EARTH SCIENCE JOURNAL for KiDS

Where did my plastic go?

Adapted by Erin Conlisk

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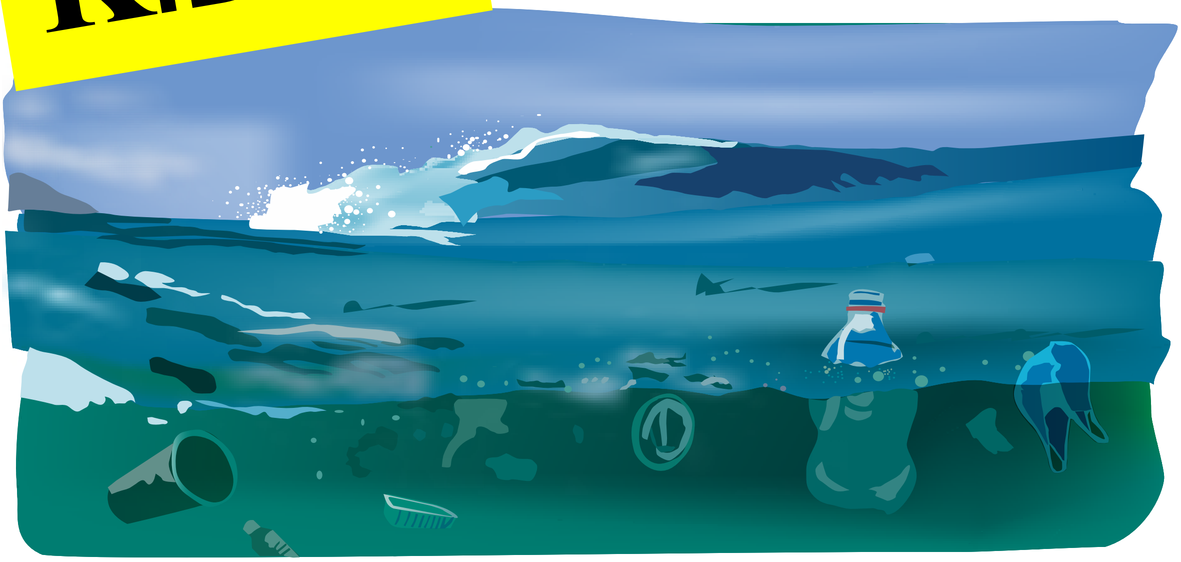

Abstract

Try to spend a day not touching plastic and you find that plastic is everywhere: in cups, plates, packaging, toys, computers, phones, clothes, cars, bikes … the list goes on and on. So where does the plastic go when we are done with it? Some gets recycled, some goes to dumps, and some, unfortunately, ends up as litter
on land and in the ocean. How much plastic trash is in the ocean? The short answer is: a lot. Tons, in fact. But there are very few scientific estimates of plastic waste. Further, not every piece of plastic is the same: some pieces are big and some are too small to see. It is important to determine the different kinds of plastic, as they can have very different impacts on wildlife and ocean health.

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Introduction

Plastics are named for their "plasticity", or ability to be shaped and molded. Most plastics are typically man-made from chemicals found when oil (the type put in cars) is removed from the ground. (Much less commonly, there are plastics being made from corn and other natural products.) Chemicals are added to plastics to give them a variety of shapes and flexibilities. Plastics degrade very slowly. Unlike a piece of paper dropped in the ocean, a piece of plastic will remain in the ocean for centuries. During this time, the sun and ocean will break the plastic into smaller and smaller pieces.

Two properties make plastics dangerous to wildlife: (1) they stick around a long time, often breaking into small pieces, and (2) they absorb chemicals. Some plastics can cause problems before they break down, but others are more of a danger when they are small and get eaten by wildlife **(Figure 1)**. Because plastics readily absorb other chemicals, they can absorb harmful, or toxic, chemicals as they float in the ocean.

Figure 1. (Left) The intact soda can holder is wrapped around the turtle's body, preventing it from growing properly. (Right) The albatross ate a bunch of small pieces of plastic after they had degraded in the ocean. The bird likely died because it didn't have space for any food in its stomach. *Photo credits: http://free-stock-illustration.com/turtle+plastic+ring and CF000774 from the series Midway: Message from the Gyre, photo by Chris Jordan*

In addition, some of the chemicals added to plastics to give them their shape and function are also toxic. Thus, eating plastic is bad for wildlife (and human!) health.

There are five areas in the ocean where plastic trash is common; they are called the five oceanic gyres. Gyres, or large rotating currents, can pick up plastic from litter off the coast and drag it along in the current. The plastic leaves the current by washing up on shore, or getting "caught" in the relatively still waters inside the rotating current. Previous estimates of plastic waste discuss "garbage patches" the size of Texas to twice the size of the entire US! However, there is no single "garbage patch" where everything stays all clumped together. Instead, there are small bits of plastic, within huge areas inside the ocean gyres, making it difficult to estimate the total amount of plastic. Searching that whole area is impossible, thus, the need for innovative science experiments to estimate how much plastic is in the ocean.

Methods

So, if scientists can't search the whole gyre, how should they get an estimate of how much plastic is in the ocean? They can sample a small fraction of the area inside of each gyre and then expand that estimate upward to get an estimate for the total area. They choose their routes through each of the five gyres carefully to obtain samples that are "representative", or typical, of the total amount of plastic within the gyre.

The scientists wanted to sample for various sizes of plastic waste. To sample for small plastics, they dragged nets behind their boats for 15-60 minutes to capture all particles greater than 0.33 mm (the width of a grain of salt). Then, they sorted the samples under a microscope, counted the number of particles, and weighed all the particles collected.

To sample for large particles, they watched outside their boat, up to 20 m away (a little more than the width of a basketball court), for 15-60 minutes. They wrote descriptions of everything they saw. To get an estimate of weight, they weighed similar items to the ones written in their scientific logs, and used that weight for calculations.

Then they used computer models of the ocean currents to estimate what was in the whole ocean judging from their samples. The models gave them a prediction of where they expect to see the most plastic trash. They could validate the models (a fancy way of saying that the models made sense), by comparing them to the samples they took. They compared where their samples recorded the most trash to where the models said the most trash should be.

Results

Of the 680 samples from nets, more than 9 out of 10 had plastic waste in them. The scientists saw the most plastics inside the gyres, as expected. Most particles were between 1 and 4 mm (roughly the width and length of an ant). The largest amount of plastic waste (by weight), however, was composed of particles with a diameter of 200 mm (roughly the size of a volleyball). The North Pacific gyre had the highest estimate of plastic and the Indian Ocean had the next highest **(Figure 2)**. The total estimate of plastics across all five gyres was 5.25 trillion particles and 270,000 tons (or the combined weight of 54,000 elephants!).

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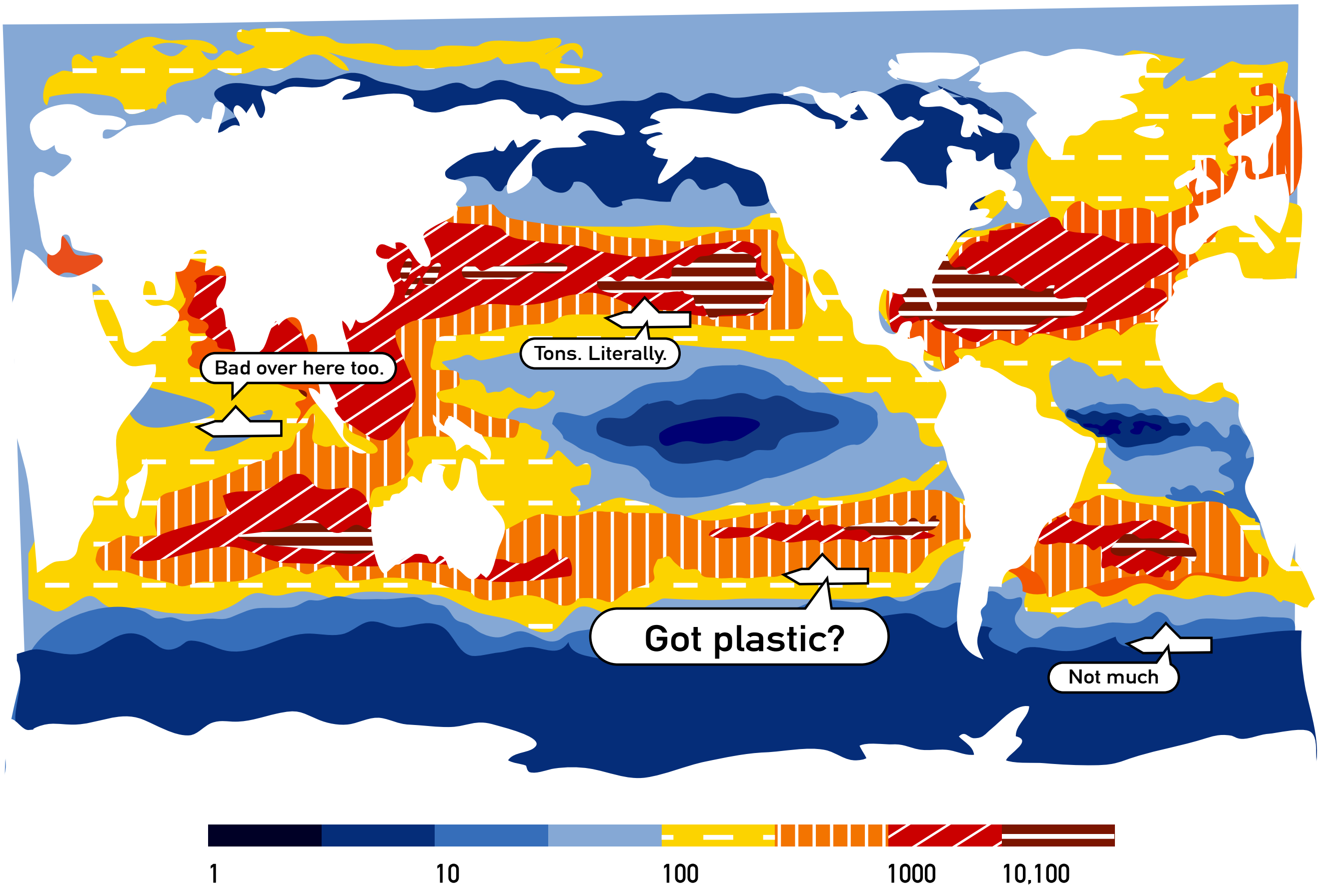
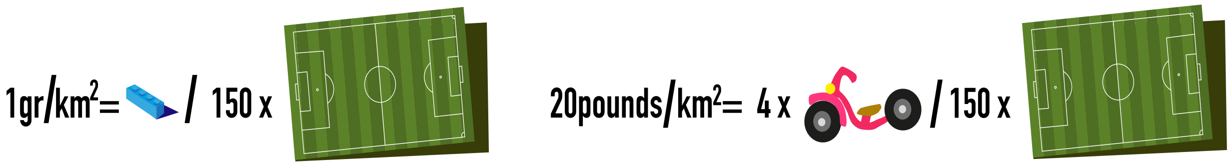


Figure 2. Distribution of plastic waste around the world's oceans. Dark blue means that the scientists only found 1 gram of plastic per kilometer-squared. (This is like 1 small lego block per 150 soccer fields.) Stripy dark red means they found up to 20 pounds of plastic in the same area. (This is like 4 toddler bikes per 150 soccer fields.)



Discussion

Despite the enormous amount of plastic waste the scientists estimated, they actually think this might be an underestimation. They describe a number of reasons why that might be the case:

1. they purposefully underestimated the weight of large plastic particles during sampling,
2. they found that many large plastic particles were difficult to see when they looked outside the boat (for example, buoys are often colored to match the color of the water),
3. they only measured the surface of the water (and not deeper waters), and
4. they do not estimate what is eaten by wildlife. In fact, they believe that wildlife is likely eating a large amount of the tiny particles.

The scientists found more 1-4 mm (ant-sized) plastic particles than 0.33 mm (salt-grain-sized) particles.

They did not expect this. Instead they expected that large particles would break into roughly 16 medium particles; medium particles would break into roughly 625 small particles; and small particles would break up into 6 tiny particles. Instead, they found a lot fewer tiny particles than what they had predicted. So where are these smallest particles? And where is the final resting place of all of this plastic? The ocean floor? The scientists suggested doing more work to answer these questions.

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Finally, the scientists compared their estimate of ocean plastic waste to the total amount of plastic made each year. The waste they estimate was in the ocean is only 0.1% of the annual production of plastic. Thus, a large fraction of plastic must end up somewhere else. Again, the scientists suggested doing more work to determine where the extra plastic is going.

Conclusion

Plastic isn't going away anytime soon (even if we stopped producing it!). Because it hasn't been in the environment long enough (mass production of plastics began in the late 1940s), we don't know the full story on potential hazards. Thus, it makes good sense to reduce the amount of plastic you use. Cutting back on packaging is a great way to start, but also consider whether you can find a non-plastic or once-recycled plastic alternative. When you do use plastic,
recycling it will help fight plastic waste.

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Vocabulary

Gyre: a vortex, or whirlpool. In the ocean it means a large system of rotating currents. There are five gyres across three oceans: the North Atlantic, South Atlantic, North Pacific, South Pacific, and Indian gyre. The rotating ocean current traps plastics at the center of it.

Model: a representation of an object, process, or physical system.

Plastic: a material consisting of any of a wide range of synthetic or semi-synthetic organics that can be molded into diverse shapes, with diverse flexibilities and high strength. Plastics are usually synthetic, most commonly derived from petrochemicals (chemical products derived from petroleum), but many are partially natural.

Petroleum: Latin for "rock-oil", a liquid fossil fuel. (Fossil fuel is an energy-dense material, such as coal or oil, that comes from organisms that have been dead and buried for millions of years.)

Representative experimental sampling: to take samples that are "typical", so as not to accidentally get too high or too low of an estimate. For example, if we were measuring average heights of all citizens in California, but we accidentally sampled only children, then our estimate would be too low. We would want to sample an array of ages that are typical for the state.

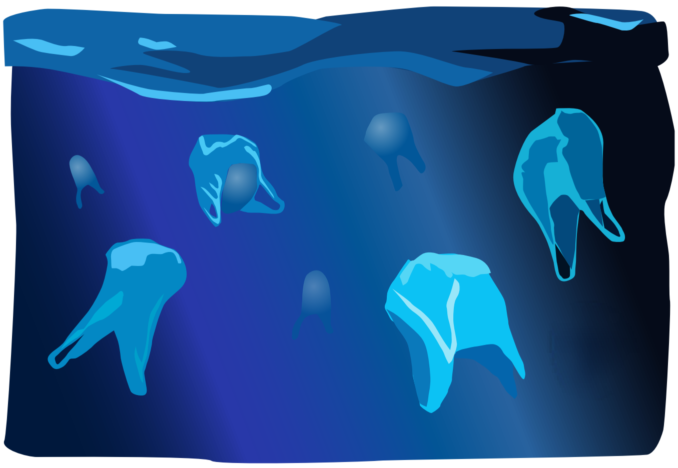
Ton: 1000 kilograms (where one kilogram is 2.2 pounds).

Toxic: poisonous, capable of causing harm.

Validate: to check the accuracy of something, in this case a model of where we should see the most plastic within a gyre.

Teacher's guide:

Grade level: 9-10
Key terms: plastic, toxic, gyre, current, pollution, model, degradation.



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