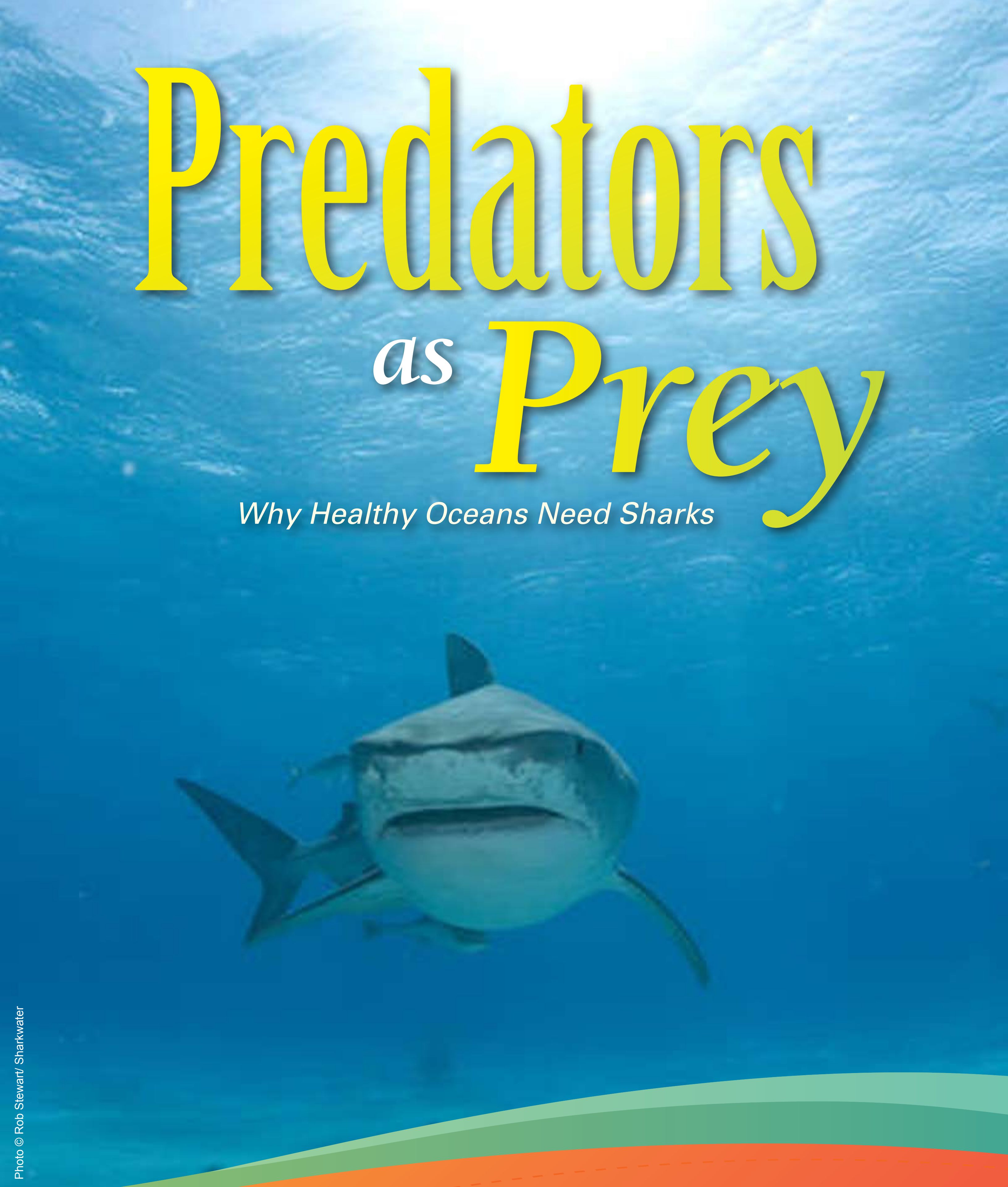
Predators as Prey

Why Healthy Oceans Need Sharks



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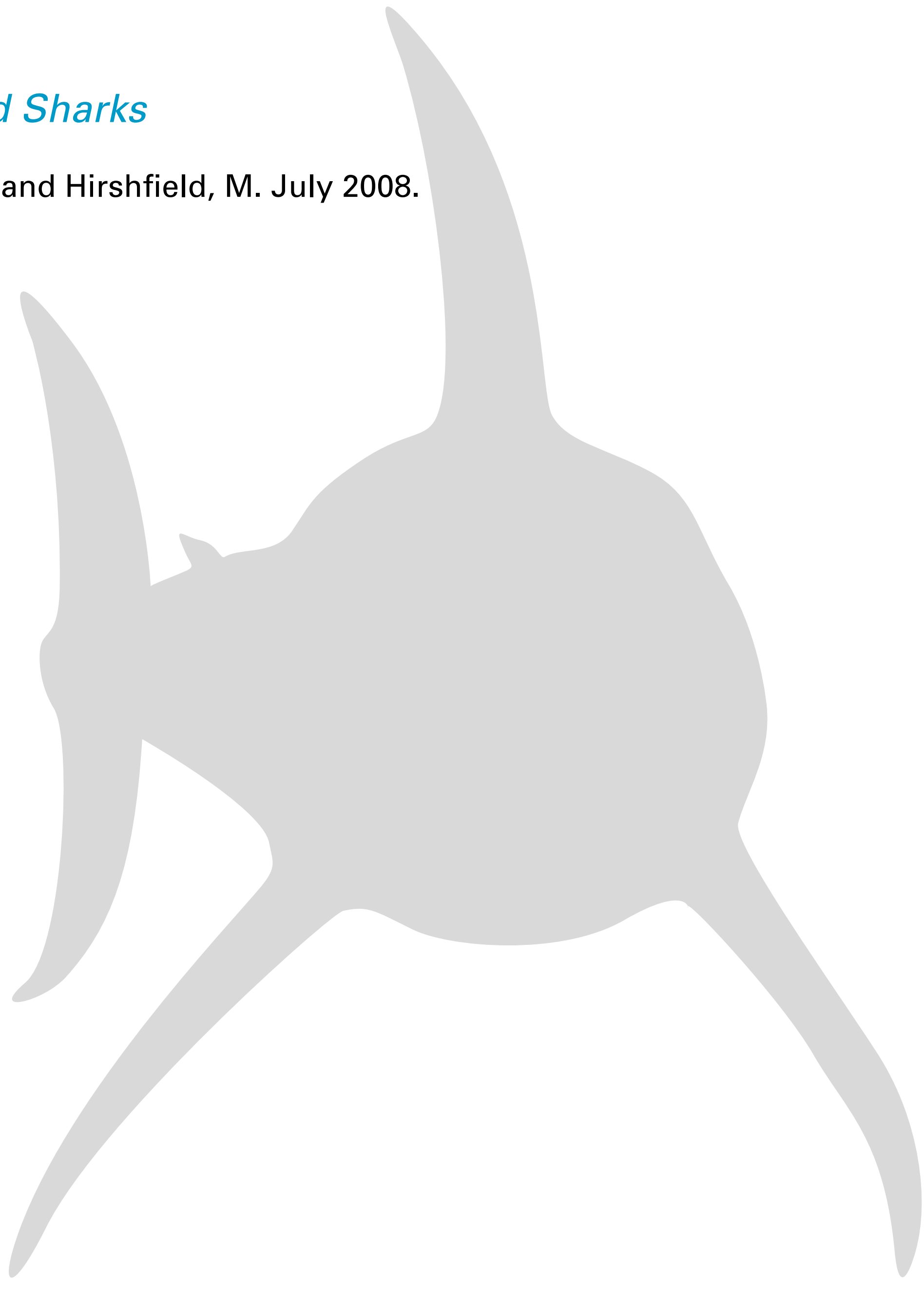
Predators as Prey:
Why Healthy Oceans Need Sharks

Griffin, E., Miller, K.L., Freitas, B. and Hirshfield, M. July 2008.



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Sharks have been swimming the world's oceans for more than 400 million years – 100 million years before the first dinosaurs appeared on land. But today, shark populations are being decimated by commercial fishing, putting some species in danger of extinction.

Sharks have unfortunately fallen victim to the man-hungry stereotype society has created for them. However, what the world should really fear is a world without sharks. Each year, humans kill more than 100 million sharks worldwide. This includes the tens of millions of sharks that are caught annually for their fins, which are one of the world's most expensive seafood products.


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As top predators, sharks help to manage healthy ocean ecosystems. And as the number of large sharks declines, the oceans will suffer unpredictable and devastating consequences. Sharks help maintain the health of ocean ecosystems, including seagrass beds and coral reefs. Healthy oceans undoubtedly depend on sharks.

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The Importance of Apex Predators to Healthy Ecosystems

Sharks are often the "apex" or top predators in their ecosystems because they have few natural predators. As apex predators, sharks feed on the animals below them in the food web, helping to regulate and maintain the balance of marine ecosystems. Apex predators directly limit the populations of their prey, which in turn affects the prey species of those animals, and so on.[1] The diets of most top predators are quite varied. This allows top predators to switch prey species when certain populations are low, thereby allowing prey species to persist.[2,3]

Apex predators not only affect population dynamics by consuming prey, but they also can control the spatial distribution of potential prey through intimidation. Fear of shark predation causes some species to alter their habitat use and activity level, leading to shifts in abundance in lower trophic levels.[4] Top predators affect other animals in a cascade effect throughout the ecosystem, ultimately influencing community structure.[5]

By preventing one species from monopolizing a limited resource, predators increase the species diversity of the ecosystem. To put it simply, more predators lead to greater diversity.[6] Comparisons of areas with and without apex predators show that apex predators provide greater biodiversity and higher densities of individuals, while areas without apex predators experience species absences.[7] Without apex predators there is the potential for unchecked predation by other lower predatory species, overeating of vegetation by herbivorous prey species and increased competition that ultimately affects the species richness and abundance within the system.[8] Apex predators, including many shark species, are a necessary component to maintaining a complex ecosystem full of diversity and life.

In addition to regulating species abundance, distribution and diversity, top predators provide essential food sources for scavengers[9] and remove the sick and weak individuals from prey populations.[10]

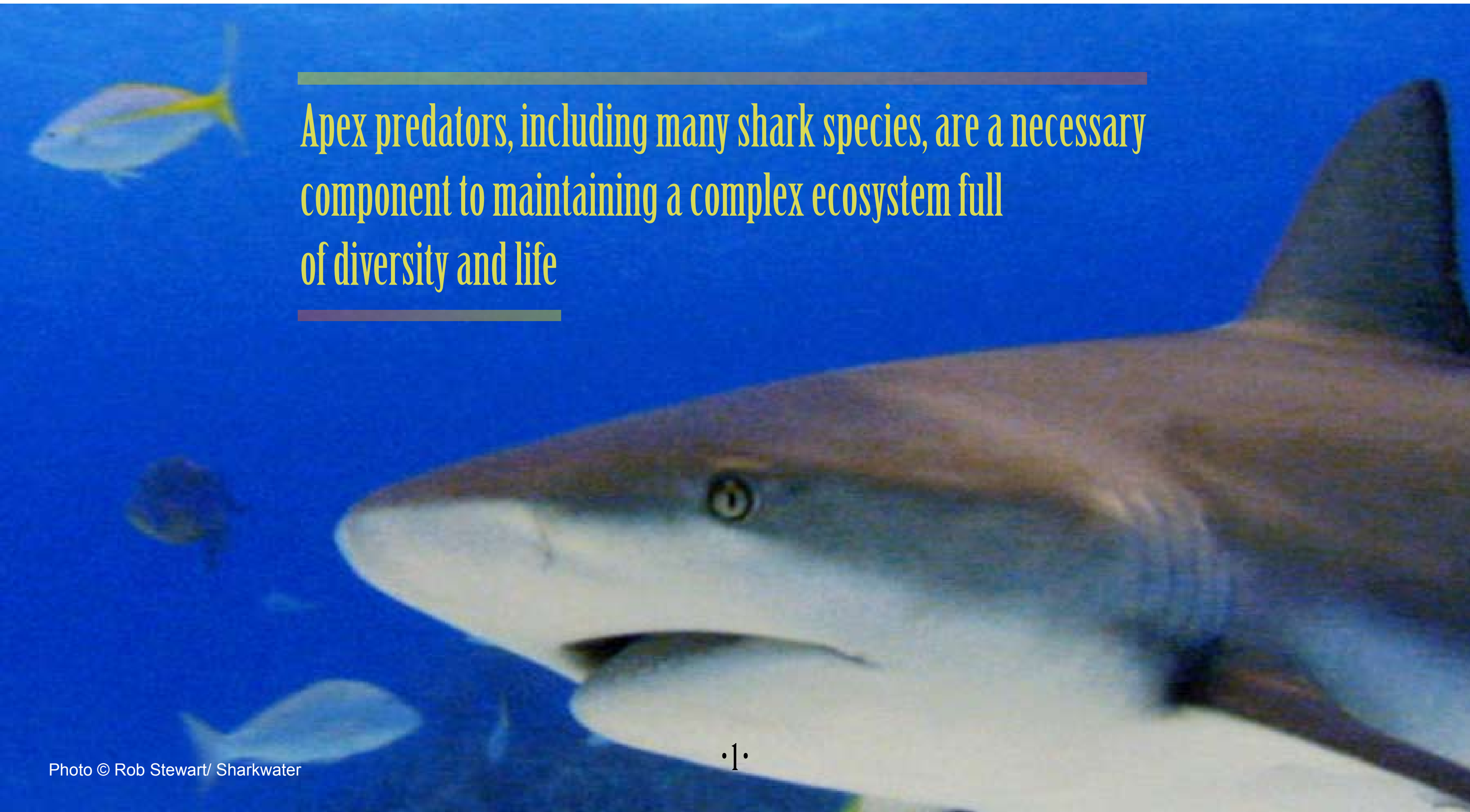

Apex predators, including many shark species, are a necessary component to maintaining a complex ecosystem full of diversity and life

Photo © Rob Stewart/ Sharkwater

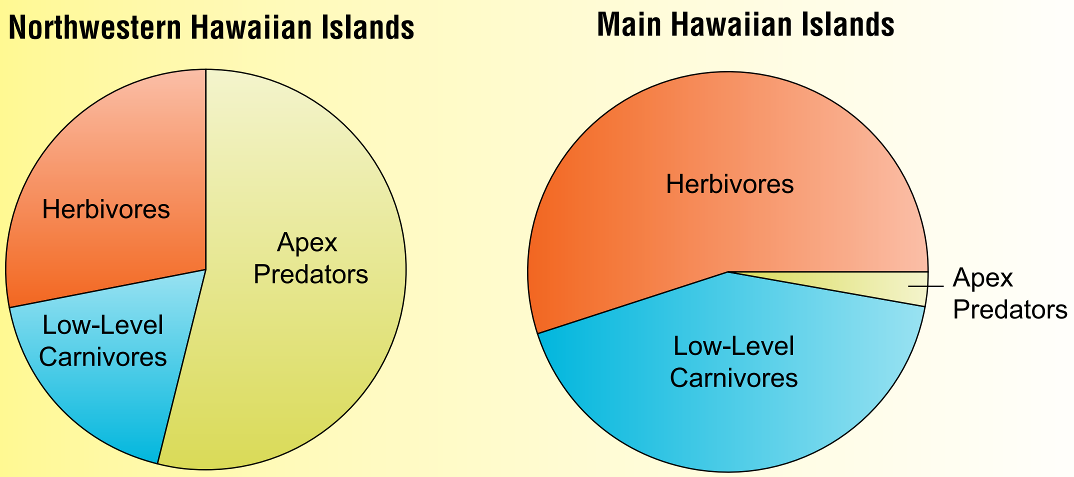
The Hawaiian Islands, An Example of a Balanced Marine Ecosystem

There are very few, if any, pristine locations left in the ocean that are untouched by human activities, especially by the impacts of fishing. Even the most remote locations of the world, such as the Northwestern Hawaiian Islands (NWHI), are not free from human interference. However, studying these locations may yield the best possible insight into the structure and natural functioning of unaltered ecosystems. Recent surveys conducted in the central Pacific off the coasts of the NWHI and Palmyra have provided comparisons to the ecosystems of the nearby inhabited Christmas and Fanning Islands and the heavily populated main Hawaiian Islands (MHI).[11,12]

In these surveys, researchers observed a larger number of fish surrounding the uninhabited islands, with a drastically different composition of species. Most surprising was the fact that apex predators accounted for over half the fish biomass surrounding Palmyra and the NWHI, while the apex predators at Christmas, Fanning and the MHI were less than 10 percent of the fish biomass.[13,14] In addition, the apex predators, such as sharks, were larger in the waters surrounding the uninhabited islands.[15]

Locations with greater apex predator biomass also had a higher biomass of herbivorous fish, which support the general hypothesis that a coral reef ecosystem with many apex predators also will have many herbivorous fish.[16] Notably, most of the dominant predators found in the NWHI were rare or absent in the MHI.[17] These studies illustrate that a typical trophic pyramid for an unfished coral reef is actually inverted, meaning that most of the fish biomass is at the top levels. It also shows that typical overfished ecosystems are lacking apex predators.[18]

Figure 1: Comparison of Trophic Structure Between the Northwestern Hawaiian Islands and the Main Hawaiian Islands Based on Biomass[19]



Typical overfished ecosystems are lacking their apex predators

Sharks: Jinxed by "Jaws"

Sharks have unfortunately fallen victim to the man-hungry stereotype society has created for them. We consider this the "Jaws" image. However in reality, sharks are some of the world's most misunderstood animals. There are more than 350 distinct species of sharks that vary in size, diet and habitat, but the vast majority are harmless to humans. In fact, nearly two-thirds of all shark attacks involve just three species— white, tiger and bull.

The reality is that humans are the true top predators of the sea, killing more than 100 million sharks each year in fisheries,[20] while sharks mistakenly kill between five and 15 people during that same period.[21] Scientists estimate that fishing has reduced large predatory fish populations worldwide by 90 percent over the past 50 to 100 years.[22] Sharks now represent the largest group of threatened marine species on the World Conservation Union's (IUCN) Red List of threatened species.[23] Yet only three of the 350 shark species — basking, whale and white — are protected from the pressures of international trade. The remaining species are ignored or seen as low priorities despite their vulnerability to overfishing[24] and their important role in their ecosystems.

Humans kill more than 100 million sharks each year

Shark Finning

The practice of shark finning kills 26 to 73 million sharks each year for their fins.[25] Once reserved as a delicacy and a sign of prestige in Asian cultures, shark fin soup consumption is on the rise. Because a bowl of soup can cost up to $100, the fins are the most economically valuable part of a shark. And since shark carcasses are bulky, take up space and are worth less money, the practice of removing the fins and throwing the bleeding carcasses overboard is far too common. This practice, known as "shark finning," only uses between one and five percent of the shark. Furthermore, without the bodies, it is nearly impossible for fisheries managers and scientists to accurately identify the species and determine the number of sharks that are being killed.

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Bycatch

Some fisheries directly target sharks as their intended catch, but other fisheries capture sharks incidentally as "bycatch", a term used for unintended catch. Unwanted sharks are then thrown overboard, with many of them left dead or injured. Trawl fisheries are responsible for the largest bycatch numbers in coastal areas, while longlines capture the majority of sharks as bycatch on the high seas.[26] It is estimated that tens of millions of sharks are caught as bycatch each year, which is nearly half of the total shark catch worldwide.[27] These startling numbers demonstrate the extreme threat that commercial fisheries pose to the survival of these top predators. Remarkably, bycatch estimates fail to appear in most fishery statistics, resulting in the continued mismanagement of shark bycatch.[28, 29]

> Removing apex shark species can have unpredictable and devastating consequences on marine ecosystems

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Although removing top predators can have different effects on various ocean communities, an increasing number of studies have detected large-scale effects on ocean ecosystems, often called "cascades."[30] The following case studies from around the globe show that the removal of apex shark species can have unpredictable and devastating consequences on marine ecosystems.

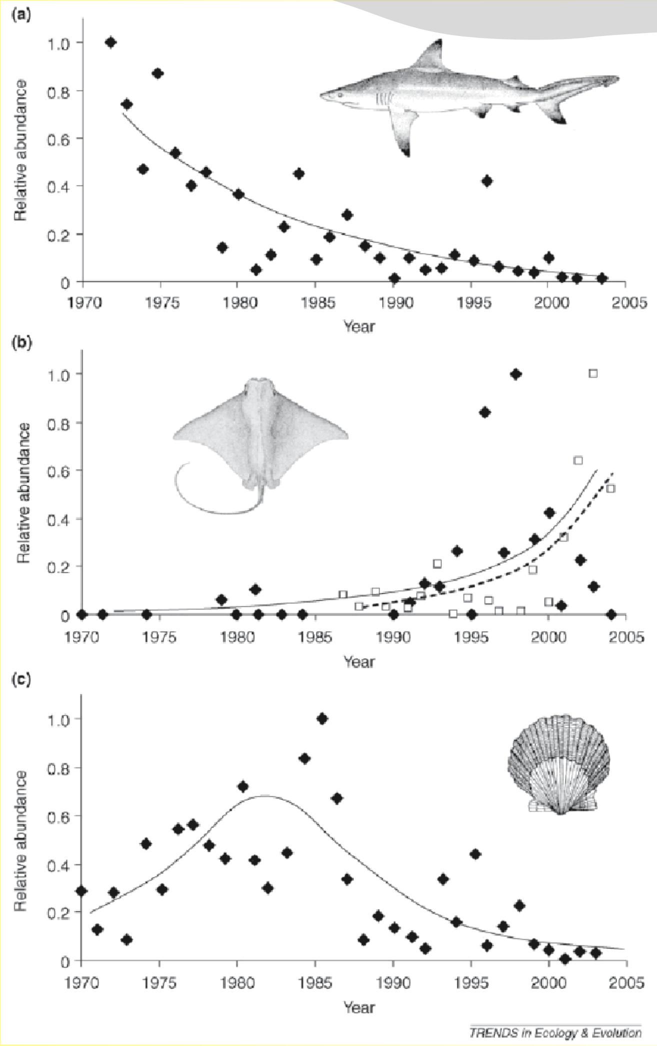
The Loss of the Great Sharks in the North Atlantic

Surveys show that the abundance of the 11 great sharks (sharks more than two meters in length) along the eastern coast of the United States has declined to levels of functional elimination. This means that the sharks are now unable to perform their ecological role as top predators.[31] All of the species in this area, except for the mako, have declined by more than 50 percent in the past eight to 15 years.[32] Scalloped hammerhead, white and thresher shark abundances are estimated to have declined by more than 75 percent in the past 15 years.[33] During this same period, their prey — 12 species of rays, skates and smaller sharks — have increased in abundance by as much as ten-fold.[34]

The effect of this decline has cascaded throughout the entire ecosystem, resulting in the collapse of a century-old scallop fishery. The species that increased most in abundance was the cownose ray, which migrates up and down the eastern coast consuming scallops, clams and oysters.[35] By 2004, bivalve predation by cownose rays had removed most of the bay scallops, terminating the North Carolina fishery.[36] Without bay scallops to eat, the cownose ray, along with other rays, skates and small sharks, is expected to expand its foraging to clams and oysters.[37] This has already been seen with the loss of another bivalve, a hard clam known as the Quahog.[38] The decline of the Quahog, a key ingredient in clam chowder, is forcing many restaurants to remove this American classic from their menus.[39] The disappearance of scallops and clams demonstrates that the elimination of sharks can cause harm to the economy in addition to ecosystems.

Photo © Rob Stewart/Sharkwater

Figure 2: As (a) catch rates of large sharks, such as blacktip sharks, declined during research surveys along the east coast of the U.S., (b) cownose rays began to increase, leading to eventual declines in (c) catches of North Carolina bay scallops.[40]

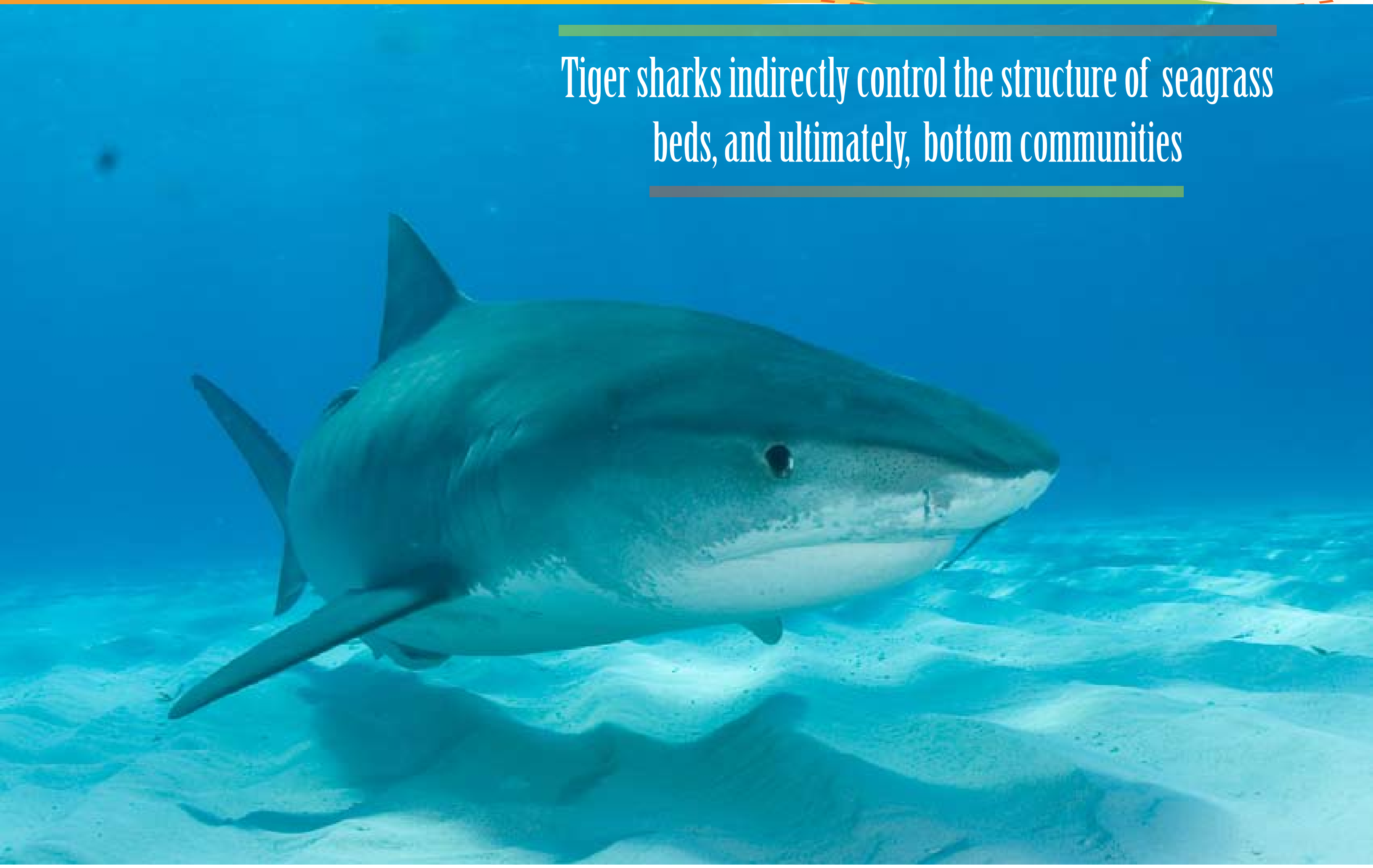


Source: Heithaus et al. (2008)

"Like a swimming pool with a broken filter, a coastal environment without bivalves could choke with blooms of uncontrolled algae."

Brierley, 2007

Shifts in species abundance are not the only consequence of removing top predators, as habitats also can be altered. Hungry rays roaming the waters and hunting for food have the potential of uprooting seagrass at higher rates, leading to poorer quality nursery grounds for fish.[41] Additionally, bivalves are not only a food source for rays, but a filtration system for the ocean. Bivalves feed on phytoplankton that they filter from the water column, which helps maintain a high level of water quality.[42] With the decline in scallops, clams and other bivalves, this filtration system is disappearing. As a result, already stressed coastal areas could experience additional uncontrolled algal blooms and dead zones, damaging ocean ecosystems.[43]



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Tiger Sharks in Shark Bay, Australia

Tiger shark intimidation alters the spatial distribution of their prey and structures the dynamics of the seagrass community. In Shark Bay, Australia, dugongs and green sea turtles, which are common tiger shark prey, alter their habitat selection based on the presence of tiger sharks. This creates a trade-off between safety and food quality for the species. Tiger sharks also intimidate and affect the location of species that are relatively rare in their diet, such as bottlenose dolphins and pied cormorants.

Dugongs prefer the nutritious seagrass found in the middle of large grassy patches, but it is very difficult to escape from a tiger shark in these locations. When tiger shark abundance is high, dugongs feed on the lower quality seagrass located near a patch's edge, thereby reducing their risk of predation.[44] Dugongs alter their distribution on a daily basis depending on the number and location of sharks in the area.[45] When grazing, dugongs remove the entire seagrass plant, altering the composition and structure of the seagrass meadow, the nutrient content of the plant and the detrital structure of the system.[46,47] By forcing dugongs to change their habitat selection, tiger sharks keep grazing in check, which in turn keeps the seagrass at relatively constant levels.[48] Tiger sharks are indirectly controlling the structure of seagrass beds and, ultimately, bottom communities.[49]


Photo © R.P. van Dam

Green sea turtles exhibit a similar response. Green sea turtles feed by removing the top portion of seagrass blades from a specific plot.[50,51] The continued grazing in these plots produces a high quality diet for the turtles, while stimulating rapid growth of the seagrass blades and an increased rate of nutrient recycling.[52,53] In the presence of tiger sharks, healthy green sea turtles were found foraging in lower quality habitat that was safer, while sick or injured green sea turtles risked predation to forage in higher quality habitats.[54] The tiger sharks' influence on green sea turtles was shown to redistribute their grazing patterns, which altered the seagrass community, the chemical composition of the blades and the detrital cycle.[55]

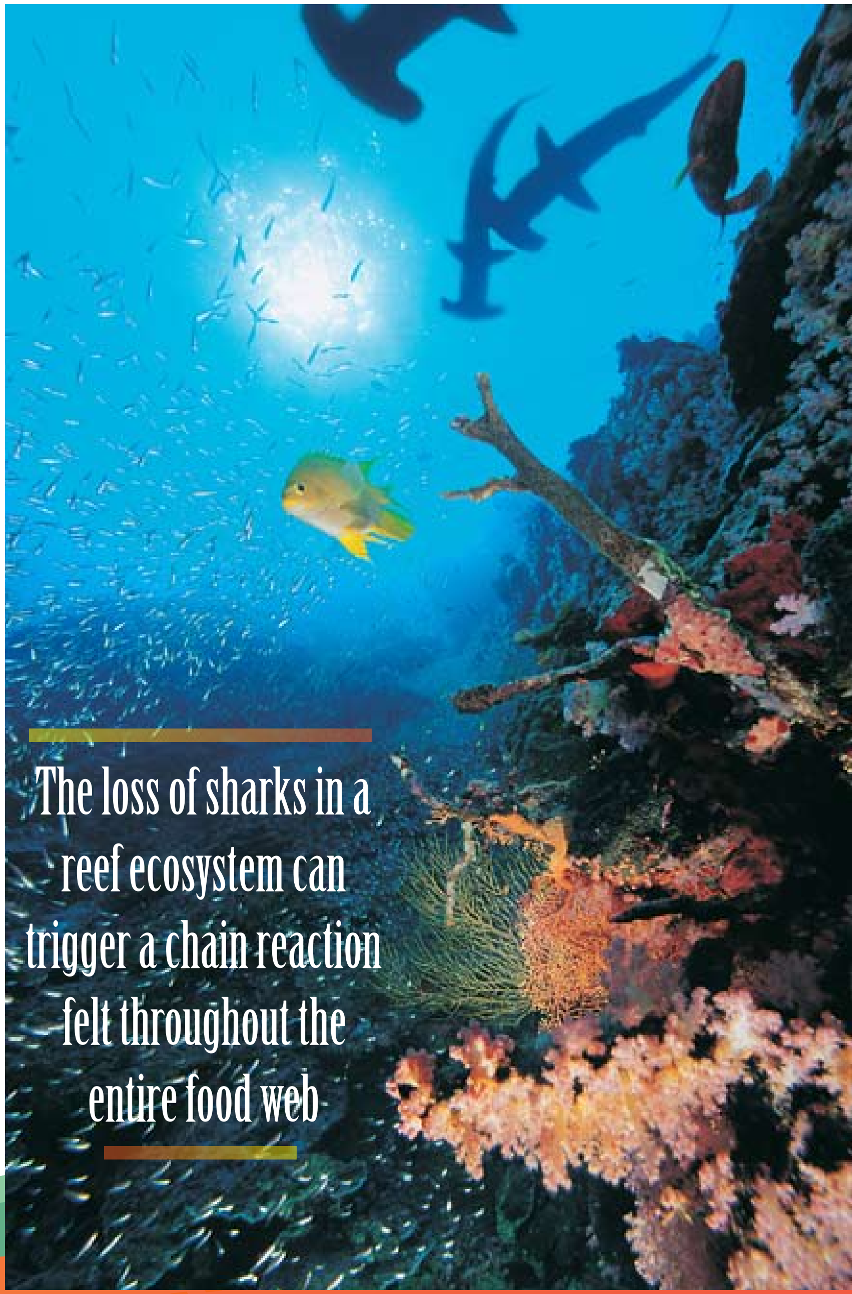
Tiger sharks not only influence the distribution of their prey, but also intimidate species that rarely appear in their diet. Tiger sharks have been shown to directly and indirectly affect the location of bottlenose dolphin and pied cormorant foraging. Although shallow waters are the most productive habitat, bottlenose dolphins and pied cormorants avoid shallow waters when sharks are present.[56,57] Once sharks leave the area, dolphins and pied cormorants are able to occupy all habitats and freely pursue their food.[58] Even though tiger sharks do not kill many of these species, the changes they induce in their prey's behavior are equivalent or greater in magnitude than the effects of direct mortality.[59]

The Caribbean Coral Reef Ecosystem

Healthy coral reefs provide a complex, three-dimensional habitat that promotes species diversity and abundance.[60] The loss of sharks in a reef ecosystem, like that of the Caribbean Sea, can trigger a chain reaction that is felt throughout the entire food web, ultimately leading to the degradation of coral reefs on a local or even regional scale.

Since macroalgae compete with coral for settlement on reefs,[61] coral depend on herbivorous fish to graze the algae and provide space for coral to settle and grow.[62] A reduction in herbivorous fish prevents coral from thriving. The loss of sharks as top predators in the ecosystem allows the number of grouper, which eat other fish species, to increase.[63] The groupers in turn reduce the number of herbivores, such as parrotfish, blennies and gobies, in the system. Without these herbivores to eat algae off the coral, algae will take over a reef system.[64] This overgrowth of macroalgae makes the habitat homogeneous, minimizes the number of available niches for fish species and decreases the species diversity.[65] The shifts in abundance following coral decline change the overall species diversity and composition of the entire reef system, which even affect fish species that have no reliance on the live coral.[66] The removal of sharks from the coral reef ecosystem can ultimately affect the resilience of coral reefs to disturbance, leading to a homogeneous habitat with declines in species diversity and abundance.

The coral reefs of Jamaica demonstrate this shift from a healthy to damaged state. Over the past 30 to 40 years, the species composition in Jamaica has changed drastically. Sharks, snappers, jacks, triggerfish and groupers are now replaced by small herbivorous fish.[67] Along with this change in species composition, coral abundance has declined from more than 50 percent in the late 70s to less than five percent in the 90s.[68] Even though the remaining fish are herbivores, they are too small (more than half are below reproductive size) to reverse the shift from a coral to algae-dominated system.[69] Because coral cannot compete, macroalgae now cover more than 90 percent of the reefs.[70] Jamaica provides a clear example of the time and scale on which a shift from coral to algae can occur as a result of the loss of sharks from an ecosystem.



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Sleeper Sharks in Prince William Sound, Alaska

Models of spatial and dietary shifts of harbor seals in response to sleeper sharks provide another example of shark intimidation resulting in behavioral modification of prey species and a change in abundance of commercially important fish species. Even though mortality from sharks is low, harbor seals alter their habitat and foraging in response to predation pressure.[71]

Two top prey items for seals in this area are Pacific herring and walleye pollock.[72] Herring are fatty fish that congregate near the surface of the water and are often widely dispersed.[73] Pollock, on the other hand, are found in the deeper waters preferred by sharks, but are larger and have a more continuous distribution, which makes them a more predictable resource for seals.[74] When sleeper sharks are present, shark intimidation reduces seal foraging in the deeper waters and therefore directly increases the mortality of herring while decreasing the mortality of pollock.[75] The health of a seal dictates how much risk it is willing to assume. For example, if herring is scarce and the seal's energy state is poor, it is more willing to venture into deeper water in search of pollock.[76] The removal of sharks changed this response by releasing seals from fear, allowing them to increase their use of deep waters to consume pollock and decrease their foraging of herring on the surface.[77]

The presence of sleeper sharks directly alters the behavior of their prey. These changes can alter the population density or fitness of other species.[78] Species at lower levels in the food chain may experience declines or even extinction as a result of disruptions resulting from chain reactions in the ecosystem.[79] When the behavioral responses of prey species are altered, the changes in their foraging patterns can cause cascading impacts throughout the food web.

Photo © NMFS

When the behavioral responses of prey species are altered, the changes in their foraging patterns can cause cascading impacts throughout the food web

Conclusions and Recommendations

Sharks as apex predators can regulate species abundance, distribution and diversity, which in turn can impact the health of marine habitats. Additionally, they provide essential food sources for scavengers and remove the sick and weak from populations of prey species. The decimation of these important shark species can have cascading effects throughout the ecosystems they inhabit, resulting in economically and ecologically devastating consequences.

Unfortunately, sharks have been eliminated from so many parts of the ocean that we now have very few good examples that explicitly document their importance to ocean ecosystems. Nevertheless, as the examples of the Northwest Hawaiian Islands and Palymyra show, ecosystems that we consider healthy — the last marine wilderness areas — contain large numbers of sharks. On the other hand, some studies show what the oceans will look like without sharks. Economically important fisheries shut down. Coral reefs shift to algae dominated systems. Seagrass beds in decline. Ecological chain reactions set in motion. Species diversity and abundance declines with the loss of habitats. And the list goes on...

Protecting sharks and allowing their populations to recover is essential to restoring the health of our oceans. The following three actions are essential to making that happen:

Three Key Steps to Protect Sharks:

- Reduce the number of sharks captured in commercial fisheries through improved shark management, including requiring strict species-specific fishing quotas and stock assessments.
- Truly end shark finning by requiring that all sharks be landed whole with their fins still naturally attached.
- Reduce the demand for shark products such as shark fin soup.

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