Name

Date

Reading Guides A-D:
ANSWER KEY

Reading Guide A:
What Happens to the Plastic We Throw Out

Website: *https://www.nationalgeographic.com/magazine/2018/06/the-journey-of-plastic-around-the-globe/?ngscourse*

NOTE: Each tiny dot on this map represents 20 kilograms (about 44 pounds) of plastic. This is about the weight of an average six-year-old child.

1. Summarize how plastics can reach Henderson Island even though it is remote and uninhabited.

Answers will vary, but should include some of the following points:

- Plastic waste on land is not always placed into trash cans or recycling bins. This is known as waste mismanagement.
- Plastics that are dumped on land eventually flow into rivers and downstream to the ocean, carried by wind, water, and gravity. Once plastics reach the ocean, they are carried by waves, tides, and currents.
- Currents sometimes flow in circles called gyres. Henderson Island is located in the South Pacific gyre, which is why plastics often end up there from around the world.

2. Why do you think countries in Asia have challenges managing their plastic waste?

Answers will vary, but may include some of the following reasons:

- Asia (especially India and China) has greater populations than North America and Europe.
- China and India are the two most populous countries on the planet.
- Rapidly developing economies where consumerism grows quickly make waste challenging to manage since the development of management systems takes time. Similarly, some of these places still do not have access to clean water and sanitation.

- No access to clean water increases the need for water in bottles and bags.

- Plastics are new materials in our waste stream, so historical practices don't work. Also, when the United States went through its "growing pains" of growth and waste management, plastics were a very low percent in the waste stream.

- Island nations such as the Philippines, Indonesia, and the Caribbean do not have access to much land for landfills, and their populations are concentrated on the coasts.

3. Predict how you think this infographic would look if it measured mismanaged plastics *per person*, instead of total mismanaged plastics.

Students may or may not be aware of the many political, historical, and economic factors behind the reasons why Asian countries appear to mismanage so much plastic waste. They may need your help to understand these nuances, which provide much-needed context for the raw data in the infographic. For example:

- The U.S. is the only high-income country in the "top 20" countries with leakage of plastics. Even with the formal management systems in the U.S., since we produce so much waste, a small amount of litter creates relatively high leakage rates compared to other high-income countries.

- Americans are among the highest per-capita producers of plastic waste in the world. Given its population size, the U.S. produces more waste than any Asian country. We, therefore, produce the most plastic waste in the world per person.

- Large amounts of American waste are transported to Asian countries where municipal waste management systems and infrastructure are not equipped to handle it in an environmentally sound manner.

4. Which do you think is more dangerous to marine organisms: one piece of plastic with a mass of 100 grams, or 100 pieces of plastic with a mass of one gram each? Explain why.

Answers will vary, but a "correct" answer should include reasonable and logical justification. For example:

- A large piece of plastic can be harmful to a large organism, such as a turtle or whale, which could choke on it. On the other hand, it could be beneficial to a smaller organism, such as a crab, by providing shelter and habitat.

- Small pieces of plastic are more likely to harm smaller organisms, such as plankton, which are important for the food chain. If a lot of plankton consume small pieces of plastic, they could make their way up the food chain and eventually affect larger organisms as well.

5. How do the text and images in this resource work together to support your understanding of the issue? How can it serve as a model for your own unit project?

Answers will vary, but should include some of the following points:

- This source combines maps, infographics, photographs, and videos.

- The maps and infographics provide information about where plastic pollution comes from, using both colors and sized bubbles to indicate hot spots.

- The photographs and videos help readers visualize what plastic pollution means for the people and animals living in those places.

- Our unit project could combine photographs, maps, infographics, and text to provide a complete, accurate, and compelling picture of the ocean plastics problem.

6. When you return to your project group, what information can you share with them from this resource about how to update and improve your model of ocean plastic transport?

Answers will vary, but should include some of the following points:

- Plastic pollution in the ocean comes from land.
- China, Indonesia, and the Philippines are some of the largest contributors. However, the U.S. consumes the most plastics per person, and exports some of its plastic garbage to these countries.
- Plastic pollution is often "mismanaged" trash or recycling that is not put in the trash can or recycling bin because there are not any available, or littered on the ground on purpose or accidentally.
- Plastics make their way to the ocean carried by wind or water, often through rivers.
- On reaching the ocean, plastic moves in large circular paths called gyres, carried by tides and currents.

Reading Guide B:
10 Shocking Facts about Plastic Pollution

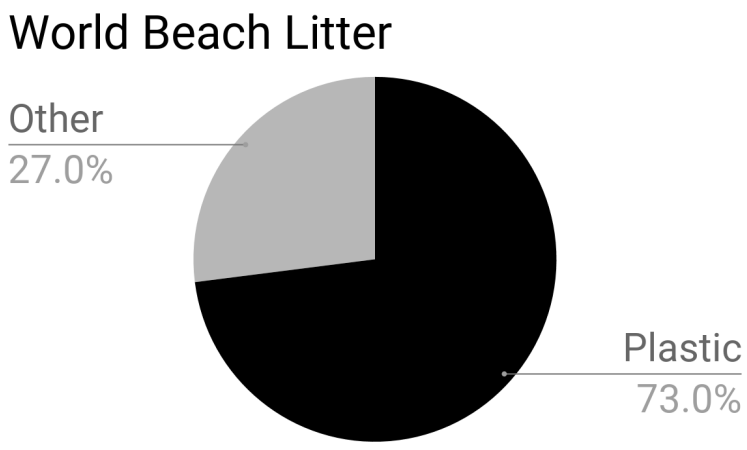
Website: *https://www.nationalgeographic.com/environment/plastic-facts/*

1. Scientists estimate that more than five trillion pieces of plastic are in the ocean. But how much is that, really? In what other ways can you express this number?

Possible answers include:

- 5,000,000,000,000 = 5 thousand billion = 5 million million = 5 x 1,000 x 1,000 x 1,000 x 1,000
- 5 x 10^12
- The number of pennies needed to make $50 billion
- About 625 pieces for every person on the planet, assuming human population = 8 billion
- 5 trillion seconds = 158,548 years

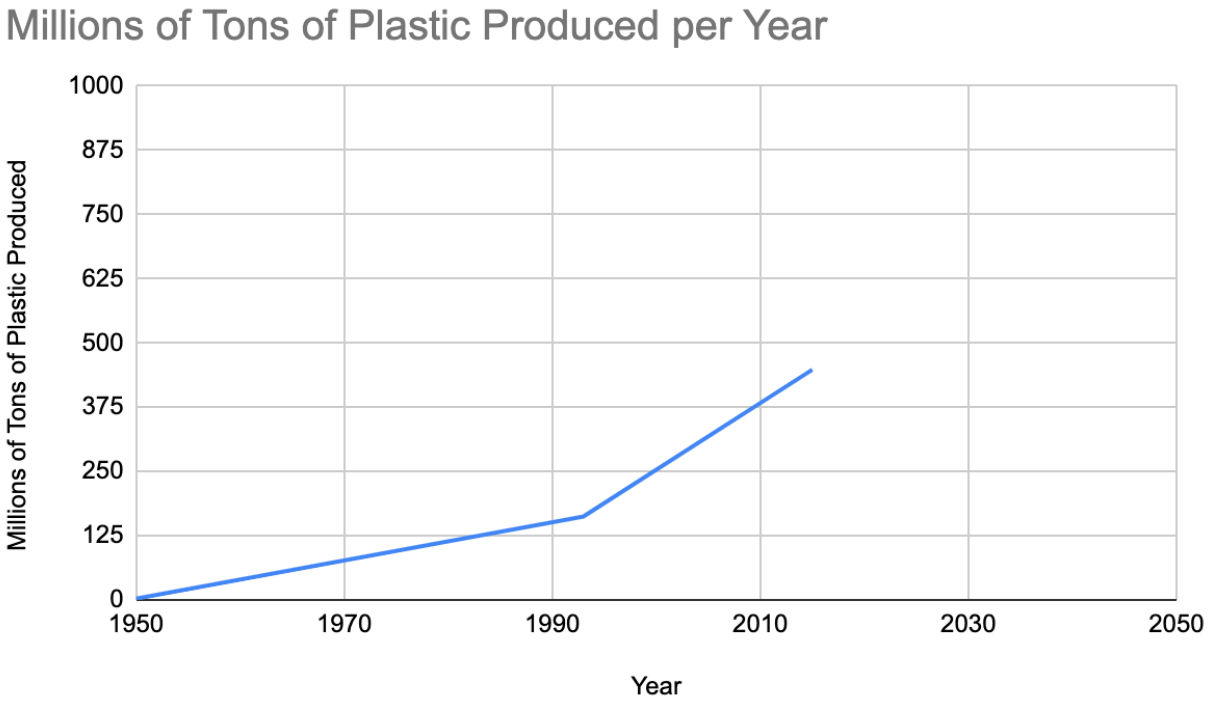
2. Worldwide, 73 percent of beach litter is plastics. Create a pie chart to represent this. What do you think the other 27 percent could be?



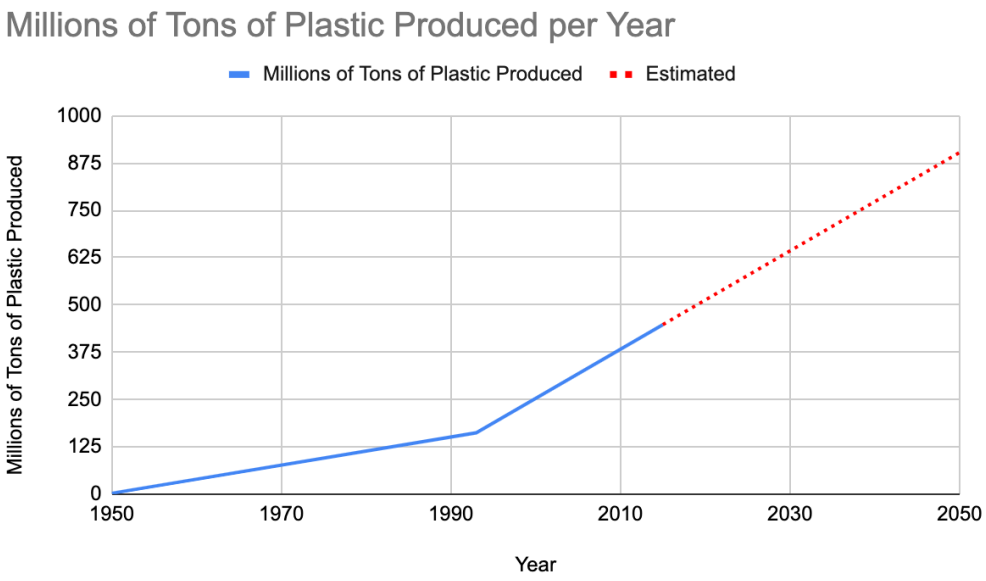
Accept all reasonable answers, as long as they are non-plastic substances. The other 27 percent could be paper, glass, metal (including aluminum cans), or liquids such as paint or oil.

3. World plastic production has increased from 2.3 million tons in 1950, to 162 million in 1993, to 448 million in 2015. Make an estimate for what world plastic production will be in 2050, and justify your estimate. Do you think plastic production will ever start to decrease, and if so, why or why not?

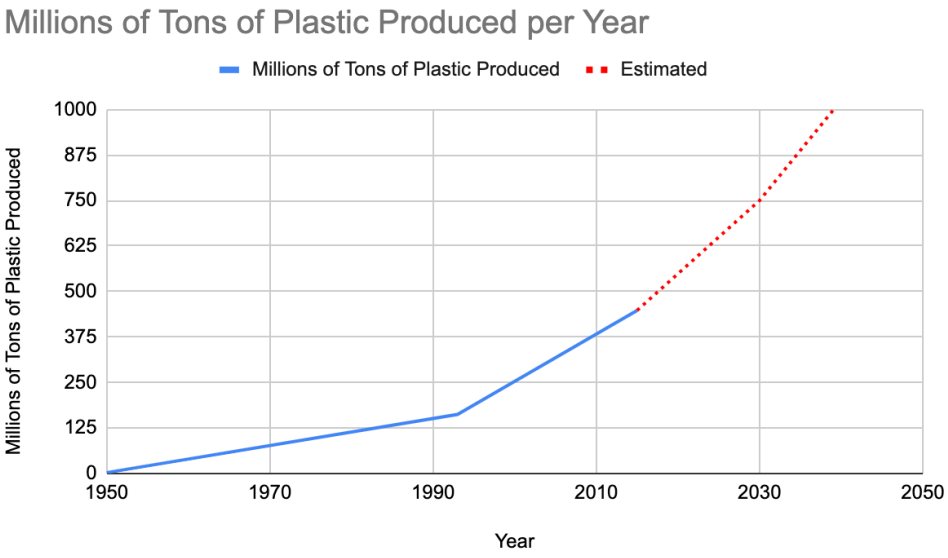
    - A reasonable answer should begin by plotting the given points on the graph: (1950, 2.3), (1993, 162), (2015, 448). See graph below.



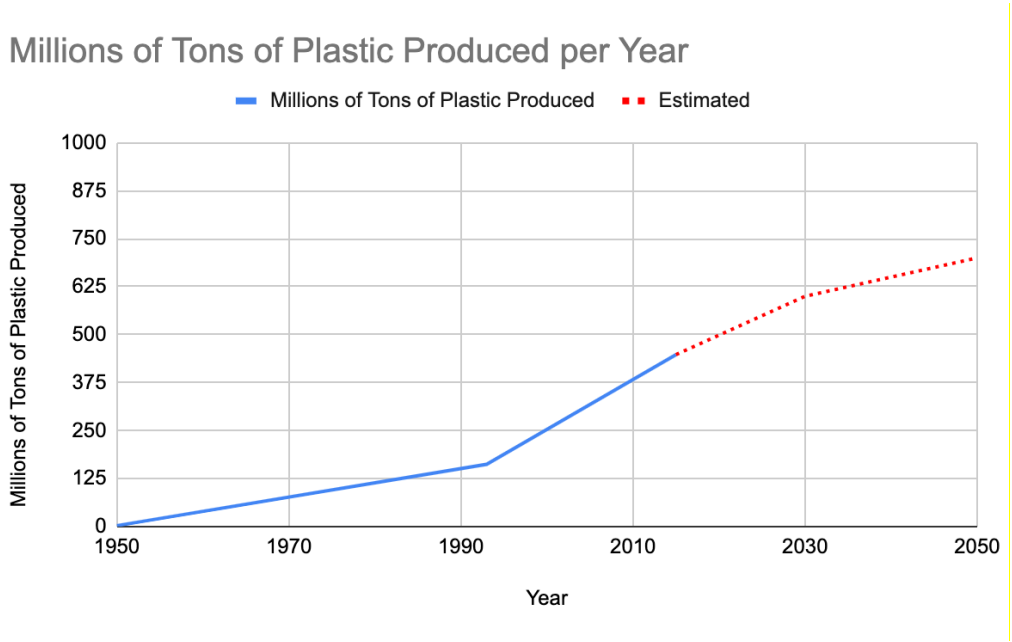
- To estimate the increase from 2015 to 2050, students may simply extend a straight line, using a ruler, from (1993, 162) to (2015, 448) onward, yielding an estimate of approximately 900 million tons by 2050 (see graph below). A graph such as this should be accompanied by an explanation that students expect the amount of plastic produced to continue to increase at a constant rate.



- Students with more experience plotting lines on a graph and finding the slope of lines may notice that the rate of change from 1990-2015 is greater than the rate of change from 1950-90. They could conclude that plastic production is increasing exponentially instead of linearly, and may choose to extend the line non-linearly, yielding an estimate well over 1,000 million tons by 2050 (see graph below). A graph like this should be accompanied by an explanation that the rate of plastic production increased from 1950 to 1993 to 2015, and, therefore, will probably continue to increase.



- Some students may instead argue that people are becoming more aware of the plastic pollution problem, and that with increased awareness will come a decrease in the demand and production of plastics. Therefore, they may produce a graph like this, with the curve leveling off somewhat. A graph like this should be accompanied by an explanation of why the curve would level off.



4. Only nine percent of plastic waste is recycled. Why do you think this number is so low? How could we increase the recycling rate of plastics?

Answers will vary. Reasonable answers will contain some of the following points:

- Recycling rates could be low because:
  - Some people don't know how to recycle.
  - Some people don't care about recycling.
  - Some people don't have a recycling program in their area.
  - Not all plastics are made to be recyclable.

- We could improve the recycling rate by:
  - developing plastics that are easier to recycle
  - educating people about how and why to recycle
  - making sure people have access to recycling bins
  - using less plastics overall
  - giving people, governments, and companies better incentives to recycle

- Research indicates that people's attitudes about littering and recycling are related to their poverty level, so reducing poverty could also contribute to improved recycling rates.

5. How do the text and images in this resource work together to support your understanding of the issue? How can it serve as a model for your own unit project?

Answers will vary, but may include some of the following points:

- The photographs are emotionally powerful because they show animals interacting with plastics in a way that is unusual, unexpected, shocking, or tragic.

- Some photographs show a single piece of plastic against a pristine background, while others show a seemingly unending sea of plastics; both are effective and visually striking.

- Some photographs are extremely colorful, while others are drab and uniform; again, both strategies can be effective.

6. When you return to your project group, what information can you share with them from this resource about how to update and improve your model of ocean plastic transport?

Possible answers may include:

- Plastics can last 450 years or more in the environment without breaking down, so once plastics enter the oceans, they will remain there for a very long time.

- Plastics affect approximately 700 different species of ocean wildlife that eat them and/or become entangled in them, so plastics are not just floating around in the ocean, but affecting animals and possibly being moved by them.

- Plastic production is increasing every year, so the amount of plastics in the oceans will probably continue to increase every year as well.

- Most beach litter is plastic, so a lot of plastics in the oceans probably come from beaches.

- Only nine percent of plastic waste is recycled, so improving recycling could help stop the ocean plastic crisis.

Reading Guide C:
Ocean Trash: 5.25 Trillion Pieces and Counting

Website: *https://www.nationalgeographic.org/article/ocean-trash-525-trillion-pieces-and-counting-big-questions-remain/6th-grade/*

NOTE: Select sixth-grade text level to answer the questions below.

1. What information are scientists still working on learning about ocean plastics?

A complete answer will include all of the following:

- Scientists do not know very much about the amount of plastics in remote regions of the Southern Hemisphere.
- They do not know if plastics release poisons as they break down, and if so, how much.
- They do not know exactly how microplastics affect the fish that swallow them.
- They are also still working to learn where exactly plastics go in the oceans.

2. Large pieces of plastic (macroplastics) and small pieces of plastic (microplastics) have different effects on marine organisms, and scientists don't know which is more harmful. If you were a scientist, how could you figure out whether macroplastics or microplastics are more harmful?

A "correct" answer will describe in detail several steps of an experimental procedure to study how plastics impact marine organisms. Two example procedures are listed here, although students may come up with their own alternatives, as long as they contain a similar level of detail:

- You could design a study of marine organisms that have already been exposed to plastics in their natural habitat. You could harvest animals that have died from plastic-related causes in different habitats and dissect them to determine how they died. You could record the total number of micro- and macro-plastics found in or on each animal. You would probably find that different organisms are impacted by plastics in different ways.

- You could design an experiment with different species of marine organisms and different sizes of plastics. You could conduct the experiment in tanks, so the plastics do not reach the ocean. The experiment may be harmful and dangerous to the animals involved, but this could save the lives of many millions of other animals. After the animals die, you could perform an autopsy to see where the plastics went in their bodies and determine if the animals died from plastic poisoning, strangulation, or some other cause.

3. "We already know that plastic in the oceans is killing animals and harming the environment. Scientists should stop doing research and focus on fixing the problem." Do you agree or disagree with this opinion, and why?

Answers will vary; accept any response that includes a justification. For example:

- Some students will respond that research is important because scientists still do not know exactly where the plastics go in the ocean, exactly how they impact different species, and whether plastics release poisons as they break down.

- Other students will argue that scientists already know that the problem is very bad, affecting organisms all over the world, so they should focus on cleaning up the plastics and making sure that more plastics do not enter the oceans.

4. How do scientists collect new data about ocean plastics? What kinds of evidence do they look for?

A complete answer should contain the following points from the article:

- Scientists conduct beach surveys.

- They use computer models based on samples collected at sea.

- They estimate how much trash is entering the oceans based on how much plastics are produced, thrown away, and recycled.

- Marcus Eriksen's estimate of 5.25 trillion pieces of plastic in the ocean took more than four years and 24 separate survey trips to develop.

5. Pretend you are a scientist on the *Sea Dragon* studying ocean plastic. Write a journal entry describing what you find on the third day of your voyage.

Accept all reasonable answers. For example:

- Dear Journal, I can't believe we've been at sea for three days! I'm aboard the *Sea Dragon*, a 72-foot research vessel sampling the sea for plastic trash. I've been amazed at how much plastic trash we have found out here, even though we are hundreds of miles from any land. Even when the ocean looks clear on the surface, when we drag up a water sample from our net, it's always filled with plastics—bottle caps, fishing nets, children's toys, and thousands, maybe even millions, of pieces of microplastic too small to see without a microscope! Our research vessel is working to study the effect of these microplastics, because we still don't know exactly how they affect the fish that eat them. Worst of all is seeing all the animals that are affected by this plastic. Today I saw a dolphin that couldn't open its mouth because it was trapped in a plastic ring. Fortunately, we were able to cut the ring loose and save the dolphin, but how many more animals are out there suffering due to human actions?

6. When you return to your project group, what information can you share with them from this resource about how to update and improve your model of ocean plastic transport?

Possible answers may include:

- The amount of plastics in the ocean is extremely high: over five trillion pieces, or 269,000 tons.
- Even where the water looks clear, microplastics can be very tiny and they can float below the surface, even in the deep sea.
- Scientists are still working to figure out the exact amount of plastics in the ocean, where they go, and how they impact the animals that live there.
- Scientists know that plastics tend to collect in five large gyres, where they break down into smaller and smaller pieces.
- These small pieces fall into deeper water, and currents carry these small pieces all around the world.

Reading Guide D:
Sailing Seas of Plastic

Website: *https://app.dumpark.com/seas-of-plastic-2/#*

NOTE: Each tiny dot on this map represents 20 kg (about 44 pounds) of plastic. This is about the weight of an average six-year-old child.

1. Spend five minutes exploring this interactive website freely. What did you find? What questions do you have?

Answers will vary.

2. Now, go back to the main page. Find the Gulf of Mexico and zoom in so that you can see the coastline of the U.S. and Mexico. What do you notice? What do you wonder?

Students may notice that:

- There is a lot of plastic on the eastern coast of Mexico.
- In general, there seems to be more plastic near the coasts, but this is not always true.
- For example, around the coast of Louisiana, there is not much plastic, and around the southern edge of the Gulf of Mexico, there is not much plastic either.

Students may wonder:

- Why is there so much plastic around Mexico, but so little around Louisiana?
- Why do some areas have a lot of plastic, and others have much less?

3. Zoom out so you can see the whole map. Then answer parts a-d.
   a. Which areas of the ocean seem to have the most plastic pollution? Create a hypothesis to explain why this might be.

Answers will vary; accept any reasonable hypotheses. For example:

- The Atlantic and Pacific Oceans, in the mid-Northern latitudes, have the most plastic. This could be because these areas are near a lot of human settlements, including the U.S., China, Japan, Mexico, and Europe.

- There is also a lot of plastic in the Indian Ocean, especially around India, which could be due to its high population.

b. Which areas of the ocean seem to have the <u>least</u> plastic pollution? Create a hypothesis to explain why this might be.

Answers will vary; accept any reasonable hypotheses. For example:

- The amount of plastics decreases as you travel away from the equator and toward the poles. This could be due to fewer cities being located near the poles and more around the equator and temperate latitudes.

- There are also a couple of "empty" patches without much plastic in the southern Pacific and Atlantic Oceans. It is possible that waves, tides, winds, or currents tend to keep plastic in the middle latitudes.

c. Which areas of the coastline seem to have the <u>most</u> plastic pollution? Create a hypothesis to explain why this might be.

Answers will vary; accept any reasonable hypotheses. For example:

- The Mediterranean coast has a lot of plastic pollution, possibly because it is densely populated and relatively enclosed.

- The east coast of the U.S. has a lot of plastic pollution, also probably due to dense population.

- The entire coastline of South and Southeast Asia is full of plastic pollution, again due to high population density (and underdeveloped waste management systems).

d. Which areas of the coastline seem to have the <u>least</u> plastic pollution? Create a hypothesis to explain why this might be.

Answers will vary; accept any reasonable hypotheses. For example:

- The northern coast of Russia, the western coast of Australia, and the western coasts of southern Africa and South America are almost plastics-free. This could be due to low populations.

- Low-plastics areas could also be due to the continental landmasses blocking the flow of plastics in that direction.

4. Click on "Expeditions" at the bottom of the screen. Then click on the blue tab on the right side that says "Expedition stages." Now click on the first expedition, "Austral Fisheries - Reisser JI2-12(f)." Answer the following questions based on the map you see.
    a. What size of plastic was most commonly found on this expedition? Include units.

1.00-4.75 mm

    b. What size of plastic was least commonly found on this expedition? Include units.

>200 mm

    c. Compare the amount of plastic found in the first half of the expedition to the amount of plastic found in the second half of the expedition. Create a hypothesis to explain why this might be.

A complete answer will include the following information:

- Much more plastics were found in the first half of the expedition. In the second half, many samples returned with no plastics at all.

- This could be due to the location of these samples around the peninsula. The eastern coast of the peninsula appears to have more plastics than the western coast.

- This could be due to the peninsula blocking plastics from reaching the western side, or because there are no human settlements on the western side of the peninsula.

    d. What evidence would you need to support your hypothesis?

- We would need to know:
    - Locations of human settlements along this peninsula/population density
    - Direction of water flow

- If the water flows from east to west, that would support our hypothesis.

- If there are few or no human settlements on the western coast, that would also support our hypothesis.

e. What evidence would disprove your hypothesis?

- If there were many human settlements on the west coast of the peninsula, that would disprove our hypothesis.
- If the water were flowing west to east toward the peninsula, this would disprove our hypothesis.

5. When you return to your project group, what information can you share with them from this resource about how to update and improve your model of ocean plastic transport?

Possible answers may include:

- There are many places in the ocean where plastics accumulate, and other places where plastics seem not to accumulate.
- In general, plastic accumulation is higher around coastal areas with high populations.
- Around most major landforms, plastics tend to accumulate along one coast, but not the opposite coast. For example, plastics accumulate around the southern and eastern coasts of Australia, but not around its northern or western coasts.