FRB FONDATION POUR LA RECHERCHE SUR LA BIODIVERSITÉ

CESAB
CENTRE FOR THE SYNTHESIS AND ANALYSIS OF BIODIVERSITY

Project summary

PELAGIC

Prioritizing ecologically significant and globally important marine conservation areas for vertebrates: synthesizing the best available knowledge to inform management and policy

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Declines in marine predators intensified globally in the 1950's, as industrial fleets targeted previously inaccessible populations of sharks, tunas, and billfishes. These spatially extensive fisheries continue to expand, while global catches continue to decline.

Context and objectives

Given the difficulty of managing these fisheries sustainably, large no-take Marine Protected Areas (MPAs) have been proposed for halting and reversing these declines. These MPAs require knowledge of the critical habitats that maintain these predators and that are relatively immune from the effects of human disturbances. This crucial knowledge is currently severely limited since based primarily on species

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geographic distributions obtained through fishery catches that remain biased with untargeted species, unfished areas and deliberate underreporting.

Here, PELAGIC planned to overcome this limitation by collecting the most up-to-date and complete information on the biogeography and habitat use of marine mammals, sharks and fishes. Then PELAGIC experts evaluated the current performance of the global system of MPAs for all vertebrates and proposed some options to optimize the design of future MPAs to insure the long-term persistence of vertebrates in the oceans.

Principal conclusions

PELAGIC used baited videos across the Indo-Pacific to model the distribution of vertebrate species richness, body size, and shark abundance hotspots (top 5% value) in surface waters (Figures 1, 2 & 3). They found that vertebrate species richness is primarily explained by environmental conditions (25%, e.g. sea surface temperature) and geomorphology (39%, e.g distance to seamount). **Human pressure is the main driver of the distribution of predator mean maximum body size (21%) and shark abundance (12.3%). Refuges were detected at > 950 km from humans for large body-size individuals (>107cm) and at >1,200 km for sharks.** These few refuges are shallow seabed features such as seamounts, submerged banks, and continental slopes remote from human markets. They represent the large areas hosting large individuals and abundant sharks. Elsewhere the top end of the trophic structure is missing. Worryingly, these refuges are presently under-represented within large no-take MPAs that are adequate for protecting marine predators. In order to conserve the last hotspots of large-bodied marine predators, MPA design should also include wilderness areas remote from humans in a precautionary principle.

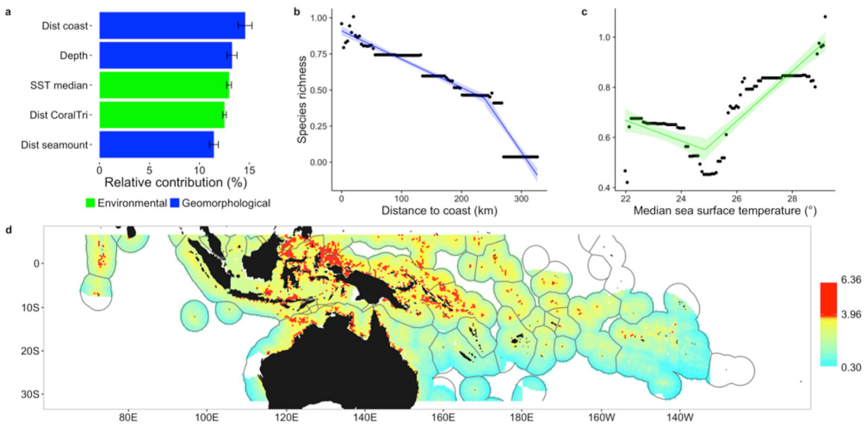

Figure 1: **Drivers and patterns of species richness in the Indo-Pacific.**
a. Relative contribution of main drivers explaining variations in species richness. b, c, Species Richness related to the distance to the coast (b) and to the sea surface temperature (c). d, Predictions of species richness (top 5% values, in red).

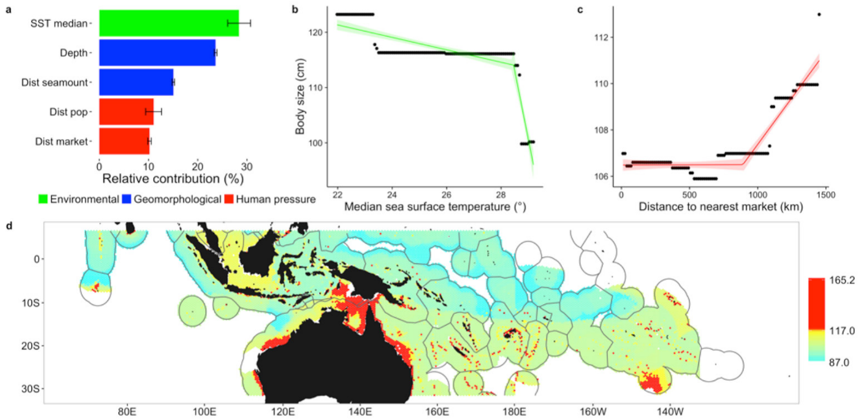

Figure 2: **Drivers and patterns in body size in the Indo-Pacific.**

a. Relative contribution of drivers to mean maximum body size. b, c, Body size related to the sea surface temperature (b) and to the distance to nearest market (thresholds represented by breaking point, c). d, Predictions of body size (top 5% values, in red).

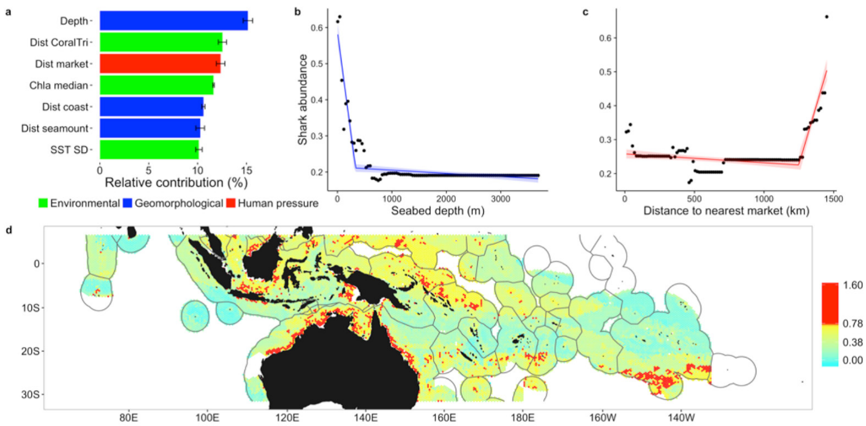

Figure 3: **Drivers and patterns of shark abundance in the Indo-Pacific.**

a. Relative contribution of drivers to shark abundance. b, c, Shark abundance related to the seabed depth (b) and to the distance to nearest market (thresholds represented by breaking point, c). d, Predictions of shark abundance and hotspots (top 5% values, in red).

Beyond over-exploitation and the global defaunation of all ecosystems on Earth, humans can induce behavioral alterations on animals with potential consequences on their fitness. For instance, terrestrial wildlife like mammals and birds are more vigilant near humans, resulting in decreased food intake and reduced reproductive success. Similarly, marine mammals show behavioral alterations due to nautical activities resulting in additional energetic costs to avoid interactions or nuisance. Sharks exhibit high learning abilities similar to most terrestrial vertebrates. Behavior experiments demonstrate that sharks can learn discriminative tasks and retain information for long time periods.

These abilities make sharks likely to demonstrate long-lasting adaptive responses to external stimuli including interactions with human activities. For instance, the catchability of blacktip reef sharks (*Carcharhinus melanopterus*) decreases after several catches and releases while bull sharks (*Carcharhinus leucas*) show a modified behavior related to food provisioning. Although human impacts on shark behavior have been documented, we still lack empirical evidence of behavioral alterations along a wide gradient of human activities from densely populated areas to the last wilderness areas.

Using an extensive sampling of 367 baited underwater videos, PELAGIC demonstrated modifications in grey reef shark (*Carcharhinus amblyrhynchos*) occurrence and feeding behavior along a marked gradient of isolation from humans across the New Caledonian archipelago (South-Western Pacific). The probability of occurrence decreased by 68.9% between wilderness areas (more than 25 hours travel time from the capital city) while the few individuals occurring in impacted areas exhibited cautious behavior. PELAGIC also showed that only large no-entry reserves (above 150 km²) can preserve the behavior of grey reef sharks found in the wilderness.

Anticipated (or actual) impact of these results for science, society, and public and private decision making

Using the first extensive videography survey of marine predators across a large gradient of environmental conditions, geomorphology, and human pressures, **PELAGIC showed that very few locations still detected more than three species (25%) with an average maximum body size greater than one meter (52%). Sharks were detected only in 11% of the locations, and these locations tended to be outside a 1,000 km radius from human markets, suggesting that their ecological functions are likely to have been eroded at closer distances.** Shallow, remote habitats are thus the last refuges for predators sensitive to human pressures in the ocean, and as such should deserve the status of large no-take MPAs in order to enhance population recovery. Besides PELAGIC showed that only no-entry MPAs can protect the behavior of top predators like sharks.

The researchers also identified specific areas that, if protected, would safeguard over 80% of the habitats for endangered marine species, and increase fishing catches by more than eight million metric tons. These results, published in *Nature* in 2021 show that a targeted strict ocean protection can contribute to a more abundant supply of healthy seafood and provide a cheap, natural solution to address climate change—in addition to protecting embattled species and habitats. The study is also the first to quantify the potential release of carbon dioxide into the ocean from trawling, a widespread fishing practice—and finds that trawling is pumping hundreds of millions of tons of carbon dioxide into the ocean every year, a volume of emissions similar to those of aviation.

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