Marine conservation

https://doi.org/10.1038/s41559-024-02393-w

Mixed management boosts reef shark abundance

David M. P. Jacoby

A global survey using baited cameras on coral reefs demonstrates a near twofold increase in the relative abundance of reef sharks in marine protected areas that are also embedded within areas of effective fisheries management. However, such conservation benefits were not evident for wide-ranging sharks or rays found on the reef.

The complex and debated questions of what makes an effective marine protected area (MPA) and what we mean by protected area effectiveness underpin how we understand and measure marine conservation goals. They are challenging because MPAs range in size and age, and from minimal to full protection[1]. It seems, however, that effective MPAs combine some or all of five key features: they are large, old, well enforced and isolated, and have no-take protection. It is predicted that these characteristics will lead to substantial increases in fish size and biomass when compared to areas under fishing pressure[2]. Yet it remains difficult to quantify the effectiveness of MPAs and other conservation solutions at scale. Writing in *Nature Ecology & Evolution*, Goetze et al.[3] use data from more than 18,000 video surveys in 36 different countries to compare the relative abundance of wide-ranging and reef-associated sharks and rays from inside and outside of 66 fully protected areas. They show unequivocal benefits of a mixed-management approach of MPAs embedded in areas of effective fisheries management for reef-associated sharks, but mixed results for other elasmobranch species.

Fishing has had marked negative effects on large-bodied, predatory elasmobranchs (which include sharks and rays) around the world[4,5]; however, other human impacts also affect these species. As a tool for shark conservation, MPAs tend to be most effective in remote places that are far removed from human activities[6]. But anthropogenic effects are often more nuanced than this, as Goetze et al. demonstrate. Using the metric of 'gravity' (a measure of human population size and distance to a fully protected area), they show us that in low-gravity, remote, fully protected areas where human impacts are low, the abundance of top predator species is high both inside and outside of the protected area. However, as gravity increases, the abundance of sharks increases inside the fully protected area relative to outside (Fig. 1). In short, the conservation benefits of fully protected areas are greatest where the human impacts are high, as well as where reefs are distinct (isolated reefs that are more than 20 km from their nearest neighbouring reef). Goetze et al. show that if these areas are also situated in locations where catch limits are imposed and gillnets or longlines are prohibited through fisheries management in the area that surrounds the MPAs, then the abundance of reef sharks doubles as compared to locations where there is no effective fisheries management (Fig. 1).

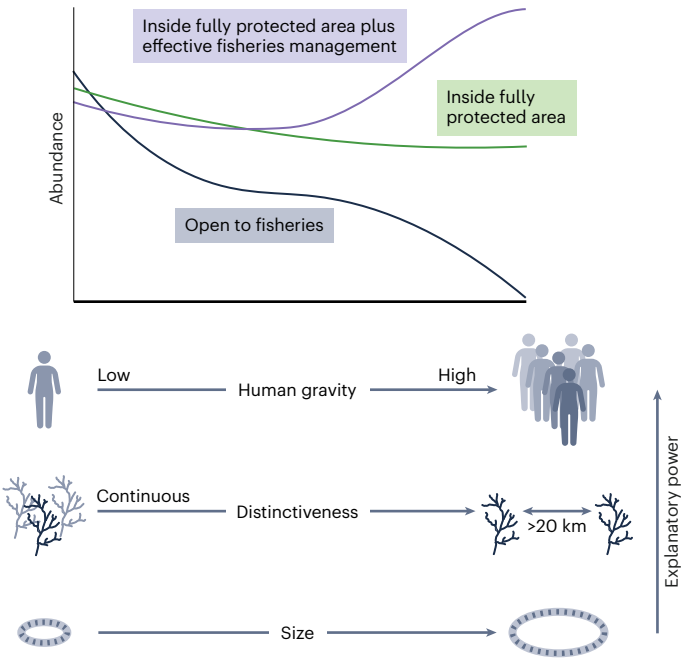

Fig. 1 | Relative abundance of reef-associated sharks is influenced by social, geographical and management factors. Goetze and colleagues show that reef shark abundance in fully protected areas is most strongly influenced by three characteristics of the protected area (in order of their explanatory power): gravity (a measure of human disturbance), distinctiveness (a measure of protected areas that contain isolated reefs more than 20 km from one another) and size. They also show that embedding fully protected areas within areas of effective fisheries management (for example, where catch limits and bans on gillnets and longlines are imposed) can nearly double the conservation benefits of the protected area for reef-associated shark species.

This provides an important advance in our broad understanding of the key factors that influence successful reef-shark conservation.

Perhaps unsurprisingly, these mixed-management effects do not hold for wide-ranging sharks that are capable of spending prolonged periods of time outside of protected area boundaries. More surprising, however, is Goetze and colleagues' finding that they also do not hold for either large-bodied or small-bodied rays, which are themselves subject to considerable fishing pressure. The authors suggest this reflects a potential methodological bias that causes reduced detection of these flattened elasmobranchs on the baited remote underwater video stations (BRUVS) used in the surveys.

Of course, biotic factors cannot be ignored — and reef sharks are an ecologically and demographically diverse assemblage. The authors offer an intriguing hint that in some areas and species complexes,

ecological traits and even behaviour may explain some of the variation in relative abundance seen between sites. For example, they describe more heterogeneity and lower confidence in the conservation benefits for blacktip reef sharks (*Carcharhinus melanopterus*), which implies that BRUVS sampling fails to capture some interspecific interaction effects (such as competitive exclusion) that are known to influence space use in this species in particular locations[7]. Integrating species-specific standardized movement metrics derived from tracking data with predictive models, to explicitly inform marine spatial planning, is undoubtedly offering exciting and important developments in research and policy implementation[8–11].

One message that becomes clear in reading Goetze and colleagues' work is that both geography and culture can contribute to bucking the global trends. MPAs can have both positive and negative social, cultural, political and economic effects on local communities[12], and the notion of 'success' can vary between stakeholders[13]. Outlier locations in these global analyses — such as Marovo in the Solomon Islands — therefore warrant careful attention. Outliers reflect areas where other factors (such as cultural significance, low effort or demand, or geographical factors) can lead to a low catch and high abundance of sharks, without the need for effective fisheries management or fully protected areas. Crucially, these geographical and cultural factors also influence enforcement and compliance in protected areas[14]. A lack of quantitative data on patrol effort, infringements or community support for regulations meant compliance was assigned by park authorities or scientists as simply high, moderate or low in Goetze and colleagues' model. Given the importance of compliance in driving conservation success in teleost fishes[2], including it as a qualitative factor (which explained none of the model variation) may unintentionally mislead us into assuming that compliance has no influence. What we should take from this, though, is that in advocating for the benefits of a mixed-management approach, we need to work harder across disciplines and with local managers and users to accumulate long-term, standardized data on MPA efficacy after designation, and at scales that are appropriate for global assessments such as this.

The Global FinPrint survey, which provided the data used by Goetze and colleagues, has already generated fundamental insights into the shifting state of elasmobranch assemblages on our world's coral reefs[4,11]. This study not only adds weight to the recommended expansion of networks of highly protected areas, but also highlights the numerous fully protected areas that do not confer significant benefits to elasmobranchs — these areas are in need of improved management or design. As a taxonomic superorder, rays (Batoidea) are known to be more imperilled than sharks: 36% of species are now threatened[15]. Importantly, Goetze et al. provide a global assessment of protected area effectiveness for rays and, in doing so, emphasize the need to better understand (and perhaps better measure) what drives conservation benefits in this group.

Using this remarkable dataset, Goetze and colleagues deliver the evidence that mixed-management approaches to reef shark conservation can achieve benefits that are much greater than the sum of their parts. In doing so, they provide another reminder that conservation targets based purely on area are unlikely to be sufficient to reverse the decline in marine biodiversity and predator biomass in hyper-diverse coral reef ecosystems.

David M. P. Jacoby
Lancaster Environment Centre, Lancaster University, Lancaster, UK.
e-mail: d.jacoby@lancaster.ac.uk

Published online: 20 May 2024

References

1. Grorud-Colvert, K. et al. *Science* **373**, eabf0861 (2021).
2. Edgar, G. J. et al. *Nature* **506**, 216–220 (2014).
3. Goetze, J. S. et al. *Nat. Ecol. Evol.* https://doi.org/10.1038/s41559-024-02386-9 (2024).
4. MacNeil, M. A. et al. *Nature* **583**, 801–806 (2020).
5. Queiroz, N. et al. *Nature* **572**, 461–466 (2019).
6. Juhel, J. B. et al. *J. Appl. Ecol.* **55**, 673–683 (2018).
7. Sabando, M. A., Rieucau, G., Bradley, D., Caselle, J. E. & Papastamatiou, Y. P. *Oecologia* **193**, 371–376 (2020).
8. Lennox, R. J. et al. *Can. J. Fish. Aquat. Sci.* **76**, 497–509 (2019).
9. Hays, G. C. et al. *Trends Ecol. Evol.* **34**, 459–473 (2019).
10. Lédée, E. J. I. et al. *Fish Fish.* **22**, 987–1005 (2021).
11. Dwyer, R. G. et al. *Curr. Biol.* **30**, 480–489.e5 (2020).
12. Bennett, N. J. & Dearden, P. *Mar. Policy* **44**, 107–116 (2014).
13. MacKeracher, T., Diedrich, A. & Simpfendorfer, C. A. *Fish Fish.* **20**, 255–267 (2018).
14. Arias, A., Cinner, J. E., Jones, R. E. & Pressey, R. L. *Ecol. Soc.* **20**, 19 (2015).
15. Dulvy, N. K. et al. *Curr. Biol.* **31**, 4773–4787.e8 (2021).

Competing interests

The author declares no competing interests.