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How can we clean up plastic in the ocean?

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Abstract

Trillions of pieces of plastic currently pollute the ocean, harming sea life, contaminating ecosystems and making a mess on beaches. It's important to clean up the plastic in the ocean, but nobody knows how best to do so yet.

Some people suggest deploying giant plastic-removing devices to clean up the plastic mess. We set out to find where in the ocean would be the most effective places to put these devices. To do so, we made a computerized simulation of plastics entering the ocean, ocean currents, and hypothetical plastic-removing devices to take the litter out of the water. We found that if we take plastic out of the ocean very close to the shore, particularly off the coast of East Asia, it would remove the most plastic and be most beneficial for ocean creatures.

Introduction

Scientists estimate that there are currently trillions of pieces of plastic in the ocean – that means there are more pieces of plastic in the ocean than stars in our galaxy.

This plastic starts out in all shapes and sizes, like toys, drinking straws, and plastic bags, to name just a few. Unfortunately, a lot of plastic makes it into the ocean when it is littered into coastal waterways abandoned along the shore, or spilled off ships. (Fig.1)

Once in the ocean, plastic items don't disappear. Instead, the action of the wind, waves, and sun slowly shred them into smaller and smaller pieces. The resulting tiny pieces of plastic, called "microplastics", float along the surface and are carried by ocean currents to massive swirling gyres out in the middle of each ocean basin. There are five gyres in total, and the ones with the most plastic are in the North Pacific between Hawaii and California, and in the North Atlantic just off Bermuda.

Figure 1.
Plastic waste off the coast of Egypt. (Image: Wikipedia)

Plastic, regardless of its size, isn't healthy for our oceans. Sea creatures can mistake plastic items for food, harming them and causing them to starve because there's no space in their stomachs for actual food. They can also get tangled in larger pieces of plastic, hampering their ability to swim.

Now, inventors are developing ways to remove plastic from the ocean – like using massive floating strainers, for example. Some have suggested putting these plastic-removing devices into the middle of ocean gyres to clean up the litter that has accumulated there. But are the ocean gyres really the most effective places to deploy plastic-removal devices if we want to rid the ocean of plastic and protect marine life from its effects?

Methods

We made a computerized simulation, also known as a model, of how plastics enter into the ocean and move around with the ocean currents.

It would be an impossibly large problem to make an exact replica of how plastic enters the ocean, moves around with the currents, affects wildlife and is optimally removed. So we simplified the model by making some reasonable assumptions.

Assumptions:

1. We used other scientists' previous calculations about the amount of plastic that enters the ocean, based on the amount of plastic people use in different cultures and the amount of litter they produce.
2. We assumed that 29 plastic-removing devices could be used and maintained anywhere in the ocean, and that they would be able to clean up 45% of the plastic in their location.
3. The plastic-removing devices would most likely work best in places with the most plastic passing through.
4. Plastic that enters the ocean stays on the surface (it doesn't get washed ashore or sink to the bottom).
5. We assumed that the amount of marine algae in any given part of the ocean approximates the amount of wildlife that lives there – this is a reasonable assumption since marine algae are the basis for food webs in the ocean.

In our model, we then put the plastic-removing devices in different parts of the virtual ocean to see where they would be most effective at both cleaning up the litter and protecting wildlife.

Results

We found that many of the most effective locations for plastic-removing devices would be off the coast of East Asia. (Fig.2) If people were to start using plastic-removing devices at these locations in the ocean now, it would clean up nearly a third of the floating plastic junk by 2025. In parts of the ocean where there is a lot of wildlife, it would cut the amount of plastic litter nearly in half.

Though we assumed 29 plastic-removing devices were available to use, placing just 10 of these devices was already pretty effective – they were able to clean up 83% of the total plastic removed, which was a total of 92,000 metric tonnes, or approximately the weight of 500 blue whales! (Fig.3)

Figure 2

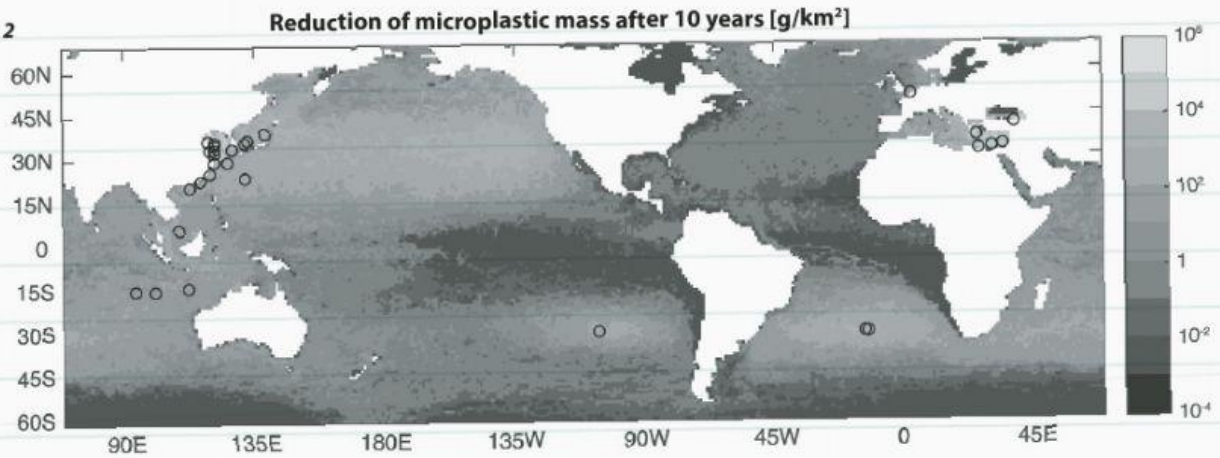

Figure 2. *Putting plastic-removal devices in the locations shown with the black circles would lead to the most effective way to clean plastic out of the ocean. Light shaded areas show the places with the most improvement after 10 years of litter removal.*

Figure 3

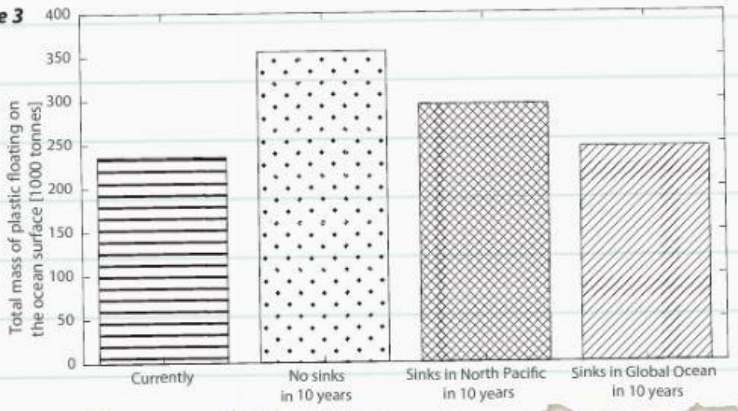

Figure 3. *The amount of plastics in the ocean now and in the three modelled scenarios depending on where the plastic-removal devices are located*

Discussion

Our model showed that although the ocean gyres have the greatest concentration of plastic litter per square kilometer of ocean, plastic-removal devices work best at cleaning up the mess if they are situated near the coast. That way, they can stop plastics where they enter the ocean, thereby limiting their time in the water and protecting the sea life that may try to munch on the litter.

In the future, we would like to expand our model to include how plastic in the ocean affects fish, birds, and marine mammals. We would also like to include the costs of making and using devices to remove the plastic, and compare it to the costs of continuing to pollute the ocean with plastic debris (like damage to ships, fishers' lost earnings, and more).

Despite using 29 plastic-removal devices in the ocean, we estimate that overall plastic debris in the ocean would still increase slightly (by 4%) by the year 2025, because more and more plastic is produced and used – and also littered— worldwide each year. So really what we need to be doing is to prevent plastic from getting into the ocean in the first place; solely using removal devices is like mopping up the mess without closing the tap first.

As a next step, we'd like to investigate what actions will have the greatest effect on reducing plastic in the ocean – whether it's deploying plastic-removal devices, changing the amount of plastic people use, making laws about how much plastic is sold, or making materials that biodegrade harmlessly in the ocean.

Conclusion

Plastic litter is a huge problem in the ocean. While putting devices in the water near the coasts to clean up the floating plastic is an important first step, it's not enough to solve the problem. Additional solutions include producing and using less plastic. We can replace some of the plastics we currently use with biodegradable materials that break down quickly and harmlessly in the ocean and the environment (some of these materials already exist, like disposable utensils made from potatoes). Finally, the plastics we do use should be recycled, not littered.

Glossary of Key Terms

Biodegradable

Materials that can be harmlessly decomposed by bacteria, fungi, and other living organisms.

Computerized simulation

An imitation of a real-life system, simplified and designed on a computer.

Food web

An interlocking set of species that eat and are eaten by each other in an ecosystem.

Microplastic

Tiny pieces of plastic, often created when larger pieces of plastic break up in the environment. Some of these tiny pieces are too small to be seen with the naked eye.

Metric tonne

1,000 kilograms, or about 2,205 pounds.

Ocean current

The continuous movement of ocean water, which can be caused by wind, temperature differences, or the rotation of the Earth.

Ocean gyre

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. These rotating ocean currents trap plastics in the middle.

Plastic-removal device

A machine or contraption that can be used to remove microplastic from the ocean.

References

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Where does plastic end up? www.plasticadrift.org

KEY TERMS

Plastic, ocean pollution, microplastic, ocean current, ocean gyre, recycling, food web, model