Understanding cookiecutter sharks

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University of Delaware assistant professor Aaron Carlisle led a study published in *Scientific Reports* that uncovered the potential diet and habitat of Cookiecutter sharks, a small, under-studied shark that is distributed throughout the world's tropical and subtropical oceanic waters. The Cookiecutter sharks are unique because they feed on everything from the biggest, toughest apex predators—like white sharks and orcas—down to the smallest creatures in the ocean. Credit: Tammy Beeson

For years, researchers studying marine life in the wild would occasionally come across animals—such as dolphins, swordfish, leatherback sea turtles, whales, white sharks and even humans—with

oddly shaped plugs of tissue taken out of their bodies. Those fresh bites and scars were almost like someone took a cookie cutter and surgically removed a hunk of tissue. These bites were not only restricted to animals, as submarines in the 1970s and 1980s were having their rubber-coated sonar sensors bitten in this same fashion and underwater electrical cables were also found to have the odd-shaped bites.

Eventually, it was discovered that the culprit was a small shark that is distributed throughout the world's tropical and subtropical oceanic waters named the Cookiecutter shark (Isistius brasiliensis). While these sharks are widely distributed throughout the world, and may be one of the more common sharks in the ocean, because they live in the deep sea, and are never held in captivity there is little known about them—especially when it comes to their eating habits.

A new study led by the University of Delaware's Aaron Carlisle has uncovered the potential diet and habitat of these Cookiecutter sharks, showing that while they might chomp on everything they can get their jaws on in the upper reaches of the ocean to supplement their diets, they primarily feed on the little critters they share a habitat with such as crustaceans, squid and small fish.

Carlisle, assistant professor in the School of Marine Science and Policy in UD's College of Earth, Ocean and Environment, said that for years, researchers assumed that Cookiecutter sharks were coming up at night, feeding on whales and bigger animals, and then heading back to the deep ocean and hanging out during the day. But it was an assumption. The feeding habits of Cookiecutters have been little studied—Carlisle said there have been maybe 150 Cookiecutter stomachs studied around the world over the last 50 years.

When researchers did study the sharks, they could only look at what was physically in the sharks' stomachs—which sometimes, was nothing at

all—and make inferences from the bites they had seen on their larger species, but they could not employ the more advanced scientific methods now available to researchers.

"At the end of the day, the paradigm was that the sharks would primarily feed on these larger animals, but we just didn't have any empirical data. So our question was, 'Are we biased by what we're seeing?' " said Carlisle. "It turns out that all these bites we see on marine mammals and larger sport and commercial fishes and things really make up a relatively smaller amount of their diet."

Carlisle noted that it is unique to have an animal that will feed on creatures from the top and the bottom of the food chain.

"These animals occupy a unique ecological role in the world's oceans," said Carlisle. "They feed on everything from the biggest, toughest apex predators—like white sharks, orcas, everything you can imagine—down to the smallest little critters. There's not very many animals that do something quite like this."

Collaborative research

For this study, the researchers used 14 Cookiecutter sharks that were collected by the Monterey Bay Aquarium from the Central Pacific around Hawaii. They utilized a variety of biochemical tracing techniques—including stable isotope analysis, fatty acid analysis, and environmental DNA—to help better understand the feeding habits and habitats of the species.

John O'Sullivan, a coauthor on the study and the director of collections at the Monterey Bay Aquarium which is planning to open a new deep-sea exhibit featuring live deep water animals next year, said that by utilizing a number of different biochemical tests in the study, the researchers

were able to get well-developed answers to their questions about the Cookiecutter's diet and possible behavior.

"It's important to do more than one test and the reason for that is the same reason that people want to get more than one opinion for any medical situation," said O'Sullivan. "The broader the test range is, with their techniques and methods, the more sound you can feel, collectively, about your results, and that just helps improve the scientific methods."

The researchers examined the sharks' stomachs and found that they were mostly empty. While that would stump researchers in the past, by utilizing these modern techniques, they could extrapolate the potential diets of the sharks.

For instance, using the environmental DNA of their stomach contents could give them an idea of what the sharks had eaten.

"Environmental DNA is an increasingly popular and powerful tool that works under the idea that, if an animal swims by in the ocean, it's going to be shedding DNA in the water," said Carlisle. "So if you take a water sample and filter it out, you can extract the DNA of everything that's been in that water mass and identify what species were there. So we tried that on their stomach contents."

Using this approach, they identified several prey species from seemingly empty stomachs, including previously unknown prey.

Habitat patterns

The researchers were also able to make inferences about their habitat.

The Cookiecutter sharks have generally only been observed near surface waters during the night, leading researchers to believe that they exhibit

vertical migration, where they ascend to shallow waters at dusk and return to deeper waters at dawn. However, this might only be the case for the larger Cookiecutter sharks, whereas the smaller, baby sharks might not vertically migrate at all.

"The little guys, we think that they may stay down deep. It appears that they don't start going up to the surface until they get to be a certain size," said Carlisle. "But again, nobody's ever really seen a baby Cookiecutter shark so we don't really know. We're trying to make these inferences based on indirect metrics of what they're eating and what their ecology is."

Carlisle stressed that with the deep ocean increasingly being exploited by fisheries and other extractive industries, it is important to continue to advance the knowledge of these deep-water species.

"Most of the animals that live in the deep sea, we call it life in the slow lane. They live a long time, and they don't make very many babies," said Carlisle. "Most of these deep sea animals are the poster children of things you don't want to fish for because they just don't have the ability to reproduce very quickly and rebound after being exploited."

O'Sullivan said that he is hopeful that through efforts like this paper, as well as the new deep sea exhibit at the Monterey Bay Aquarium, they can help to spread awareness of the importance of these creatures to the general public.

"It's about doing good science and about making wise choices," said O'Sullivan. "It's about good animal welfare, and it's about engaging the public. The best science, no matter how exciting it is, if the public can't get engaged, it falls short."

The research was published in *Scientific Reports*.

More information: Aaron B. Carlisle et al, Integrating multiple chemical tracers to elucidate the diet and habitat of Cookiecutter Sharks, *Scientific Reports* (2021). DOI: 10.1038/s41598-021-89903-z