Oceans could be harnessed to remove carbon from air, say US science leaders

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Coast of Barbados. Credit: Kevin Krajick/Earth Institute

The United States should undertake a major research program into how the oceans could be artificially harnessed to remove carbon dioxide from the air, says a new report from the National Academies of Sciences, Engineering, and Medicine.

Scientists are increasingly coming around to the position that reducing carbon emissions may not stabilize the climate, and that technologies to actively remove carbon from the air may be needed. The new report builds on a 2019 National Academies study that found that in order to meet internationally agreed upon climate goals, the world's nations would need to remove roughly 10 billion tons of CO_2 from the air every year by 2050—nearly a quarter of current annual emissions—in addition to reducing emissions. While several land-based strategies such as storing carbon in agricultural soil or changing forest management may be ready for deployment now, less is known about the risks, benefits and trade-offs of ocean-based strategies, say the authors. Some prospective methods could include cultivating seaweed on vast scales, manipulating seawater nutrients, or even passing electrical currents through the water.

The report recommends a $125 million research program to better understand the technological challenges, as well as potential economic and social impacts. The research should start now and continue over the next 10 years, it says.

"All of the land-based approaches have limitations, so it's important to evaluate the possibility of also using the oceans," said coauthor Romany Webb, a senior fellow and associate research scholar at Columbia University's Sabin Center for Climate Change Law. "Importantly, the report identifies not only key scientific questions that need to be answered, but also social, legal, regulatory and policy ones."

"Ocean carbon dioxide removal strategies are already being discussed by scientists, non-governmental organizations and entrepreneurs as potential climate response strategies," said Scott Doney, chair of the committee and professor in environmental sciences at the University of Virginia. "Right now, society and policymakers do not have the information they need to evaluate the impacts and trade-offs."

The report explores six basic approaches:

Nutrient Fertilization. This would involve adding nutrients such as phosphorus or nitrogen to the ocean surface to increase photosynthesis by phytoplankton. A portion of phytoplankton sink when they die, so this would increase the transfer of carbon to the deep ocean, where it can stay for a century or longer. The report says there is medium to high confidence that this approach would be effective and scalable, with medium environmental risks and with low scale-up costs beyond the costs for environmental monitoring. The report estimates $290 million would be needed for research including field experiments and tracking the amount of carbon sequestered as a result.

Seaweed Cultivation. Large-scale seaweed farming that transports carbon to the deep ocean or into sediments would have medium efficacy and medium to high durability for removing atmospheric CO_2, the report says. But there would be medium to high environmental risks. The report estimates $130 million for research to understand technologies for efficient large-scale farming and harvesting, the long-term fates of seaweed biomass, and the environmental impacts.

Ecosystem Recovery. Protection and restoration of coastal ecosystems and the subsequent recovery of fish, whales and other marine wildlife could help capture and sequester carbon. It comes with the lowest environmental risks among the assessed approaches, and with high co-benefits, say the authors. The report says it could have low to medium efficacy. It estimates $220 million for research, including to study effects on macroalgae, marine animals and marine protected areas.

Ocean Alkalinity Enhancement. This approach chemically alters ocean water to increase its alkalinity in order to enhance reactions that take up atmospheric CO_2. The report says there is high confidence in its efficacy. Ocean alkalinity enhancement carries medium environmental risks and medium to high scale-up costs. The report estimates $125 million to $200 million for research, including field and laboratory experiments to explore the impact on marine organisms.

Electrochemical Processes. Passing an electric current through water could either increase the acidity of seawater in order to release CO_2, or increase its alkalinity to enhance its ability to retain it. There is high confidence in its efficacy, and medium to high confidence in its scalability. However, this approach carries the highest scale-up cost of any of the approaches assessed, and medium to high environmental risks. The report estimates $350 million for research, including for demonstration projects and to develop and assess improved materials that would be needed.

Artificial Upwelling and Downwelling. Upwelling moves cooler, more nutrient- and CO_2-rich deep water to the surface, stimulating the growth of phytoplankton. Downwelling moves surface water and carbon to the deep ocean. The report says there is low confidence in the efficacy and scalability of these approaches, and that they carry medium to high environmental risks, along with high costs and challenges for carbon accounting. The report estimates $25 million would be needed for research, such as technological readiness and limited and controlled ocean trials.

More information: A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration: www.nap.edu/catalog/26278/a-re … al-and-sequestration