



Bart Shepherd, co-leader of the Hope for Reefs initiative, holds fish in a decompression chamber while on expedition in Vanuatu.

CALIFORNIA ACADEMY OF SCIENCES

Cities collaborate to safeguard oceans

Key targets for marine conservation missed a 2020 deadline, but momentum is growing. **By Michael Eisenstein**

For about 30 minutes each year, vast colonies of corals in the waters of Palau, an island nation in the western Pacific, erupt in an almost perfectly synchronized mass-spawning event. Releasing buoyant packages of sperm and egg cells into the water to be fertilized by neighbouring colonies, these hermaphroditic species must make the most of rare opportunities to seed new life.

In one of the world's few indoor coral-culturing labs, Rebecca Albright and her team at the California Academy of Sciences in San Francisco are recreating the seasonal and lunar

shifts that trigger such an event. The aim is to create multiple spawning systems that can be studied under controlled conditions. "Corals are notorious for being fickle animals to keep in captivity," says Albright, a coral biologist and co-leader of Hope for Reefs, a global initiative to research and restore crucial coral-reef systems. "Most only sexually reproduce once a year, so you have to simulate all these environmental cues to elicit that."

Strategies for cultivating and transplanting healthy corals into depleted areas are a crucial part of strengthening populations against

what Albright describes as the "one-two punch effect" of climate change. Rising temperatures cause coral bleaching and death, while ocean acidification caused by increased levels of carbon dioxide makes corals less resilient and prevents regrowth. "If we are able to cap warming at 1.5 °C, we're still going to lose 90% of reefs by 2050," she says. "And if we edge towards 2 °C, we risk losing 97% to 99%."

Of the United Nations' 17 Sustainable Development Goals (SDGs), Life below water (SDG14) and other SDGs related to environmental sustainability – Responsible consumption and

production (SDG12), Climate action (SDG13) and Life on land (SDG15) – were the weakest in both donor funding and outcomes, attracting less than US\$25 billion between them in 2000–13, according to the 2021 UNESCO Science Report (see go.nature.com/3zlojva). SDGs that are more directly related to economic growth – Industry, innovation and infrastructure (SDG9) and Sustainable cities and communities (SDG11) – by comparison, received \$130 billion and \$147 billion, respectively, over the same period.

James Leape, co-director of Stanford University's Center for Ocean Solutions in California, notes that four of the ten targets for SDG14, which aims to “conserve and sustainably use the oceans, seas and marine resources”, were due in 2020. All were missed. These include controlling the global damage wrought by illegal and unregulated fishing, which remains largely unchecked, and implementing scientifically grounded strategies for restoring affected fish stocks.

But there are signs of momentum. The amount of ocean being conserved and managed within marine protected areas (MPAs), for example, has increased from 0.9% to 7.7% since 2000, says Leape. MPAs are regions in which fishing, mining and other activities are restricted. Efforts are under way to further expand the number of MPAs globally.

Coastal collaborations

As the world's leading fishing nation, responsible for 15% of the reported global wild fish catch, China has ramped up efforts to designate new MPAs. Since 1980, China has designated more than 270 MPAs, comprising about 5% of its national waters. But it's a long way off efforts by countries such as the United States, which has more than 1,000 MPAs that cover about 26% of its waters, and the United Kingdom, with 371 MPAs comprising 38% of its seas. In a 2019 *Nature* correspondence, fisheries researchers Yunzhou Li and Yiping Ren, from the Ocean University of China in Qingdao and Yong Chen from the University of Maine, Orono, say that effective monitoring and strict enforcement will also be essential to the success of China's efforts (see *Nature* 573, 346; 2019).

In a city-based analysis by the Nature Index, Beijing had the greatest output related to SDG14 in the 82 natural-sciences journals tracked by the index in 2015–20, with a Share of 17.88, followed by the coastal city of Townsville in northeastern Queensland, Australia (Share 15.59) and the Boston metropolitan area (Share 13.66). The San Francisco Bay Area, second only to Beijing in output related to all 17 SDGs, had the sixth-highest Share for SDG14 (13.24).

Many small island states face serious

threats from the rapid decline of their coral reefs, which represent one of the world's most diverse ecosystems. Gildas Todinahary, a marine biologist at the Fisheries and Marine Science Institute at the University of Toliara in Madagascar, says the percentage of live coral cover surrounding the island nation has dropped from more than 80% in the 1980s to less than 10%, on average, today. “Decades ago, they used to say there will always be fish in the sea,” says Todinahary. “Now they say there are no more fish.” This has jeopardized the livelihood of the fishing communities on the island's western shore, he says.

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Christopher Golden, an ecologist and epidemiologist at the Harvard School of Public Health in Boston, is working with Todinahary and his colleagues to deploy a series of small tiered platforms, designed to mimic the cracks and crevices of the reef, into healthy coral communities along the Madagascar coast. Once colonized, these structures are transported into degraded reefs in an effort to repopulate them. “If we can create a healthier reef, we can then rehabilitate some of the fish populations, and that will lead to improved fish-catch and greater access to seafood as a nutritional resource,” says Golden.

Todinahary is enthusiastic about the potential for seeding new reefs in barren coastal stretches, but says education and outreach to fishing communities will be key to ensuring that those restoration efforts endure. “It's important to help communities change their habits and activities,” he says – for example, by providing training for alternative livelihoods such as aquaculture.

Buy-in from community leaders is also crucial to the success of partnerships between researchers in leading science cities and colleagues in low- and middle-income maritime nations in SDG-related projects. In 2016, the government of Palau invited Leape and his team at Stanford to develop a strategy for turning 80% of its exclusive economic zone, a 370-km radius surrounding the island, into a protected area where fishing is prohibited. The initiative went into effect in January 2020. “We're using satellite tracking to understand the patterns of use of the sanctuary by large pelagic species, and using DNA analysis to monitor biodiversity in the sanctuary,” says Leape. Palau's programme has helped to

motivate other island nations in the region to extend marine protection and conservation efforts as part of the Micronesia Challenge, an initiative to conserve 50% of marine resources and 30% of terrestrial resources by 2030.

Golden's research emphasizes both the sustainability and food-security sides of the fisheries-management coin, with routine health assessments of communities in places such as Madagascar and the Republic of Kiribati, an island nation in the central Pacific Ocean, coupled with close monitoring of the ecological health of their surrounding waters. To help this effort, Golden and his colleagues developed the Aquatic Food Composition Database, which compiles detailed nutritional information on more than 3,700 local plant and animal species to provide ecologically grounded guidance to local fishers. “We can look at what type of resilience there might be if we lose access to one species and have to focus on another,” says Golden. “We can understand the type of nourishment that people are actually getting from their catch.”

Stanford's Center for Ocean Solutions is also leveraging new technologies to guide sustainable fishing practices that benefit small-scale fishers, whose livelihood SDG14 aims to safeguard. “Their catches account for about two-thirds of the seafood we eat, and 90% of the fishery jobs,” says Leape. The centre is partnering with ABALOBI, an organization in South Africa founded by fisheries researcher Serge Raemaekers, from the University of Cape Town. ABALOBI has designed a mobile app toolbox to help fishers track specific fish populations, coordinate boats and crews, and bring catches to market. Leape is hopeful that early pilot testing in Africa and the Indian Ocean will pave the way for broader deployment in the near future.

In parallel, Leape's team is working on strategies to crack down on illegal fishing – currently estimated to account for roughly 20% of the global catch. This is being achieved partly through tools such as the satellite-based fishery monitoring efforts of Global Fishing Watch, a website run by Google in partnership with conservation non-profit organizations Oceana and SkyTruth. But technology is only part of the solution. Leape sees a crucial role for aggressive government enforcement and getting major corporations to engage in closer oversight of fishing practices. “We've been using Global Fishing Watch and other data sources to understand the patterns and areas for illegal fishing,” he says. “We're working with these partners to try to translate that data into a more concerted effort to crack the problem.”

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