

LENFEST OCEAN PROGRAM

RESEARCH SERIES

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How do large sharks shape marine communities?

GLOBAL CONSEQUENCES OF SHARK DECLINES

A SUMMARY OF NEW SCIENTIFIC ANALYSIS:

Ferretti, F., B. Worm, G.L. Britten, M.R. Heithaus and H.K. Lotze. 2010. Patterns and ecosystem consequences of shark declines in the ocean. *Ecology Letters* 13:1055-1071.

POPULATIONS OF LARGE SHARKS are declining in many parts of the world. Scientists suspect these declines could have significant impacts on marine ecosystems because of large sharks' predominant role as top predators. Yet, because sharks are fast-moving and wide-ranging animals, and marine ecosystems are complex, researchers have found it difficult to predict consistently what might happen as large sharks' numbers are reduced.

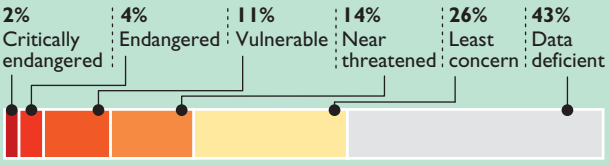
In order to investigate this question, Francesco Ferretti and his coauthors conducted an extensive review of scientific literature to describe the effects of large shark declines in a variety of marine ecosystems. The researchers show that while unperturbed ecosystems have a high diversity and abundance of sharks, sharks may be quite vulnerable even to light fishing pressure. They also found that the effects of shark declines vary with habitat type, degree of marine species diversity, rate of shark population replenishment and fishing intensity. The authors suggest that large sharks can exert strong control on large long-lived marine animals such as mammals, turtles and smaller sharks for which natural mortality is usually low and mostly caused by shark predation. These effects may occur throughout the oceans and over long periods of time, but the generality of the consequences needs to be tested further. This *Lenfest Ocean Program Research Series* report is a summary of the scientists' study.

FIGURE 1. LOSS OF SHARK POPULATIONS

The decline of shark and ray species across the globe is primarily related to the effects of fishing, though habitat destruction and pollution also play a role.

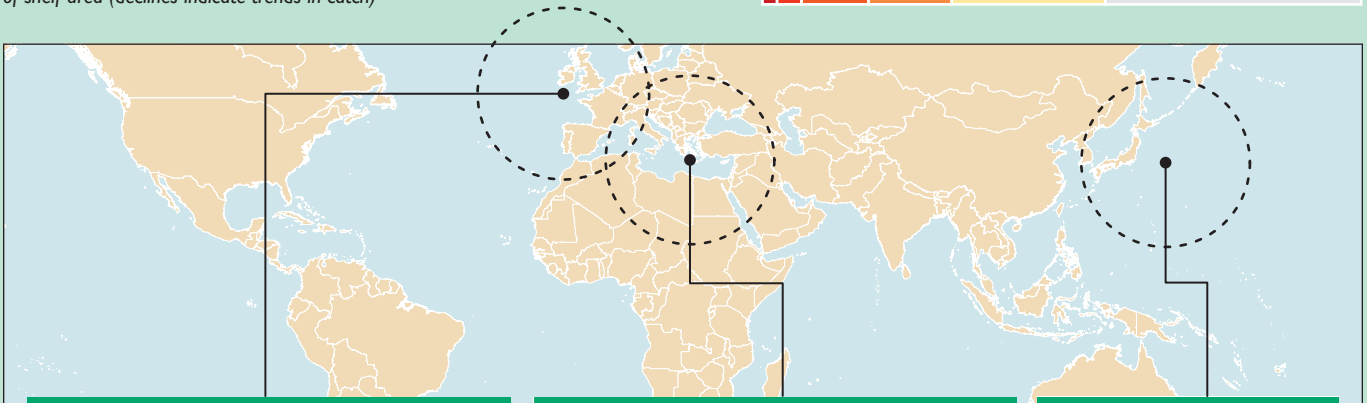
Global conservation picture

Globally, of the 881 species of chondrichthyans—sharks, rays and chimaeras—evaluated by the International Union for the Conservation of Nature, nearly a third are at higher levels of concern.



CRITICAL REGIONS, AT A GLANCE

1950-2007 United Nations Food and Agriculture Organization data for sharks and rays, catches in thousands of metric tons per square kilometer of shelf area (declines indicate trends in catch)



Northeast Atlantic

Though catch trajectories have fluctuated, the recent downward trend here and in the Mediterranean supports recent findings that the regions have experienced major depletions in sharks and rays. In the North Sea and around the British isles, trawl fisheries depleted most large elasmobranch (sharks and rays) species to under detectable levels. Here, the shark and ray community became composed of fewer, smaller and more resilient populations.

Mediterranean/Black Sea

The Mediterranean has a long history of fishing exploitation, so long that data beginning in 1950 do not capture the true extent of shark species loss in the region. A century of trawl fishing in the region has eliminated 16 of 31 elasmobranch species in the Tyrrhenian Sea and 6 of 33 species in the Adriatic. The intense exploitation has virtually eliminated all large open ocean shark species in this region.

Northwest Pacific

Catches in the northwest Pacific region have steadily declined since the 1950s and may have peaked even before then, probably due to long-term fisheries in the area and the ongoing shark fin trade.

Note: See Ecology Letters paper for citations.

STUDY METHODS

The authors evaluated peer-reviewed papers, predominantly published over the last decade, that described: (1) the ecology and evolution of sharks to provide context for their diversity, abundance, prey preferences and reproductive rates; and (2) the results of experiments, field observations, fishery and scientific survey data, and predictive models that illustrate the status of sharks and their role in marine ecosystems. The scientists used this information to examine trends in declines and determine the ecological consequences of removing sharks from different habitats.

Shark declines may result in the rearrangement of marine communities throughout the oceans.

PATTERNS OF SHARK DECLINES

The researchers' review shows that shark populations in many coastal, continental shelf and open ocean ecosystems have substantially declined across the globe (see Figure 1). Open ocean sharks are particularly vulnerable—the IUCN has classified more than half (58 percent) of these species as "threatened" with extinction. The major threat for most shark species is fishing, both directed fishing for shark fins and meat and as unintended bycatch in fisheries. Many species are difficult to assess in terms of extinction risk because of the scarcity of relevant data.

WHY LOSING SHARKS CAN MATTER TO ECOSYSTEMS

Although sharks feed at different levels of the food web, many species are top predators and have the potential to structure ecosystems in crucial ways. They not only consume prey directly, but may influence their prey's distribution by changing where and when their prey feed—so-called "risk effects" (see Figure 2).

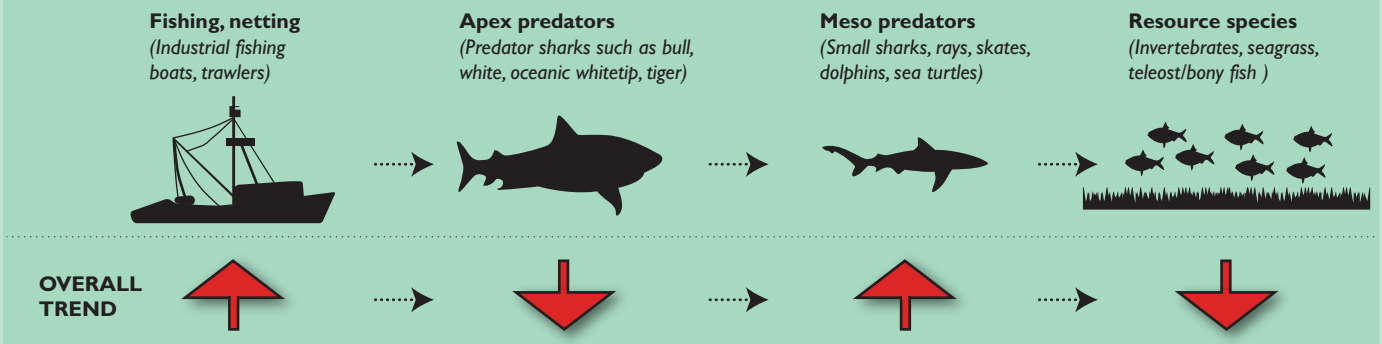
Because of these characteristics, declines in shark populations could trigger cascading effects through food webs. So-called "mesopredators" like smaller sharks, rays and marine mammals can increase in number, extend their distributions, or change their feeding habitats because of decreased predation risk. These "mesopredators" in turn could consume greater numbers of smaller fish, crustaceans or shellfish, including some commercially-important species.

The literature provides more evidence of food web impacts from sharks in coastal ecosystems (where fishing pressure has historically been more intense) than in shelf and open ocean ecosystems, which are more difficult to study. The authors of the study point out that fishing can affect both sharks, their competitors and their prey, potentially masking the detection of clear patterns in the open ocean. Further studies may illuminate additional effects in these vast and important habitats.

FIGURE 2. HOW OVEREXPLOITATION OF PREDATORY SHARKS AFFECTS AN ECOSYSTEM

Large sharks can shape communities in two pathways: direct consumption of prey or risk effects, by which prey change their behavior, such as feeding in sub-optimal areas to avoid predation risk. The following figures show how shifts in shark presence or absence can influence community structure and function.

DIRECT EFFECTS: Cascading ecosystem effects



EXAMPLES

Northwest Atlantic

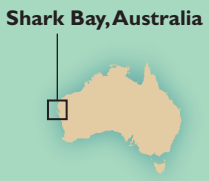
In the Northwest Atlantic, large shark declines have corresponded with an increase in the shark's prey species – cownose rays – and a decrease in bay scallops, which are prey of the rays (Myers et al. 2007). While the effects of rays on scallops were confirmed by exclusion experiments, the effects of sharks on rays is less well documented.

South Africa

A 50-year shark netting program along the Kwala-Zulu Natal shore in South Africa resulted in a significant decrease of large predatory sharks. Simultaneously, populations of smaller sharks increased, and declines of bony fish were observed, as these fish are prey of the small sharks. Later, the population of smaller sharks decreased due to overexploitation by recreational fisheries and an increase in bony fish was observed.

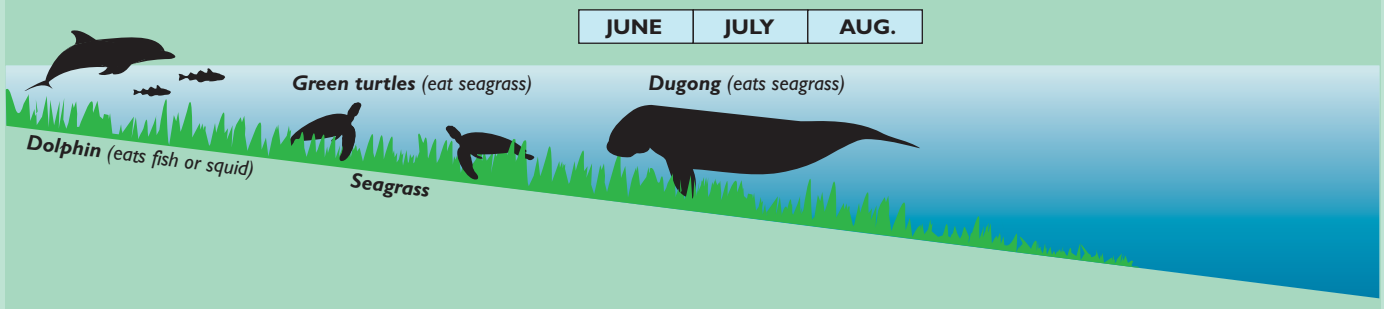
RISK EFFECTS: Changes in behavior and distribution

In Shark Bay, Australia, in the cold months when the threat from predation from tiger sharks is low, because they are elsewhere, animals such as dolphins, dugongs and green sea turtles feed in shallow, highly productive seagrass beds. When tiger sharks return to this area in the warmer months, only animals in the poorest condition risk remaining in these areas.



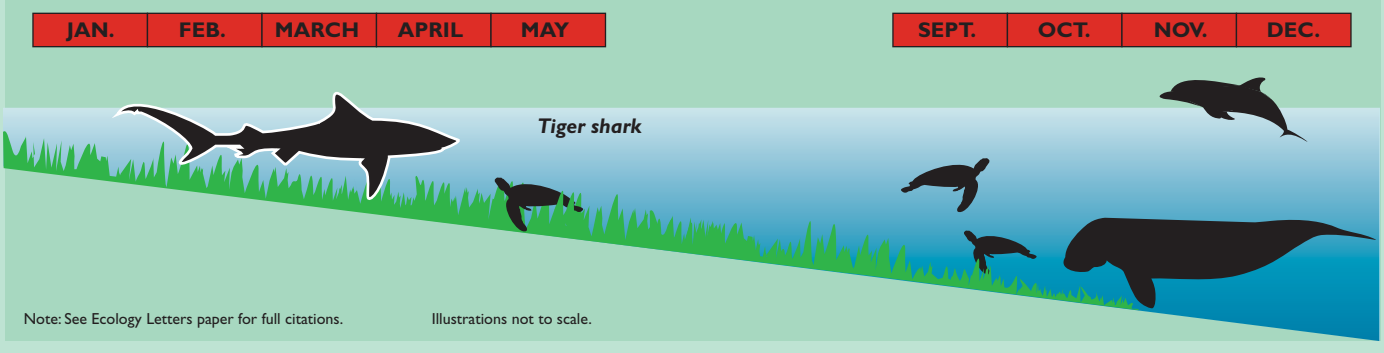
COLD MONTHS *Typical ecosystem when tiger sharks are elsewhere*

Animals, such as dolphins, dugongs and turtles forage in the productive shallow seagrass habitat during cold months when tiger sharks, one of their only predators, are elsewhere.



WARM MONTHS *Typical ecosystem when tiger sharks are present*

When tiger sharks visit these areas during warmer months, only the turtles in the poorest condition (i.e., the hungriest) risk feeding in the shallow productive seagrass beds. Most individuals forage elsewhere.



Note: See Ecology Letters paper for full citations. Illustrations not to scale.

CONCLUSIONS

This review suggests that many shark species are declining and these declines could result in the rearrangement of marine ecosystems. However, the community effects appear to be context-dependent:

- The disappearance of sharks could produce greater changes in ecosystems with low species diversity—those habitats where sharks prey on a small range of species and where there are few other large fish to take their place as top predators.
- The loss of large sharks may have the greatest ecological impact on long-lived, slow-growing large marine organisms (other sharks and rays, sea turtles and marine mammals) for which sharks are the main predation threat.
- With their wide ranging distribution, sharks could impact many different ecosystems throughout the oceans.
- Recognizing the full extent of shark impacts can be difficult because of the confounding effect of fisheries, as exploitation can impact sharks as well as their prey and competitors at the same time.

Sharks have been a relatively stable force in ocean ecosystems over evolutionary time, and possess a unique combination of ecological traits that makes them especially vulnerable. Given the documented declines in many shark populations, including commercially-important species, it is crucial to continue to gather evidence about their role in marine ecosystems. This review illustrates not only the important roles of large sharks in controlling the abundance and behavior of "mesopredators" like smaller sharks and rays, sea turtles and marine mammals, but also the need for more comprehensive research into the complex cascading effects that appear to play out in some large ecosystems.

The loss of large sharks may have the greatest ecological impact on long-lived, slow-growing large marine organisms.

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The Lenfest Ocean Program was established in 2004 by the Lenfest Foundation and is managed by the Pew Environment Group. For more information about the Program or the Ecology Letters *paper, please visit www.lenfestocean.org or contact us at info@lenfestocean.org.*

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