and does not show real world composting/landfill conditions. It's important to note that this is a measure of degradation, rather than a pass/fail test. It was been incorrectly used by companies and municipalities to claim that a material is "proven" to degrade in landfills. This test method is equivalent to ISO 15985.

ASTM D6868 tests the compostability of biodegradable plastic linings and coatings for products and packaging that want to claim, "compostable in municipal and industrial composting facilities." It

must compost at a rate similar to other compostable materials and not diminish the quality of the resulting compost. This specification covers biodegradable plastics and products (including packaging), where plastic film or sheet is attached (either through lamination or extrusion directly onto the paper) to substrates and the entire product or package is designed to be composted.

ASTM D6691 tests the biodegradabilty of bioplastics in marine sediment at temperatures as high as 28C. It has been used by some companies to claim "marine degradable," though in the ocean, temperatures in deeper waters fall well below this (4C at 2000 m). Testing bioplastic degradation in a relatively warm, microbe-rich laboratory setting is very different from the cold, dark environment where microbial activity slows down. Since PHA and PLA sink in seawater, they would likely remain intact for a very long time.

ASTM D6954 measures the degree to which plastics degrade in the environment by a combination of oxidation and biodegradation.

EN 13432 sets limits on the kind of chemical additives used (Cu, Zn, Ni, Cd, Pb, Hg, Cr, Mo, Se, As and fluoride) and requires biodegradation of 90% of the material in six months or less. It also requires that physical decomposition in the first three months be defined by a 90% breakdown of the material into particles less than 2x2mm.

ISO 14855 is a test that determines ultimate biodegradation of plastic materials under composting conditions. It measures the anaerobic biodegradation by the analysis of carbon dioxide created by microorganisms during the biodegradation process. Like D6400, this test is for a minimum of 90 days and reflects composting conditions similar to an industrial composting facility, not a backyard compost bin.

ASTM D7081 tested whether or not materials are marine degradable. (*This standard has been withdrawn and not replaced as of 2017*). This specification covered plastic products (including packaging and coatings) designed to be biodegradable under the marine environmental conditions of aerobic marine waters or anaerobic marine sediments, or both, in 30 °C for 180 days. (Possible environments are shallow and deep salt water, as well as brackish water. This specification is intended to establish the requirements for labeling materials and products, including packaging, as "biodegradable in marine waters and sediments."

There are a variety of home compostability certifications, including those used in (left to right) Germany, Belgium, and Australia & New Zealand.

Home Composting Certifications.[17] There are two that specify home compostability: DIN CERTO in Germany and Vin-Cotte in Belgium. Australia and New Zealand use AS 5810[18] for home compostable plastics, which require that after 180 days all of the material must pass through a 2mm sieve and leave zero toxicity from the material, inks, dyes, or other additives.

BAN OXO-BIODEGRADABLES

Polyethylene, polypropylene or polystyrene combined with a metal salt additive to speed up the oxidation process is known as oxo-biodegradable plastic. These plastics are not considered compostable according to ASTM D6400 and EN13432, primarily because they do not meet the 180 day degradation limit, even in a high-heat municipal composting environment. There are additionally many cases where degradation results in fragmentation, leaving residual microplastic behind. One study of oxo-biodegradable plastic bags in the marine environment found that after 40 weeks more than 90% of the material was still present.[19] In other similar studies, degradation was found to be incomplete.[20] Because of the lack of environmental performance relative to claims, some countries are considering bans on oxo-biodegradable packaging.[21] The New Plastics Economy has organized over 150 organizations and companies to support a global ban on oxo-biodegradable plastics.[22]

ARE BIOPLASTICS THE ANSWER?

THE CASE STUDY

FOCUS

This case study is focused on understanding the performance of bioplastic products and packaging in two realistic settings. These settings—the ocean and a typical backyard compost bin—were established for two years. Twenty different items were placed in each setting. The results show that most bioplastic products persist in the environment like their petroleum-based plastic counterparts. Therefore, the same argument made for restricting single-use disposable plastic products should apply to bioplastic products.

METHODOLOGY

To understand the performance of a variety of products using confusing terms and claims about their degradation properties—like cups, utensils, straws and bags—we collected 20 different products made from PLA (polylactic acid) and PHA (polyhydroxyalkanoate), as well as some non-bioplastic polyethylene-lined products.

One important caveat to note here: some of these products claim that they must be placed in an industrial composting facility, where large piles of decomposing natural materials provide a microbe-rich, moist and warm setting for decomposition. What happens however when these products are lost in the environment, like many other single-use, throw away types of packaging? To answer this question, we tested them in real environmental conditions on land and in the sea: a home compost box and under a dock in a saltwater marina.

We made 4 sets of each of the 20 products and packaging, burying one in a backyard compost box for 6 months, a second for 12 months, and the last for two years. The composting environment was an open-air box, with the items placed in clay flower pots, and then buried 6 inches and left untouched in the composting bed until recovered. This served as a stand-in "best case" scenario for if that product was littered on land and was in contact with soil. It was not meant to simulate an actively managed and turned home compost system or an industrial compost environment.

The fourth set was submerged under a dock in the ocean for 2 years. Each of the 20 items was put into a 1/3 mm mesh nylon bag, then positioned side-by-side in the crate, weighted by a layer of bricks on the bottom.

One set of plastic products was tested by submerging it under a dock in the ocean for 2 years.

LESSONS LEARNED FROM THE CASE STUDY

1 Test in real conditions with real products. The purpose of this case study was to understand what happens to bioplastic products and packaging that enter the environment, whether it's the ocean or side of the road, or tossed in an average residential compost bin. ASTM, ISO and other tests often use "raw" feedstocks of biopolymers, rather than finished products that contain different plasticizers, like colorants, UV resistant agents, labels and laminates. The ASTM standards used to define the degradation of bioplastics need to mimic real conditions, such as in the ocean, where bioplastic might interact with biota, be impacted by waves, or buried under sediment. While our "sunken crate" mimicked burial in the marine environment, there's more to the story of how bioplastics behave in the marine environment. Testing the whole product, with labels and caps on, laminates of paper and metal intact, and in real environmental conditions will help better understand the true life cycle of bioplastics.

2 Labels need to be clear for consumers, recycling centers and composting facilities. Terms like "ecofriendly" or "degradable" can be misleading to consumers, but companies can be more clear if they use testing standards.[23] Of the 16 bioplastic products in this case study, only five referenced specific ASTM or ISO standards for *degradability* or *compostability*. To avoid confusion, contamination and improve proper collection, accurate certification and labeling are essential for all bioplastics. For example, a PLA cup accidentally mixed with PET bottles contaminates and devalues the recycled polymer. With no such labeling, management becomes a guessing game with the likely result that the bioplastic products end up in landfill or being incinerated.

The results show that most bioplastic products persist in the environment just like their petroleum-based plastic counterparts. Therefore, the same argument made for restricting single-use disposable plastic products should apply to bioplastic products.

3 Fragmentation is not biodegradation. Only the paper straw, starch packing peanuts and PHA beach toy decomposed beyond visual observation. In all other cases, objects either stayed whole or fragmented into smaller pieces. Volatile compounds added to plastic to make them flexible or UV resistant often oxidize, leaving the remaining plastic polymer brittle and vulnerable to fragmentation by mechanical forces. The polymer is still there, just in smaller pieces. It is important not to confuse fragmentation with degradation. However, pitting or peeling on the surface of biodegradable plastic products usually does indicate microbial activity and biodegradation.

4 Bioplastics are not functional replacements for the majority of single-use, throw away products. While the ideal packaging material would be like the skin of a grape—biodegradable in all environments (compost facilities, on land, and in water)--most bioplastics are not. The products and packaging studied here did not degrade in time frames similar to natural materials, if they even degraded at all. As more composting facilities open, and the volumes of material they receive drive them to demand fast and reliable composting rates, bioplastics are not performing as expected. Given the lack of ideal bioplastic material for all environments, following the waste hierarchy continues to make sense: reduce (eliminate use in first place), opt for reusables, and as a last resort, recycle and compost.

5 The right place for biodegradable plastics. An anonymous PHA manufacturer suggested that the market for bioplastics will be found, "in environments where degradation is desired, like agricultural films to cover crops to keep moisture in and weeds out, therefore improving harvest and leaving a nutritive material to be composted. Also in aquaculture, where occasional loss of gear to the sea happens, biodegradable plastic components eliminate long lasting waste."

6 Increasingly, many municipalities are diverting residential food waste away from landfills with curbside collection. In several cases biodegradable bags are allowed to contain food waste destined for municipal composting facilities.

CASE STUDY RESULTS BY CATEGORY

The 20 products were divided into four groups:

BAGS

PRODUCT	STANDARDS & CLAIMS	ENVIRONMENTAL PERFORMANCE
		New · 6 mo. on land · 12 mo. on land · 24 mo. on land · 24 mo. in the sea
 PrideGreen Zip-lock bags	Oxo-assimilation ASTM D6954-04. Landfill degradation in 18-36 months.	
 Bags on Board Pet waste bags	Environmentally friendly	
 Bio Bag Bags	Certified compostable. Meets ASTM D6400.	

BAGS

Three kinds of bags were tested:

- Bags on Board pet waste bags
- Pride Green ziplock bags
- Bio Bags bags

The Bags on Board pet waste bag is made of polyethylene, and as suspected, remained intact in both land and sea environments over the 2 years. The Pride Green bag is an oxo-biodegradable polymer, resulting in our test in fragmentation on land and no change at all after 2 years in the ocean. The label states it conforms to ASTM D6954—environmental degradation through a combination of biodegradation and oxidation, but in this test in real conditions as environmental pollution, it did not degrade.

The best performing of the three was the Bio Bag, which disintegrated on land in 6 months and was completely disintegrated in the ocean after 2 years. The polymer for this plastic is called Matter-Bi, described on the company website as a "pioneering proprietary technology using starches, cellulose, vegetable oils and their combinations", and advertising industrial and home composting, under ASTM D6400. While this bag degraded in all environments, we do not recommend any bioplastic polymer as a functional replacement for single-use throw away grocery bags. Although, many communities that are developing residential food waste collection are permitting collection bags, like BioBags, because of their ability to hold wet organic waste and still degrade efficiently in industrial composting conditions.

BAGS ON BOARD PET WASTE BAGS

PRIDE GREEN ZIPLOCK BAGS

BIO BAGS

BABY WIPES & DIAPERS

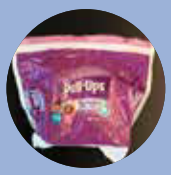
PRODUCT	STANDARDS & CLAIMS	ENVIRONMENTAL PERFORMANCE

Eco Natural Diapers

Fully compostable*, EN 13432, ASTM D6400 (*compostable in some municipal facilities)

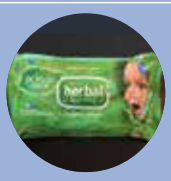
Eco-Me Baby Wipes

Made of natural materials. Please recycle wipes.



Huggies Baby Wipes

Breaks up after flushing. Safe for sewer and septic systems.

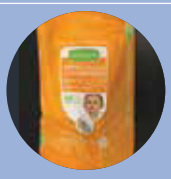


Jackson Reece Natural Herbal Baby Wipes

Biodegradable. Kinder by nature.

Earth-Friendly Baby Baby Wipes

100% Biodegradable and kinder to the environment



Elements Naturals Baby Wipes

100% natural and compostable. Compostable to ISO, ASTM, EN regulations.

BABY WIPES & DIAPERS

There were six products compared in this category:

- Eco-natural diapers
- Eco-Me baby wipes
- Huggies baby wipes
- Jackson Reece Natural Herbal baby wipes
- Earth Friendly Baby baby wipes
- Elements Naturals baby wipes

Of these, the diapers remained unchanged in all environments over time. Recycling these diapers is nearly impossible because the diaper's liner, outer shell, and the absorbent are all different polymers.

Element Naturals baby wipes, made from PLA branded as "Ingeo", did not degrade on land, but were completely degraded in the ocean. The other four brands of baby wipes were completely disintegrated after 12 months on both land and in the ocean in all time frames. Only one of the four brands, Jackson Reece, identifies the polymer, describing it as a cellulosic fiber from plant material.

ECO-NATURAL DIAPERS

ECO-ME BABY WIPES

HUGGIES BABY WIPES

EARTH FRIENDLY BABY BABY WIPES,

JACKSON REECE NATURAL HERBAL BABY WIPES

ELEMENTS NATURALS BABY WIPES.

CUPS, STRAWS & UTENSILS

PRODUCT	STANDARDS & CLAIMS	ENVIRONMENTAL PERFORMANCE

Eco Products Cold Cups

Compostable BPI certified, made from corn

Planet Compostable Hot Cups

Compostable. Made from Ingeo, a brand name for PLA.

Aardvark Paper Straws

Described as "Earth-friendly".

World Centric PLA Straws

100% compostable, ASTM D-6400, EN13432. Breaks down in commercial compost.

Rossetto Cutlery

Compostable, natural materials.

Bio-Based Eco-Products PSM Cutlery

Made from 70% renewable resources. Not compostable.

CUPS, STRAWS & UTENSILS

There were six products compared in this category:

- Eco Products cold cups
- "Planet" coffee cup (lined with Ingeo, a brand of PLA)
- Aardvark paper straws
- World Centric PLA straws
- Rossetto utensils
  (made from Plantware, a brand of PLA)
- Eco Products utensils
  (made from plant starch material—PSM)

Two brands of cups were tested. Of the two cups, one was for cold beverages and the other for hot liquids. Eco Products Cold Cups, made from PLA and commonly used at events as a substitute for throwaway plastics, did fragment into large pieces on land after two years, with its original volume seemingly intact. In the ocean, there was no recognizable change after two years, despite some warping of the cup's underside. The hot liquids cup, called "Planet", had lost all of it's paper in one year on land, and after two years in the ocean. The thin PLA lining however remained, though fragmented, on land and in the ocean.

There were two straw brands: Aardvark paper straws and World Centric PLA straws. The paper straws fragmented and were quickly unrecognizable on land, and in the ocean. The PLA straws remained unchanged in all environments after two years, with minimal fragmentation.

The two utensil brands were Rossetto and Eco-Products. The Rossetto utensils (all knives) are made from Plantware, a brand of PLA. In both land and sea there was no change, only discoloration. Eco-Products utensils, made from Plant Starch Material (PSM), performed similarly to the Rossetto utensils, with no observed change. PSM is a blend of plant starch and polypropylene and is not meant to be compostable. The company admits that their product does not meet ASTM6400, but is a step away from plastics based on fossil fuels.

ECO PRODUCTS COLD CUPS

"PLANET" COFFEE CUP

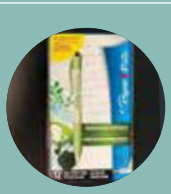
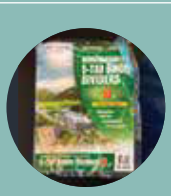
AARDVARK PAPER STRAWS

WORLD CENTRIC PLA STRAWS

ROSSETTO UTENSILS

ECO PRODUCTS UTENSILS

MISCELLANEOUS POLYMERS: PHA, PLA, STARCH, POLYSTYRENE

PRODUCT	STANDARDS & CLAIMS	ENVIRONMENTAL PERFORMANCE
		New · 6 mo. on land · 12 mo. on land · 24 mo. on land · 24 mo. in the sea
 Dansa LLC Sink Strainer	100% Biodegradable 5 months, corn starch.	
 Papermate PHA Pen	Biodegradable in soil/ compost in 1 year	
 C-Line Binder Divider	Biodegradable to ASTM D5511. Polyropylene. EcoPure, 2-5 yrs in landfill.	
 Zoe B PHA Beach Toys	First biodegradable beach toy.	
 Packing Peanuts	Foam polystyrene	
 Packing Peanuts	Starch	

MISCELLANEOUS POLYMERS

There were six products compared in this category:

- Dansa sink strainer
- Papermate pen (made from PHA)
- C-Line Binder Dividers
- Zoe-B beach toy (made from PHA)
- Packing peanuts (foamed polystyrene)
- Packing peanuts (starch)

Two were products using the polymer polyhydroxyalkanoate (PHA), a beach toy cup and a Paper Mate pen. Two were foam packing peanuts, one made from starch and the other polystyrene. We also tested a sink strainer that was labeled 100% biodegradable and made from 100% cornstarch. Lastly, we found a folder binder divider made of polyethylene, and labeled "Biodegradable" due to the additive with the brand name "EcoPure".

The results were fascinating. The packing peanuts performed as expected. The starch ones completely degraded in all environments and time frames, while the polystyrene packing peanuts were unchanged. The folder binder divider, while labeled clearly as biodegradable and used ASTM D5511 to imply degradation, remained unchanged on land and sea in our experiment. Their branded polymer EcoPure is described on their website as an additive that "allows microbes to create a film that coats the plastic waste," increasing biodegradation rates in a landfill setting. In our experiment nothing happened. There was no pitting or discoloration on the plastic surface.

The sink strainer, made from 100% cornstarch, advertised 100% biodegradability, and included a series of three photos of the strainer disappearing in a home composting environment in 5 months. In our study, the sink strainer remained unchanged after two years on land and in the ocean.

The PHA products performed the best. The Paper Mate pen had PHA components combined with metals and other plastics. Only the PHA components were tested, and in two years on land they began to fragment. Degradation was nearly complete after two years in the ocean, with only a few observable fragments remaining.

The PHA beach toy, labeled as biodegradable, remained whole after 2 years on land, though cracked and pitted. It even had a plant growing out of it two years later, with the ball of roots nestled inside the cup. Impressively, in the ocean it had completely decomposed with no fragments observed.

DANSA SINK STRAINER

C-LINE BINDER DIVIDERS

PAPERMATE PEN

ZOE-B BEACH TOY

THE SOLUTION STRATEGY

For most of the items on the Plastics Better Alternatives Now List 2.0, the best alternative is to replace harmful plastic products with reusable/refillable products that can provide the same service without using any disposable materials at all. We call this a "functional replacement" of an unnecessary, harmful plastic product.

In many cases, the next best strategy is to substitute the harmful plastic product for another disposable product that is readily biodegradable in the environment, such as paper straws and bags. Compostable materials that biodegrade in commercial composting facilities and meet established standards (ASTM D6400 or D6868) are widely available as an alternative material for many plastic packaging and food service ware products. While these biopolymers do not perform well in the environment, land or sea, they are a step away from fossil fuel-derived plastics.

We recognize that plastic helps to provide important product protection by preventing contaminants from spoiling food. Innovation will play a critical role. Consumer goods and food service companies should invest in truly biodegradable packaging technologies that allow comparable levels of product protection—without harm. And where fossil fuel based plastics are still being used in consumer products, we recommend increasing recycled content over time, ideally reaching 100% post-consumer recycled content. This will help to better foster a circular economy, spur design innovation and increase efficiency.

The best alternative is to replace harmful plastic products with reusable or refillable products that can provide the same service without using any disposable materials at all.

Better Alternatives

1. FOOD WRAPPERS & CONTAINERS

Beyond cigarette butts, food wrappers and other types of food packaging are the most abundant items found in the environment. From potato chip bags and candy wrappers, to cookie and cracker trays, single-use disposable and non-recyclable packaging is everywhere. The impacts are seen across the U.S. and in the trillions of plastic particles floating in the ocean, where they accumulate toxic chemicals and are ingested by marine wildlife.

Better Alternatives

Grocers and food-service establishments are key to giving consumers a choice of products and packaging to consume. Many grocers have adopted mission statements reflecting their values, like minimizing waste and improving the quality of their products. Examples include providing opportunities for bulk purchasing, incentives for bringing reusable bags and containers, eliminating single-use plastics from product lines and food service counters, as well as improving recovery and recycling of plastic film used to wrap pallets.

Restaurants are increasingly eliminating disposable packaging from their businesses. Programs like Surfrider's "Ocean Friendly Restaurant"[24] guide businesses toward zero waste practices. They largely focus on eliminating single-use packaging from to-go orders, but also eliminate waste indoors by providing straws only on request and then, offering paper straws.

2. BOTTLE & CONTAINER CAPS

Because bottle caps are thick and float in seawater, they fragment slowly, and are commonly found adrift and washed ashore on remote beaches worldwide. Marine life often mistake them for food. For some seabirds, such as the Laysan Albatross in the North Pacific or the Fulmar in the North Atlantic, ingestion of bottle caps and their fragments are common. This can cause perforations to the gut lining or a false sense of satiation resulting in less feeding, malnourishment and vulnerability to illness.

Better Alternatives

Using reusable bottles for water, soda and other beverages solves this problem. For commercial beverages sold in PET (#1), and HDPE (#2), companies can employ "Connect the Cap" technology to ensure that the cap stays attached to the bottle. Manufacturers should begin voluntarily making this change; policymakers can speed the process by advancing "Connect the Cap" legislation. Advances in recycling technology now enable both the bottle and cap (which are made from different plastics) to be recycled together.[25]

BOTTLE RETURN & RE-USE

THROUGHOUT CANADA brand-owners and beverage bottle importers finance the majority of container recycling and recovery costs through payments directly to municipalities to collect, process and find markets for recyclables. These costs have and likely will be borne by industry through proposed legislation. To date, many cities have used these funds on recycle bins and public awareness campaigns, resulting in a successful model to follow.

Canada's overall recovery rate for refillable and nonrefillable bottles is estimated at 66%. Of this amount, refillable beer, representing a minority of total beverage sales (19%), is recovered at a collection rate of 98%. Non-refillables, which comprise the majority of containers (81%) has an estimated collection rate of about 59%. Combined, Canadian deposit systems have a total recovery rate of 83%, while non-deposit systems have a total recovery rate of 41%, when all containers sold and recovered at home and away-from-home are accounted for (Morawaski, 2010)*.

Beverage bottlers, retailers and distributors are increasingly taking responsibility for the full lifecycle of their materials, with the aim of increasing efficiency, uniformity, consumer buy-in, all the while limiting impact on sales. Canada's models for industry participation in the circular economy is successfully shifting responsibility to the producer.

It is a model the U.S. can replicate in order to expand current U.S. bottle redemption programs beyond the 10 states that have them currently.

** Morawski, C., 2010. Who pays what: An analysis of beverage container recovery and costs in Canada. CM Consulting, Ontario, Canada.*

3. BEVERAGE BOTTLES

Across the U.S. plastic bottles, including PET (#1), HDPE (#2) and PP (#5), are recycled at a rate of 29.7% in 2016, a decrease from previous years.[26] Recycling of plastics is competing with cheaper new ethylene from producers, which is affecting the value of recycled material worldwide.[27]

Bottles of all kinds are ubiquitous as waste, and are common on remote beaches worldwide, often carrying hitchhiking marine life, called "invasive species" across oceans.

Better Alternatives

Much of the waste from bottled water can be eliminated through investing in easy-to-access public drinking fountains and water bottle refill stations. Soda and juice bottle waste can also be cut down through strategies to encourage refillable containers at specialized fountains. Businesses, institutions, universities and schools can all contribute by phasing out bottled water and encouraging reusable/refillable bottles and cups for water and other drinks. For commercially sold drinks in PET and HDPE bottles, policymakers can also help decrease litter and boost recycling by increasing the container-deposit for these bottles. Research shows these policies work: In Michigan, the state with the highest container deposit of 10 cents, container-recycling rates are at 94%, the highest in the country.

4. PLASTIC BAGS

Ubiquitous in the environment, plastic bags pose threats to wildlife on land and sea, while polluting our lakes, rivers, beaches, and ocean. Plastic bags are "escape artists" blowing out of trash cans, landfills, getting stuck in trees and tall fences, as

well as clogging storm water drains, all of which are added costs to municipal waste management and create urban blight. Increasingly, animals like goats, cows, horses and camels, are treated for plastic bag ingestion, which results in blockages, dehydration, starvation, or sepsis from bacterial infections. Plastic bags can also damage recycling infrastructure at Material Recovery Facilities and lead to costly shutdowns and repairs. When they are collected, they are often too dirty for domestic recycling markets, and therefore often exported to South East Asia where environmental and worker health standards are low or nonexistent.

Better Alternatives

Studies show that plastic bag pollution can be dramatically reduced through policies that place fees on bags or ban their use outright, as well as encouraging reusable bags. Disposable shopping bags made from high-recycled-content paper or other non-plastic, biodegradable alternatives help prevent plastic pollution. Grocers, retailers and take-out food service establishments can implement in-store policies to encourage reusable bags and phase out disposable plastic ones.

5. STRAWS & STIRRERS

Plastic straws and coffee stirrers are also common throughout the United States, topping the list on trash surveys. They're everywhere, and like bottle caps, plastic straws float. They threaten wildlife and contribute to the growing ocean plastic epidemic.

Better Alternatives

Restaurants and food-service establishments can help by switching to a "straws upon request" policy and by providing paper, rye wheat, bamboo, reusable glass, steel or metal straws for eat-in dining. For take-out, 100% paper straws can be substituted for plastic, while coffee shops can provide reusable spoons or wooden stirrers. Some paper straws have a plastic lining, which should be avoided. Policymakers should look to plastic straw bans combined with "straws upon request" requirements as a way to encourage universal adoption of these changes.

6. LIDS

Coffee and beverage cup lids are another high-pollution item. Coffee lids are typically made from polystyrene; styrene, a primary component

of polystyrene, is a suspected human carcinogen. Workers in polystyrene factories are at greatest risk for harmful health impacts from styrene exposure.[28]

Better Alternatives

The best solution is for coffee shops to encourage customers to bring reusable cups with lids, through discount incentives. Soda lid waste can also be cut down through strategies to encourage refillable containers at soda and juice fountains. While some companies have recently switched from polystyrene to polypropylene lids, we suggest the next best alternative would be to substitute with a compostable or biodegradable lid. Another important consideration is the role heat plays in drawing volatile compounds out of any plastic, therefore it is especially important that any lid designed to contain hot liquids be free of harmful additives.

7. UTENSILS

Disposable plastic utensils are another common item found in the environment with deadly consequences for marine mammals, sea turtles and birds that ingest the sharp, rigid particles from fragmented plastic forks, knives and spoons.

Better Alternatives

Restaurants and food service establishments can help solve the problem by replacing disposable plastic with reusable utensils. Research shows that going reusable saves money over disposables even when figuring in the increase of capital investment and some increased labor costs. For take-out, restaurants can also encourage customers to use their own utensils, and substitute single-use, biodegradable options such as bamboo for plastic when customers haven't brought their own. Policymakers can speed these changes by banning non-recyclable plastic utensils.

8. CIGARETTE BUTTS

For the purposes of this report, cigarette butts were assessed by the pack since they are purchased in packs of 20. The ubiquity of cigarette butts, despite increases in municipal ordinances to curb smoking in public spaces, suggests that the public still misunderstands what they are made of as well as their toxicity and persistence. Cigarette butts are made from fibrous cellulose acetate and other plastics; they are non-biodegradable and leach toxins into the environment.

Better Alternatives

Obviously—for so many reasons—the best alternative is not to smoke. For those who do however, there are biodegradable cigarette filters that can replace plastic.[29] In light of this design opportunity cigarette companies should aggressively switch to biodegradable filters, and policymakers should look into

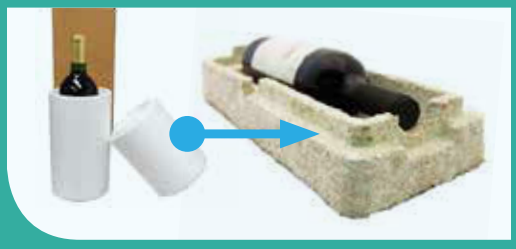
The global distribution of policy initiatives to address polystyrene waste.[30]

SOLVING THE POLYSTYRENE PROBLEM

BETTER KNOWN AS STYROFOAM, polystyrene foam (or EPS, expanded polystyrene) is often the most abundant item counted in the environment, largely because of its ability to fragment into smaller pieces. This means that EPS products often shred, and are therefore wildly underrepresented in this study's attempt to determine their numerical abundance.

Their ubiquity, durability, and ability to accumulate high levels of persistent pollutants make degraded EPS products harmful in the environment, particularly when UV degradation causes the polymer polystyrene to break down into the monomer styrene. Recycling EPS has been a failure in most cities because of food waste contamination, and the difficulty of recovering high volumes of EPS. its low market value. Replacing EPS is a high priority.

There are natural packaging alternatives—such as mushroom foam and starch-based packing peanuts—as well as certified compostable plates, cups and bowls, which are becoming more economically viable as a cost-competitive replacement. Schools are getting rid of EPS lunch trays. University and government facilities are replacing EPS packaging. The list of complete or partial polystyrene bans is sweeping the United States. The tide is turning.



Polstyrene packaging can be replaced with 100% home comopostable mushroom packaging.

requiring cigarette companies to make the switch.

Many municipalities are increasing public containers for cigarette butt waste. The organization Surfirder recently instituted a program titled, "Hold onto your Butt", to encourage users to carry their cigarette butts with them until they find a suitable waste bin.

9. TAKE-OUT CONTAINERS

Not surprisingly, plastic take-out containers are some of the most-widely found items in litter surveys. Primarily made from polystyrene foam or thermoformed PET, these products are another high-pollution item.

Better Alternatives

Restaurants and food-service establishments can institute strategies to support customers using reusable or bringing their own take-out and take-away containers. For example, restaurants, grocers and food purveyors can provide reusable containers with deposits to bring back to stores, discounts for bringing your own take-out containers, and non-plastic biodegradable alternatives for customers that don't have them. Companies should focus on making the switch to these alternatives and pushing for reusable and compostable take-out containers made without toxic chemicals. Policymakers can support this transition by banning polystyrene take-out containers and supporting changes in health-codes to enable the use of reusable containers. In some cases, certified compostable biomaterials are a viable and functional alternative. However the use of persistent, hazardous chemicals in food contact materials can negate the benefits of using certain compostable packaging. Greater transparency is needed about the chemical safety of food packaging. In addition, a viable composting infrastructure is needed to ensure the materials are actually composted.

CONCLUSION

B.A.N. LIST 2.0 IS A CALL TO ACTION!

The ubiquity of single-use plastic packaging as a pollutant across our land and waterways is unacceptable. But there are solutions that can move us toward zero waste, eliminating our dependence on single-use plastic and restoring the health of our planet. Hundreds of organizations are now working together to lead the way, demanding that producers take responsibility for the full life cycle of what they create. The public can no longer be expected to bear the sole burden of addressing this legacy of pollution. The brand owners whose products and packaging appear on this B.A.N. List must make changes, and individuals, as their customers, must demand that they do.

Moving forward, there is an important role for businesses in the United States to demonstrate global leadership to solve plastic pollution. For example:

- Many of the major fast-moving consumer goods companies, packaging suppliers and plastics manufacturers are headquartered in the United States. The decisions made in board rooms here have ripple effects throughout the world.
- A significant amount of the global consumer economy is driven by North American brands and exported globally so a consciousness shift here can help lead to transformation around the world.

Through mapping the system with leading experts, our analysis shows the most effective strategies to solve plastic pollution are to: **a)** drastically reduce and eventually eliminate the use of plastic for single-use-disposable products and applications, **b)** develop reusable systems for appropriate to-go food and beverage products, while **c)** advancing extended producer responsibility (EPR)—which makes consumer goods companies responsible for financing collection and recycling—to manage the remaining plastic in commerce.

We're going to need companies—in all shapes and sizes—to recognize that the indiscriminate use of disposable plastic packaging is a liability for their business and could negatively impact customer loyalty. We need them to see the

advantages and market opportunities inherent in more sustainable reusable packaging systems and non-plastic packaging alternatives.

In addition, we need city governments across the U.S. to prioritize action on plastic pollution. They need to work with business to implement the policies and solutions that can transform our throw-away-society, with reusable to-go food and beverage systems along with the supporting infrastructure.

EXTENDED PRODUCER RESPONSIBILITY

Extended Producer Responsibility (EPR) is our goal. This strategy integrates environmental and social justice costs into the life cycle and market price of products. Over a billion people in more than 50 countries live in jurisdictions where producers bear some or all of the cost of managing packaging when consumers are finished with it. In Europe, EPR programs for packaging have existed for decades, yet with the exception of container-deposit laws commonly called bottle bills—EPR for packaging programs do not exist in the United States.

- The 20 products on the B.A.N. List represent a design flaw, resulting in their ubiquity as waste. The industries that make these products have an opportunity to design the solution, which can include a range of possibilities: reusable alternatives, materials that are recyclable within a technical or biological system, or even simple reduction.

- Recycling must always come second, after reduction. The new narrative is about less waste, not solely waste management on the citizens' dime. Municipalities and taxpayers no longer want to subsidize increased waste management fees due to the proliferation of over-packaged and poorly designed products. EPR is about corporations transforming their product delivery systems to align with a circular economy.

It is imperative that corporations step up to the plate, be accountable for product design failures, and work on the solutions outlined in this report. B.A.N. List 2.0 is about equitable accountability between industry, government, and consumers. With shared responsibility, solutions will come.

HOLDING BRANDS RESPONSIBLE

When we scoured datasets across the U.S. for trash on the ground and in our waterways, we found lists of products and packaging, but a lack of specific brand names. This results in a skewed focus on consumer behavior for littering and government responsibility for waste management while neglecting producer responsibility for the lifecycle of what they create and sell. Though brand data is scarce, this is changing.

The mobile app Litterati encourages users to assign brands to the products and packaging they photograph. With improvements in machine learning, Litterati is getting better at identifying brands. For B.A.N. List 2.0 we were able to assign brand data to 8 of the top 20 items picked up across the U.S. For example, in the most abundant category—food wrappers—the brands *Wrigley's*,*Trident*, *Swisher Sweets*, *Starburst* and *Snickers* topped the list. For cigarette butts, the brands *Marlboro*, *Camel*, *Parliament*, *Newport* and *Pall Mall* were listed as the top polluters. These data are critical for advocacy campaigns. They can also be useful for the brands themselves to address product design choices prior to potential policy demands.

CONCLUSION

In this two-year study, 5 Gyres demonstrated that across the United States, single-use plastic products and packaging do not degrade and persistently pollute our environment. Significant environmental and economic harm is caused by this waste, yet producers have been let off the hook because the existing economic structures place responsibility to address the problem on individual taxpayers and municipalities. The brands associated with the plastic pollution documented in this study must be held accountable. They need to take part in revolutionizing the design of their products and packaging. Further, the economic systems that promote such waste must be revamped. They need to become part of the global network of organizations, governments and businesses that are advancing Zero Waste initiatives and the Circular Economy. For the health of life on our planet now and for future generations, we must usher in alternatives that promote more responsible stewardship of our natural resources.

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Acknowledgements

We would like to thank Literatti for providing brand data on the B.A.N. List product categories. • Also, Dianna Cohen for art direction for the design of this guide and Wayne M. Deselle/deselle.com for completing the graphic design of this document, and the staff of the Global Wave Conference 2018 held in Santa Cruz, CA for allowing B.A.N. List 2.0 to be launched there. • The biodegradation study could not have been completed without the hard work of students from Team Marine, an ocean conservation organization based on the campus of Santa Monica High School, in California. • The BAN list dataset was compiled and merged by Win Cowger, Graduate Student in the Gray Lab (UCR, Environmental Science)

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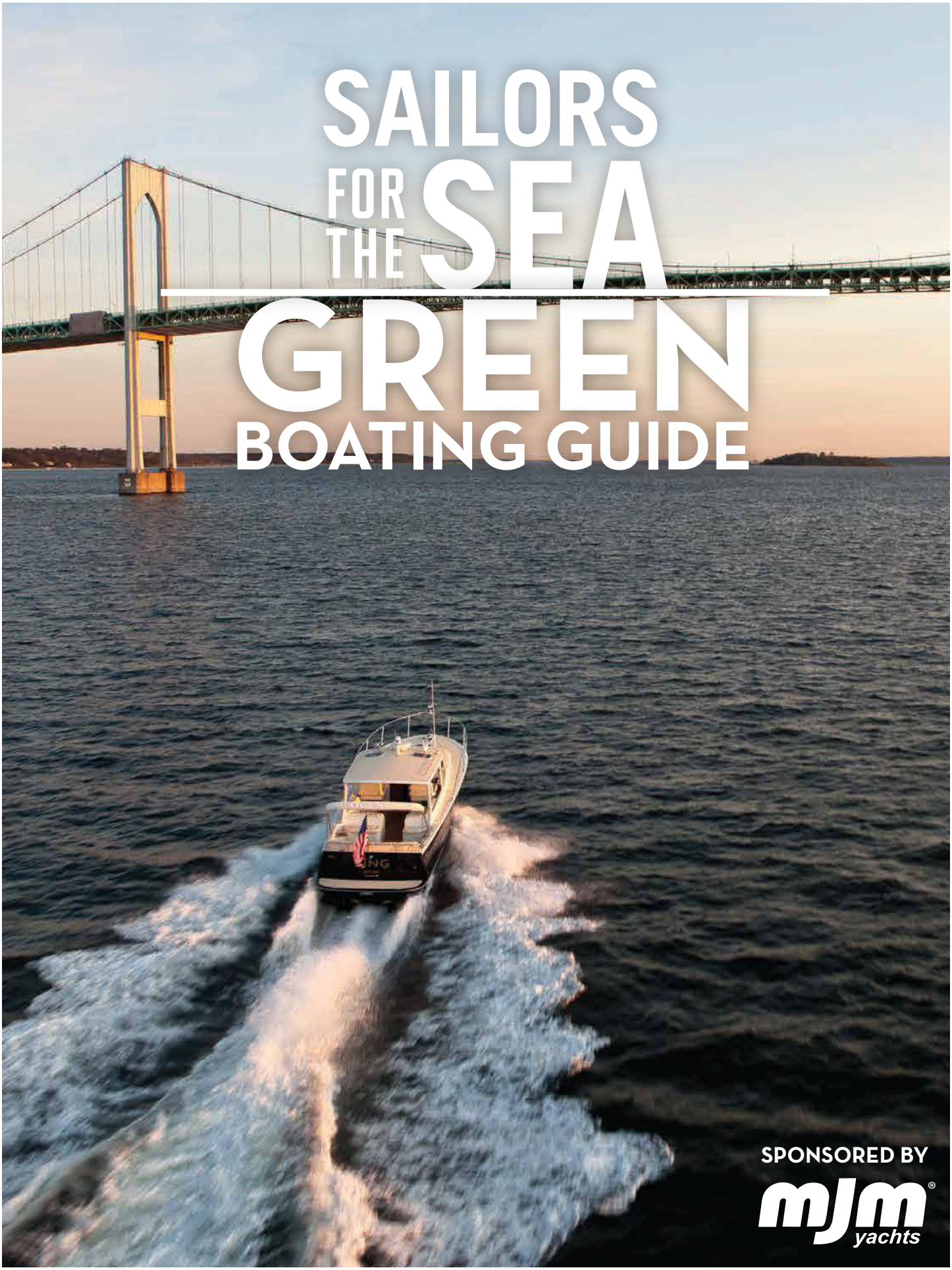
Additional Resources

- **Break Free From Plastic**—a global movement envisioning a future free from plastic pollution.
  www.breakfreefromplastic.org
- **The Last Plastic Straw**—Is helping shift away from single-use plastic straws.
  www.thelastplasticstraw.org
- **Nix the 6**—A campaign to eliminate single-use polystyrene and expanded polystyrene foam ("Styrofoam") plastics.
  www.5gyres.org/polystyrene
- **Ocean Friendly Restaurants**—Reducing single-use plastics and raising customer awareness at restaurants nationwide.
  https://www.surfrider.org/programs/ocean-friendly-restaurants
- **Plastic Bag Laws**—A resource for legislative bodies considering laws limiting the use of plastic bags.
  www.plasticbaglaws.org
- **Plastic Pollution Coalition**—A global alliance of individuals, organizations, businesses, and policymakers working toward a world free of plastic pollution and its toxic impacts on humans, animals, waterways & oceans, and the environment.
  www.plasticpollutioncoalition.org
- **Rise Above Plastics**—Offers a community action plan and information for addressing single use plastics.
  http://www.surfrider.org/programs/rise-above-plastics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GO GREEN FOR THE BIG BLUE

"I've sailed around the world now three times and I can see how much more debris there is in the water."

– Ian Walker, Winning Skipper of the 2014-2015 Volvo Ocean Race

As boaters, we are intimately connected to our waterways. We have witnessed their beauty, their tranquility and power, and even their degradation. Our oceans, coastal waters, estuaries, rivers and lakes provide us with joy, adventure and solace. One of the best ways to preserve our local waters is by proactively managing and maintaining our vessels.

The Green Boating Guide is designed to provide information, tips and product suggestions to prevent pollution and reduce our impact on the environment. Every day, we can make choices to boat in a sustainable and environmentally friendly manner to help protect our precious waterways for our children and their children.

When we set out to create this guide, our goal at Sailors for the Sea was to make something pragmatic and useful. We view this guide as a working document if you have questions, comments or suggestions please send them to greenboating@sailorsforthesea.org.

Wishing you fair winds & following seas!

Shelley Brown, Ph.D.
Marine Scientist
Education Director
Sailors for the Sea

Thanks to MJM Yachts' sponsorship for helping create a powerful wave of change!

TOP TEN CHECKLIST

☐ FILL'ER UP CAREFULLY

Proper fueling procedures can help prevent fuel and oil from sneaking into our waterways. Try using an absorbent bib or collar to catch drips, and fill your tank slowly to prevent any overflow.

☐ BE PREPARED FOR A SPILL

Store spare oil-absorbent socks, pads and pillows onboard your boat, just in case a spill occurs. Since each spill will be handled differently, be sure to contact the marina and/or the U.S. Coast Guard National Response Center at 1-800-424-8802 for cleanup advice.

☐ LOWER YOUR CARBON FOOTPRINT

Reducing your fuel usage not only lowers your carbon footprint, but also saves you money. By decreasing extra weight onboard, keeping your hull clean and performing routine maintenance on your engine, you will make fewer trips to the fuel dock too!

☐ USE YOUR HEAD

If possible, use a Marine Sanitation Device with a holding tank to store sewage until it can be transferred ashore at a pumpout facility. If you're in an area without pumpout facilities, be sure you are more than three miles offshore before you discharge your blackwater – it's the law in the U.S.

☐ COME CLEAN

Research your cleaning products. Manufacturers are not required to disclose all of the ingredients on their containers, and due to lack of marketing regulation, any product can be labeled with words like natural, non-toxic, organic or biodegradable.

☐ PROTECT YOUR BOTTOM

Copper is the most commonly used biocide, but it has been shown to be toxic to marine plants and animals. Try alternative antifouling paints – they are less toxic and can save you money, since they last longer on your hull than copper-based paint.

☐ GET TO KNOW YOUR WILDLIFE

Before you go out boating, research animals that may be in the region – knowing what species to look for can help avoid collisions. When viewing wildlife, remain at least 300 feet away and limit your viewing time to 30 minutes.

☐ STOP AN INVASION

By properly cleaning your boat and equipment after each use, you can help prevent the spread of non-native plants and animals. Removing all vegetation and spraying your boat, trailer and equipment with high-pressure water and rinsing with hot water will help stop invasive hitchhikers.

☐ DO MOOR

When choosing where to settle in for the night, first look for available mooring buoys. If you decide to anchor, check your charts to avoid sensitive habitats including seagrass beds and coral reefs.

☐ REDUCE, REUSE, RECYCLE

Limit the amount of single-plastic you use and opt for reusable items, including water bottles, plates and flatware. Boat materials, such as shrinkwrap, oil, antifreeze, fishing line and batteries can be recycled, in addition to bottles, cans and paper.

WASTE DISPOSAL & RECYCLING

Plastic pollution is one of the largest threats facing our oceans. Plastics are used in an enormous and expanding range of products due to their relatively low cost, ease of manufacture and versatility. Most are petroleum-based plastic, a product designed to last forever. They pose an ever-increasing problem to aquatic environments, as they don't biodegrade. Plastics breakdown into smaller and smaller pieces, but don't get absorbed into our natural systems and therefore never disappear.

Photo credit: Gavin Parsons/Marine Photobank

What are the impacts of marine debris?

Marine debris not only damages important habitats including coral reefs, shellfish and seagrass beds, but also causes significant harm to wildlife, including sea turtles, whales and birds. And plastics are not only toxic themselves, but they act as sponges absorbing toxins and chemicals in the water. When marine creatures consume the small plastic debris and plastic bags that resemble their food sources, the plastics and toxins enter the food chain and may eventually end up on our dinner plates.

Marine debris can also be quite large and difficult to see in the ocean, especially if it's floating just below the surface. Accidentally striking debris can severely damage or sink your vessel.

As boaters, there are many ways we can keep our oceans clean and prevent debris from entering our waterways.

Before you leave the dock:

- Buy products in bulk to reduce the amount of packaging you need to discard.
- Remove packaging from products before you carry them onto your boat.
- Choose products sold in recycled and recyclable containers.
- Use reusable containers and items.
- Reuse items numerous times – bags, containers, boxes, etc.

Onboard:

- Don't throw any trash overboard.
- Secure possessions below deck before the seas get rough, so nothing is accidentally lost overboard. If gear is lost, try to recover it by making it a man-overboard drill.
- Cut six-pack rings and similar items so that they do not become a noose for wildlife.
- Practice Plus One Boating by bringing back whatever you take out, plus one trash item you find.

Back on land:

- Take all trash ashore and dispose of it appropriately, either by recycling what you can (paper, plastic, glass, cans, plastics, antifreeze, oil, lead batteries, fishing gear and fishing line) or by placing it in the correct marina dumpster, or as part of your home waste system.
- Encourage marinas to offer recycling facilities if they don't already.

Use the mobile app Marine Debris Tracker to report debris you collect from the environment.

Did you know?

- An average of 8 million metric tons of plastic waste enters the ocean from land every year (J Jambeck, Science).
- 693 different species have encountered marine debris, many suffering from ingestion and entanglement (Plymouth University).

GREENING YOUR GALLEY

Whether you have a runabout boat or a large cruising vessel, food preparation will play a major role in the enjoyment of your trip.

Here's a list of suggestions to help green your galley:

1. Choose cookware and kitchen items that are reusable and will last. Try to avoid anything plastic and/or single-use.
   - **Cast iron cookware** is made to last multiple lifetimes, is naturally non-stick and lacks the hazardous chemicals found in Teflon. Cast iron can be used on a stovetop, in the oven and on a grill, so less cookware is required. It's also easy to clean with a stiff brush and hot water (no soap necessary).
   - **Stainless steel** is 100% recyclable. In fact, over 50% of new stainless steel is made from recycled scrap.
   - **Cook smart and heat smart** - Use the smallest sized pan for the task and the correct sized burner ring. Use lids to save energy.
   - **Glass containers** - Invest in good quality reusable glass containers – they can also be used in the microwave.
   - **Wooden utensils**, bamboo in particular, are a good alternative to plastic as they are durable, don't harbor bacteria and germs like plastic, and are long lasting. Consider a bamboo cutting board as well.
   - Use **cloth napkins**.

2. Purchase and install energy efficient appliances.
   - **Refrigeration and icemakers** - Most boat refrigerators run on 12-volt systems and can be run by your main battery bank powered by renewable energy (solar, wind, or water generators) or shore power. Make sure your battery bank is sized for the load, in both a cool and warmer environment. Do not place your refrigerator next to your engine or generator, as it will heat up and require more power to keep cool.
   - **Freezer** - Whether you use a freezer box for day sailing or a built-in freezer for cruising, a full freezer is an efficient freezer. Minimize the time you need to keep the door open.

3. Efficient galley provisioning and organization can minimize waste, and save time and money.
   - **Plan ahead** by buying local and in bulk, reducing the amount of waste you produce.
   - **Do it yourself** and avoid buying pre-prepared foods – making it yourself is healthier and there is less packaging waste.
   - Buy items you can **recycle**.
   - Purchase and use **green cleaners**. Check out our Non-toxic Cleaning Products section for suggestions.

Did you know?

- Every day Americans use 500 million plastic straws and they are on the top 10 list of marine debris items collected during the International Coastal Cleanup. Switch to reusable straws!

Photo: Erika Delemarre

THANK YOU.

This program was designed for 5 Gyres Institute by Erika Delemarre, a candidate for the Master of Advanced Studies in Marine Biodiversity and Conservation at Scripps Institution of Oceanography at University of California San Diego. Erika would like to personally thank the captains, crew, volunteers, and support staff of the sail training ships which have adopted the 5 Gyres TrawlShare STEM to Stern program and have worked to make their valuable youth development programs available to young people around the world. She is grateful for the team at the Leeuwin Ocean Adventure Foundation in Fremantle, Western Australia for the sailing adventures that originally inspired this project. Additionally, she has benefited greatly from the collective passion and knowledge of the international marine debris community.

She would also like to acknowledge immense gratitude for her capstone advisory committee who provided critical support throughout development of this project: Committee Chair Dr. Jennifer Brandon at the Birch Aquarium at Scripps Institution of Oceanography, Carolynn Box at 5 Gyres Institute, Dr. Rachel Millstone in the Department of Education Studies at University of California San Diego, and Phil Zerofski at Scripps Institution of Oceanography and director of SEACAMP San Diego. The development of this program also relied on the integral support of Captain Charles Moore and Anika Ballent at Algalita, Dr. Jennifer Lentz at the Aquarium of the Pacific, Mark Friedman and the team at the Los Angeles Maritime Institute, Marina Ivlev at 5 Gyres Institute, Master Mariner Slaven Roje, the captains, crew, and volunteers aboard the twin brigantines, Irving Johnson and Exy Johnson, the crew at Sail Training International, and all the Blue Flag Scheme sail training ships.

Samantha Murray, J.D., Dr. Richard Norris, Jane Weinzierl, and Penny Dockery at the Scripps Center for Marine Biodiversity and Conservation provided immeasurable support and encouragement throughout the development of this project. Lastly and most importantly, a thank you to my family for their support and the MAS-MBC cohort of 2017-2018 for a year of inspiration and collaboration.

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