# Scientists take a deep dive into how sharks use the ocean

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Samantha Andrzejaczek, a postdoctoral research fellow at Stanford's Hopkins Marine Station, (second from right) tagging a tiger shark. Credit: Alex Kydd

Using sophisticated electronic tags, scientists have assembled a large biologging dataset to garner comparative insights on how sharks, rays,

and skates—also known as "elasmobranchs"—use the ocean depths. While some species spend their entire lives in shallow waters close to our shores on the continental shelf, others plunge hundreds of meters or more off the slope waters into the twilight zone, beyond where sunlight penetrates. This new understanding of how elasmobranchs use the ocean will enable policymakers and resource managers the opportunity to examine the threats these animals face, and guide future management and conservation plans.

A study published Aug. 19 in *Science Advances*, led by Stanford University and ZSL (Zoological Society of London) researchers, is the largest global investigation of where and when a diverse group of elasmobranchs move vertically. A team of 171 researchers from 135 institutions across 25 countries brought together two decades of data from satellite and archival tags that remotely tracked the movements and behaviors of 38 species in oceans across the globe.

"For the first time, we have a standardized, global database that we used to fill important knowledge gaps about the diving behaviors of sharks and rays," said Samantha Andrzejaczek, co-lead author of the study and a postdoctoral research fellow at the Hopkins Marine Station of Stanford University. "This will enable better understanding of what fisheries interact with elasmobranchs and how to improve management of many of these long-lived animals."

## Movement in three dimensions

Scientists already have a wealth of movement data about many marine species that inhabit the near-surface spaces of the coastal ocean. Drones, scuba divers, and other methods, for example, survey marine communities and populations to a depth of about 50 meters, but animal movement in three dimensions, especially in the deeper, vertical spaces of the ocean, is far less understood.

"Sharks and rays are iconic but threatened ocean species. Key to their effective management is an understanding of their basic ecology," said David Curnick, head of the Ocean Predator Lab at ZSL and co-lead author of the paper. "Yet, for many species, we know relatively little about their fundamental behavior, and what we do know is often restricted to what we can observe in surface waters."

Over the past 20 years, a variety of electronic tags have come of age that provide the opportunity to tag numerous elasmobranch species. Scientists at Stanford have been at the forefront of biologging tag development and applying these technologies on sharks and rays.

One of the common vertical movements among elasmobranchs appears to match up with the ocean's diel (twice a day) vertical migration. At daybreak, tiny fish and invertebrates—followed by the animals that prey on them—begin migrating from the bright, uppermost ocean layer to the relative safety of darker, deeper water. At night, they return to the surface to feed.

"We think that sharks and rays in their diel migrations are following food resources up and down the water column," said Andrzejaczek.

The study found that about one-third of species frequently dive to depths where the water is cold, often low on oxygen due to biological activity related to productivity, and visibility is limited. Sensor records show that white sharks (Carcharodon carcharias) dive deeper than 1,200 meters while whale sharks (Rhincodon typus) have reached 1896 meters, which is near the pressure limit of 2,000 meters for today's sensors.

"Deep divers might be looking for food in deeper water or avoiding hunters themselves as potential prey," said Andrzejaczek. "Some sharks and rays are small, and some of the biggest sharks and rays will feed on them. We found that 13 species had individuals that dive to more than

1,000 meters, which is extremely deep." Some may require cooling-off periods while at depth. "When large sharks spend too long in the warm surface waters, they may have to dive to cool down, a form of behavioral thermoregulation," she added.

The researchers also identified overlaps among species in the same vertical spaces. Whale sharks, tiger sharks, and oceanic manta rays showed strikingly similar vertical distributions, although they have very different evolutionary histories. Predator-and-prey relationships likely drive this proximity. "The oceanic manta ray and whale shark both feed on plankton, and the tiger shark has been known to predate on both those species," said Andrzejaczek.

## A foundation for future management

The photic zone or epipelagic—the ocean region receiving sunlight—stretches from the surface to about 200 meters and can potentially be a dangerous area for elasmobranchs. That is where they are most likely to be exposed to fishing gear as either target species or as bycatch. Of the 38 species in the study, researchers found that 26 spent more than 95% of their time in the top 250 meters of the water column.

More than one-third of all sharks and rays are threatened with extinction, according to the IUCN Red List of Threatened Species.

"These data provide the foundation for future management of global elasmobranch resources, and it has taken a team of scientists thousands of hours tagging and tracking the sharks with global satellite and biologging systems to make this possibility happen," said Barbara Block, the Prothro Professor of Marine Sciences at Stanford, whose tagging programs such as TOPP, contributed 25% of the data set.

Understanding how elasmobranchs use vertical habitats is crucial to

understanding their current and future ecological roles in the ocean and their risks to various threats. Scientists could utilize this and future databases to investigate how changing ocean temperature and oxygen levels may influence species' distributions and create new conditions and threats.

"Human beings are unaccustomed to thinking of habitat in the vertical dimension," said Andrzejaczek. "We hope this study can make people realize that we need management strategies that incorporate this overlooked dimension of elasmobranch behavior. For example, we could use these data to better understand how sharks and human fisheries interact."

This three-year study brought together data from increasingly sophisticated and more accurate tags with sensitive sensors that can withstand the rigors of the environment while riding along on a shark or ray and function in deep water, as well as improved analytical tools to incorporate different types of movement data. The key ingredient has been cooperation among biologging scientists from around the world.

"Large-scale scientific studies like this one are not possible without a monumental collaborative effort," said Curnick. "We reconcile the collective knowledge and expertise of researchers from around the world. The result is far greater than any one researcher or institution could achieve on their own."

**More information:** Samantha Andrzejaczek et al, Diving into the vertical dimension of elasmobranch movement ecology, *Science Advances* (2022). DOI: 10.1126/sciadv.abo1754. www.science.org/doi/10.1126/sciadv.abo1754

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