Protecting coral reefs in a deteriorating environment

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Close up of polyps are arrayed on a coral, waving their tentacles. There can be thousands of polyps on a single coral branch. Credit: Wikipedia

Coral reefs around the world face growing danger from a changing climate, on top of the historic threats from local pollution and habitat destruction. In response, scientists are researching new interventions that have the potential to slow coral reef damage from warming and

acidifying oceans. The interventions span a wide range of physical and biological approaches for increasing the stability of coral reefs, but they have only been tested at small scales.

A new report from the National Academies of Sciences, Engineering, and Medicine examines these resilience tools and provides decision-makers with a process they can follow in considering whether to use one or more of the novel approaches.

Many of the new interventions seek to amplify natural resilience, such as laboratory breeding of corals that show greater heat resistance. Other methods, some merely on the horizon such as genetic manipulation of corals, might one day introduce new levels of stress tolerance. Ultimately, all interventions alter the reef in some way. These changes will result in benefits that differ across sites, and they may have varying unintended consequences—meaning that the risks and benefits need to be weighed locally, the report says.

"Maintaining the stability of coral reefs in the face of local and climate stressors is a key goal for supporting human well-being around the world," said Stephen Palumbi, chair of the 12-member committee that wrote the report, and Jane and Marshall Steel Jr. Professor in Marine Sciences at Stanford University. "Many new interventions have promise for these efforts, but they differ widely in their readiness levels, and implementing them will require careful attention to regional contexts."

Novel solutions to growing threats

Since the 1980s, tropical coral reef coverage around the world has declined by about 30% to 50%. Pollution, habitat destruction, and overfishing have long been among the culprits in many places, but increasingly, coral reef loss can be attributed to a changing climate. Rising water temperatures are increasing the frequency of mass

bleaching events and are making disease outbreaks more common. And as ocean waters become more acidic from absorbing carbon dioxide, it will become harder for corals to grow and maintain their skeletons.

Coral reefs' destruction has serious human costs, because many coastal communities depend on local reefs for fishing and tourism. Coral reefs also absorb energy from the waves that pass over them, buffering shore communities against destructive storms.

In response to these threats, researchers are developing new ways to improve corals' persistence in a changing climate—23 of which were described in the first report released by the committee last November.

The committee's new, final report includes an assessment of the technical readiness of various interventions. Some are possible to use now—for example, pre-exposing corals to mild warming in order to improve their tolerance of greater heat levels. With more research and testing, others may be available for use in the next two to five years, such as using antibiotics to treat disease, mixing cool water into reef habitats, or shading corals from sunlight and heat. Still other proposed interventions—for example, using tools such as CRISPR/Cas9 to genetically manipulate corals to make them more threat-resistant—need significantly more research and development, and are at least a decade away.

"Though all of these interventions entail some risk, the risk from doing nothing is increasing year by year," said committee member Nancy Knowlton, former holder of the Sant Chair in Marine Science at the Smithsonian Institution.

Choosing the right intervention strategy is a local, stakeholder-driven decision

Whether a specific intervention (or a combination of interventions) is suitable depends not just on its technical readiness, but on each particular ecological and social setting, the report stresses. Local factors such as the level of reef degradation, the quality of the water, and the resources and infrastructure available will determine if an intervention is needed or beneficial.

Equally important is whether the intervention is acceptable to a community, the report says. Throughout the decision-making process, it is important to engage a broad set of stakeholders—both to establish objectives and to choose a course of action that reflects community values. "Stakeholder engagement enables choosing interventions with expected outcomes that align with the goals of the community," said committee member Marissa Baskett, professor of environmental science and policy at the University of California, Davis.

The report also recommends that coral reef managers follow an "adaptive management" approach in making decisions about interventions—an approach that recognizes uncertainty and incorporates learning to adjust and improve strategies over time. "The science of coral reef interventions is still young, and particular environments may respond to them in different ways. So using a structured and adaptive decision-making approach allows managers to make decisions even when there is uncertainty," said Palumbi.

The first step of the adaptive management cycle is setting goals and objectives along with stakeholders, against which interventions' effects can be compared, and outlining acceptable courses of action. Locally-tailored models of coral reef dynamics, and how they change with different interventions, are a necessary tool to evaluate and compare the impact of different intervention strategies on coral reef outcomes. Developing a successful modeling framework requires substantial effort, the report concludes, but it pays off in the ability to assess the risks of

new interventions compared to the risks posed by taking no action.

As strategies are implemented, efforts must be invested in monitoring the effects of interventions to increase knowledge about their impacts, evaluating their results, and communicating with stakeholders. Based on the observed effects, managers can then continue or alter their approach as needed.

The ability to make informed decisions and effectively implement novel interventions could be improved if remaining gaps in research—both on the interventions and on corals themselves—were filled, the report says. It identifies priority areas for research in basic coral biology, site-based assessments, improvement of interventions, and improvements in risk assessment and modeling. Increasing the ease of use and scale of use of different interventions, so communities have a larger toolbox to choose from, are important research goals.

"We must also grapple with and solve the key problem of greenhouse gas emissions," Palumbi said. "But the wealth of intervention options gives us some hope that we can help coral reefs successfully survive the next century as diverse, productive, and beautiful places in the sea."

The study—undertaken by the Committee on Interventions to Increase the Resilience of Coral Reefs—was sponsored by NOAA and the Paul G. Allen Family Foundation. The National Academies are private, nonprofit institutions that provide independent, objective analysis and advice to the nation to solve complex problems and inform public policy decisions related to science, technology, and medicine. They operate under an 1863 congressional charter to the National Academy of Sciences, signed by President Lincoln. For more information, visit nationalacademies.org.

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