CORAL REEFS

Big data guides pragmatic management

An assessment of coral communities on more than 2,500 reefs across the Indo-Pacific identifies three categories of reef according to their functionality and vulnerability to ocean warming. This categorization reveals a sobering picture of today's coral reefs, but also provides a foundation for their future management.

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When does a coral reef cease to be a coral reef? The devastation of reefs due to the human-made climate crisis[1] has placed an unwelcome focus on this question and the myriad practical considerations concerning how we manage these valuable ecosystems[2]. How many reefs have been reduced to shells of the fast-paced, thriving system they once were? Are there still fully functional coral reefs? Do we go all-in on preserving the world's most pristine reefs and simply give up on the others? In a world where resources and political will to impose change are limited, answers to these questions are urgently needed. Writing in *Nature Ecology & Evolution*, Darling et al.[3] offer a new baseline that helps assess the tangle of ecological scenarios on coral reefs through the lens of pragmatic management.

Scleractinian corals are the foundation species of coral reefs. By growing a calcium carbonate skeleton, corals expand the three-dimensional framework of reefs and thus offset the perpetual erosion imposed by the ocean and its inhabitants[4]. This budget of reef growth versus erosion may offer a gauge by which we can judge how well a reef is doing: at or above the balance point the coral framework is stable or expanding, which may meet the minimum requirements of a functional reef. Shrinking reefs, in turn, may hardly qualify as coral reef ecosystems the way we know them.

Broad application of even this simplified definition is not trivial. Measuring the dynamics of reef growth or erosion is difficult at local scales, let alone entire ocean basins. Therefore, snapshot assessments of the extent of seafloor covered by corals are currently our best tool for large-scale assessments. However, not all coral species are equal. Among the more than 800 species of scleractinian corals[5], marked differences exist in coral growth rates and their ability to build and uphold a complex reef skeleton in the face of disturbances. In light of this complexity, some useful generalities can emerge from a bird's-eye view.

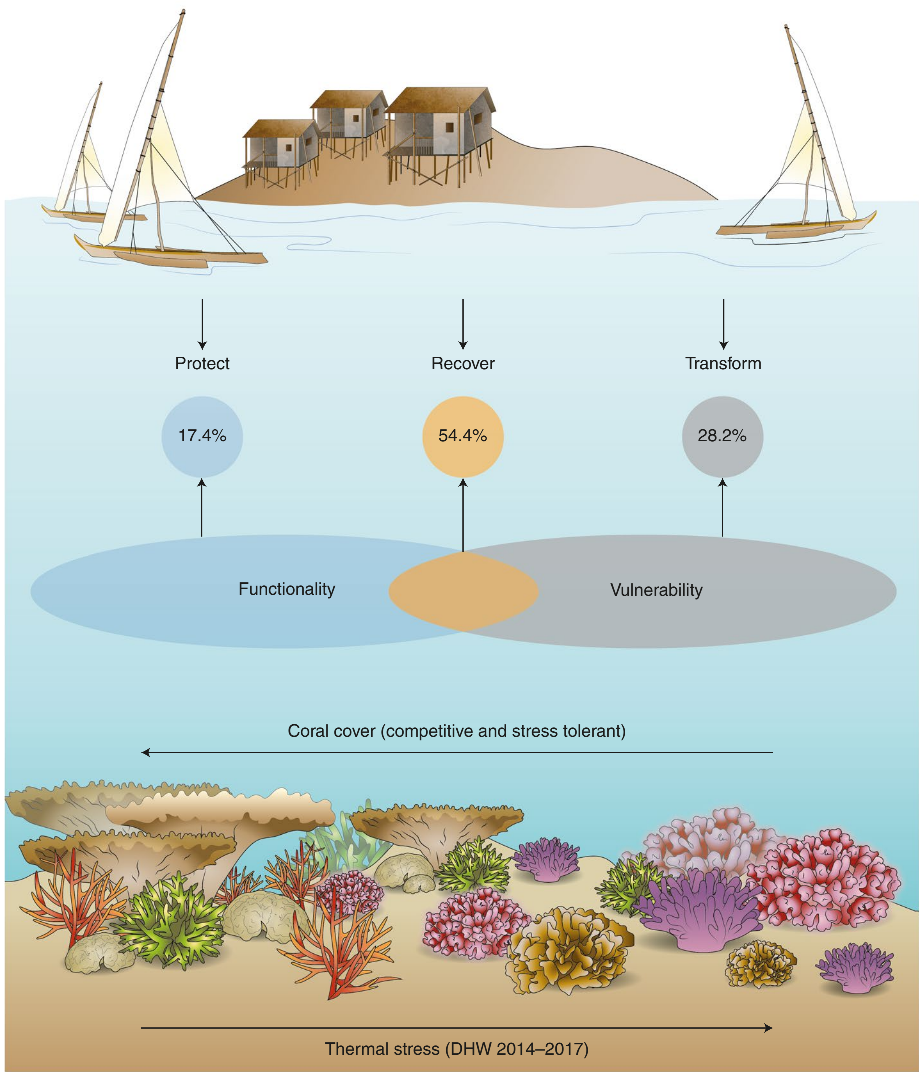

Fig. 1 | Reef categories. Darling et al. assigned coral communities across 2,584 reefs in the Indo-Pacific to three core management approaches. To do so, they considered each reef's functionality, approximated from a threshold of 10% cover by competitive and stress-tolerant corals, and their vulnerability to climate-induced bleaching in recent years, determined by exposure to degree heating weeks (DHW) from 2014 to 2017. This resulted in two opposing categories ('functional and not susceptible' and 'not functional and susceptible') and one intersectional category ('functional and susceptible'). For each category, the authors present avenues for human societies to act, proposing to protect high-performing reefs (17.4% of reefs), recover potentially functional reefs that have suffered from recent heat stress (54.4%) or transform livelihoods away from reef-based services for reefs that are not functional and vulnerable to ocean warming (28.2%).

After compiling the largest dataset on the structure of Indo-Pacific coral communities yet assembled, Darling et al. adapt an existing threshold of 10% coral cover as a litmus test, below which a reef is likely to be shrinking. However, in contrast to previous work[6], they explicitly considered the contributions made by members of two functional groups of corals: competitive, fast-growing corals that can quickly add to the reef framework; and robust, stress-tolerant dome-shaped forms that persist in the face of disturbance. Although part of a continuum of trade-offs[7], these two groups broadly contrast in their ecological roles with generalist and weedy corals that contribute less to the growth, complexity and maintenance of shallow reefs.

Darling and colleagues' findings foster both hope and concern. Although they show that many reefs across the Indo-Pacific are still dominated by strong framework-building corals (in contrast to many Caribbean reefs[8]), recent ocean warming-induced bleaching has taken a toll across all coral categories. Furthermore, the authors show that local socioeconomic and environmental factors, along with small-scale management efforts, shape coral assemblages in concert with climate-driven disturbances. This finding is consistent with recent evidence for increased ecosystem functioning under strict protection[9], but contrasts with a synthesis that found no consistent effect of local protection on coral resilience[10].

Through the thicket of potential drivers and their effects on framework-building coral cover, Darling et al. develop a simple categorization of reefs for management that hinges on their functionality and vulnerability to thermal stress (Fig. 1). Specifically, the authors use the 10% threshold of framework-building corals to infer functionality, and exposure to recent thermal stress (four degree heating weeks) as a proxy for vulnerability to heating, to sketch an overarching plan of attack for reef managers and stakeholders. According to this scheme, reefs with more than 10% cover of framework-building corals that escaped the 2014–2017 bleaching event unscathed, by virtue of their location in cooler waters, are of highest priority for protection. Some 450 reefs in the Indo-Pacific, or 17% of reefs monitored, fall into this category — 9 times the number proposed previously[11]. There is, of course, no guarantee that protection will safeguard them from climate-induced catastrophes in the long term[12], but these reefs are our best hope for the future. Darling et al. suggest that local protection of these reefs is critical (Fig. 1).

The majority (54%) of the assessed reefs fall into another management category. These are areas that had a high cover of reef-building corals before the most recent bleaching event in 2014–2017, but have had to cope with hot water recently. Here, Darling et al. suggest that social and environmental conditions appear favourable to support functional reefs, although rapidly escalating ocean warming remains a strong threat. Strategic efforts such as active coral restoration, albeit small scale in nature, could succeed in providing short-term boosts for recovery, maintain reef services for societies and foster conservation buy-in by local people[13]; however, large-scale policies to address the climate emergency are crucial for these reefs.

Finally, more than a quarter of the reefs studied seem to be in dire straits. A mélange of past climate disturbances, societal pressures and environmental conditions had pushed these reefs below the 10% threshold before they experienced extreme thermal stress between 2014 and 2017. These reefs no longer look like iconic images of coral reefs and may not be able to support human societies as they once did. Darling et al. suggest that, for these systems, urgent transformation of current reef management or, ultimately, a move towards the development of alternative livelihoods may be the most effective strategy for people. A sobering, but pragmatic approach.

In a world of trade-offs, Darling et al. sacrifice ecological subtleties to derive a broadly applicable framework to guide management efforts. The coarse life-history groupings of corals used in the study mask enormous variation in the growth and resilience of different coral species, and the neat categorical classification (albeit well established) can lead to some questionable assignments compared with traditional taxonomic groupings. Furthermore, the coral community composition data that underpin the paper reflect the 'functional potential' of each coral assemblage. While the presence of high-performing, framework-building corals is a necessary premise, actual rates of calcium carbonate production may differ substantially from what is inferred[14,15].

Nevertheless, this unprecedented examination of coral assemblages and their drivers across the world's biggest ocean basin, and Darling and colleagues' distillation of a simple applicable framework to guide management, is a timely advance that may help us in scaling-up management solutions to meet the threats to coral reefs in the Anthropocene[16]. It does not absolve ecologists, managers and stakeholders from continuing to measure and consider true ecosystem functioning on coral reefs and how it is changing. But it does offer a solid baseline for us to gauge whether we are still looking at, and trying to conserve, a modern coral reef or a system that is perhaps better termed an 'anthropocenic tropical reef'. Troubling as the latter thought may be, collaborative, 'big data' approaches like the study by Darling et al. can help to recognize such a shift, and the associated challenges of determining its ecological and societal consequences. ❒

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