Can We Clean Plastic From the Oceans?

ILLUSTRATION: PETER SYMES / AI

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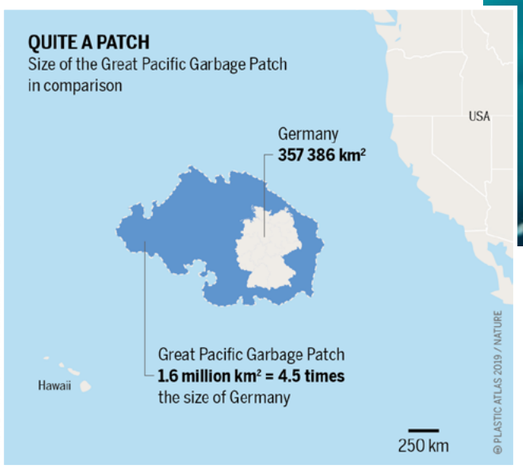
Ocean clean-up projects show limited reach as new data and emerging technologies point to prevention and coastal action as more viable long-term strategies.

The accumulation of plastic waste in the world's oceans is one of the most visible and persistent signs of global environmental degradation. From large floating debris fields to microscopic particles embedded in marine ecosystems, plastic pollution presents complex scientific, technical and policy challenges. As new research emerges and clean-up technologies develop, scientists are reassessing whether removing plastic from the sea is realistic—or if efforts should be focused elsewhere.



PLASTIC ATLAS, APPENZELLER/HECHER/SACK / WIKIMEDIA / CC BY 4.0

The Great Pacific Garbage Patch is 4.5 times the size of Germany.

Patch clean-up efforts

One of the most widely publicised responses to marine plastic pollution is The Ocean Cleanup initiative, which targets the Great Pacific Garbage Patch (GPGP) using floating barriers. The patch spans approximately 1.6 million square kilometres and contains an estimated 1.8 trillion plastic pieces. Since operations began in 2018, the project has removed over 360 tonnes of debris and continues to scale up its systems.

However, as highlighted in a recent *New Scientist* feature, experts are increasingly questioning the long-term value of offshore clean-ups. Most plastic enters the ocean near coastlines, and much of it sinks before ever reaching distant gyres like the GPGP. Oceanographic models suggest that only a small proportion of plastic pollution (less than 10 percent) is in these significant offshore accumulations.

Additionally, plastic in the open ocean often breaks down, sinks to the seabed or is consumed by marine organisms, making it difficult to recover. This limits the effectiveness of any retrieval system that targets only surface debris in remote waters.

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Microplastic lifespan

Plastic pollution is not limited to visible waste. Larger plastic items degrade over time into smaller fragments known as microplastics, which measure less than 5 millimetres in diameter. These particles are widely dispersed and can persist in the marine environment, posing risks to animals and ecosystems.

A new method for estimating the age of microplastics—detailed in a Newswise article—analyses chemical oxidation to determine how long plastic has been exposed to marine conditions. Researchers applied this technique to fragments recovered from surface waters in various ocean basins. The results suggest that the average age of these microplastics is around 3.2 years—much shorter than previously assumed.

The findings imply a relatively rapid turnover of microplastics at the ocean surface, raising questions about what happens to particles after a few years. They may sink, break down further or enter biological pathways through ingestion. While the data introduces new insights into microplastic persistence, it complicates clean-up strategies. Microplastics appear to degrade and disperse before surface-collection devices can effectively retrieve them.

Nanorobot innovation

At the microscopic scale, scientists are also exploring more advanced tools for tackling plastic pollution. A recent development by researchers in the Czech Republic has demonstrated the use of nanorobots to remove plastic fragments from water in laboratory settings.

These nanorobots are designed to self-propel and bind to microplastic particles, using magnetic and chemical properties to cluster and remove debris. In trials, the robots were able to eliminate up to 70 percent of plastic particles from test samples.

Although the technology remains in the early stages, it suggests a possible future role in water treatment facilities or targeted interventions in controlled environments. However, scaling such techniques to cover open marine environments is unlikely in the foreseeable future.

Shifting focus to coasts

Many experts advocate for upstream solutions because most ocean plastic originates from land, primarily through rivers and coastal runoff. The *New Scientist* article emphasises that interception efforts near the source—such as in rivers and estuaries—are more effective and cost-efficient than offshore clean-up.

Preventing plastic from entering the ocean in the first place also reduces the risks associated with ecological disruption. Coastal interventions may provide more immediate and sustainable impacts, including trash barriers, waste management reform and public policy focused on reducing single-use plastics.

According to the 5 Gyres Institute, founded by marine researcher Marcus Eriksen, plastic pollution should be tackled using a "source-to-sea" strategy that prioritises upstream prevention. In public statements, Eriksen has argued that relying solely on ocean clean-up is akin to "mopping the floor while the tap is still running."

Ecological risks

Even well-intentioned clean-up efforts can carry unintended consequences. Surface skimming devices used in projects like The Ocean Cleanup may disrupt plankton and other small marine organisms that form the foundation of the ocean food web.

Floating debris also serves as a habitat for some marine life, and millimetre-sized polymers have created a new pelagic habitat for microorganisms and invertebrates. Studies have observed coastal invertebrates colonising plastic waste in the open sea, potentially altering existing ecological balances. Removing this debris may affect emerging ecosystems in ways that are not yet fully understood.

There are more than 170 trillion pieces of plastic afloat in the world's oceans, but solutions start on land.

— 5 Gyres

Reassessing clean-ups

While technological innovation continues to offer new possibilities for addressing plastic pollution, it is increasingly evident that no single solution can solve the problem. Clean-up initiatives play a role in public engagement and awareness, but their practical impact is limited to specific conditions and locations.

Recent research into the lifecycle of microplastics and the logistical challenges of ocean-wide retrieval reinforces the importance of prevention. Investment in waste reduction, product redesign and international policy coordination may yield greater results than attempting to extract plastics already dispersed throughout marine systems.

Conclusion

The ocean cannot be fully cleaned of plastics using current technologies. While large-scale clean-up projects and laboratory advances show promise in particular contexts, they do not address the bulk of plastic pollution, which originates on land and often sinks or breaks down before it can be collected. New scientific insights into microplastic degradation and innovative approaches such as nanorobots are expanding our understanding, but experts increasingly agree that prevention—particularly through coastal and upstream action—offers the most effective path forward. ■

SOURCES: NEW SCIENTIST, NEWSWISE, MARINE POLLUTION BULLETIN, 5GYRES.ORG

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Beach trash and plastic debris