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ECOLOGY

Recovering the potential of coral reefs

An analysis of fish declines in coral reefs shows that simple fishing limits and implementation of marine protected areas can be enough to support recovery of coral ecosystem resilience.

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Fishing has transformed today's coral reefs, but its effects can be insidious and hard to detect[1,2]. Defining conservation strategies without an appropriate frame of reference is therefore a serious challenge for coral-reef conservation. In a paper published on *Nature*'s website today, MacNeil *et al.*[3] use a combination of data from protected, near-pristine and fished reefs to document the extent of fish biomass declines that have arisen as a result of fishing. Furthermore, they provide comprehensive evidence that simple forms of fisheries management can successfully restore fish-community biomass.

Conservation biologists typically rely on monitoring over time to track the decline and recovery of biodiversity and ecosystem states[4]. But ecosystem-scale underwater research on coral reefs has been possible only in the past 20 years, so that few suitable time series exist for this purpose. To overcome this challenge, MacNeil and colleagues use a space-for-time substitution[5] to estimate fish biomass from underwater surveys of 832 reefs across the world's tropical oceans. The authors combine data on fish biomass in marine protected areas (MPAs), in which fishing is prohibited, with data from 22 unfished sites that are more than 200 kilometres from the nearest human settlements — the most pristine reefs in the world. This provides an estimate of historical biomass in coral-reef ecosystems on an unprecedented global scale.

The authors find that, on average, there is no more than one tonne of fish biomass in each hectare of protected or near-pristine coral reef, although local ecological conditions can lead to considerable variation (Fig. 1). By comparison, 83% of the fished reefs — both managed and unmanaged — have less than half of this biomass. The range of depletion varies widely, from the most severely degraded reefs in the Caribbean and western Pacific, to almost undetectable depletion in the most remote, least-inhabited islands, such as Pitcairn and Easter islands. The reefs in Guam and Papua New Guinea are near collapse, with only 10% of the historical estimate of fish biomass present.

Although these declines seem dire, an equally important finding is that fisheries management works. This is a message of hope to those working in conservation. Over the past decade, many have given up on fisheries management because it is perceived as being too difficult, expensive or beyond the capacity of academics and non-governmental organizations[6]. Many instead turned to MPAs as a blanket solution to marine-conservation challenges. But to be effective, MPAs need to be protected and enforced, which requires them to be large, old and isolated[7]. Effective MPAs can halt declines, but the build-up of biomass to historical levels takes time. MacNeil and colleagues show that recovery takes at least 35 years, twice as long as previous estimates[8]. Patience, persistence and continued financial investment will be essential to the success of the ocean's increasing number of MPAs.

As MacNeil and colleagues recognize, MPAs are simply not an option in areas where people depend on fish from reefs. Coral reefs lie in the waters of more than 100 developing countries, many of which have dense, rapidly growing coastal populations. Enforced MPAs might not be viable because of the burden of displacing fishers, the unknown effects of redistributing fishing and the time it takes for biomass to recover. But the authors show that those reefs that had some form of management, such as restrictions on fishing equipment, species or access, had 27% more fish biomass than reefs open to fishing.

Even in depleted reef communities, regulations protecting key species can promote ecosystem resilience and recovery. For example, prohibiting specific equipment can allow herbivorous fishes to recover, promoting coral resilience[9]. MacNeil *et al.* take this analysis one step further, comparing MPAs of different ages to predict the recovery speed and sequence of different fish groups following implementation of management measures. Their models predict that species at the base of the food web, including herbivores, will recover rapidly. Some of these low-trophic-level species, such as parrotfishes, recover in a nonlinear manner, reaching the greatest biomass soon after management is implemented. The researchers predict that these species will be most abundant — and therefore at their most effective for grazing, excavating or scraping away algal overgrowth that limits coral growth — at the time when the reefs recover half of their historic fish biomass.

Piscine predators have historically been the first group to be overfished, and this study shows that they are the last to recover. Because they are almost absent from present-day reefs, their relevance to healthy coral ecosystems is sometimes overlooked. But piscine predators have two essential roles in reef communities.

ALEX MUSTARD/NATUREPL.COM

Figure 1 | How overfished is this reef? MacNeil *et al.*[3] show how conservation targets and the recovery rates of key fish groups can be estimated from large-scale comparisons of fish biomass at protected and remote sites.

First, they suppress mesopredators such as starfish, preventing trophic cascades that change the dominant reef substrate from hard coral to algal overgrowth. Second, they integrate oceanic and reef food webs, feasting on the planktivorous fishes that vacuum up oceanic zooplankton[10]. Without predatory fishes, reefs are potentially condemned to a state of lowered biomass. Prevention of this negative outcome requires effective fisheries governance, including improved monitoring, equipment restrictions to reduce unintentional catch, and increased transparency in the supply and trade of high-value seafood products[11].

There has been much discussion about coral-reef conservation, but little analysis of the efficacy of alternative management options. Currently, most of the world's coral reefs have little or no management — in part because of the persistent lack of recognition by international development agencies and local governments of the social and economic benefits that small-scale fisheries have for the poorest coastal peoples of the world[11]. MacNeil *et al.* provide definitive confirmation that simple fisheries governance tools, including protected areas and equipment, access and species restrictions, can be effective. If adopted seriously, these measures can secure a sustainable future for coral reefs and the people who depend on them. ■

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