Hammerhead sharks found to hold their breath on deep water hunts to stay warm

May 11 2023

Scalloped hammerhead sharks off the coast of the Big Island of Hawai'i. Credit: Cory Fults

Scalloped hammerhead sharks hold their breath to keep their bodies warm during deep dives into cold water where they hunt prey such as

deep sea squids. This discovery, published in *Science* by University of Hawai'i at Mānoa researchers, provides important new insights into the physiology and ecology of a species that serves as an important link between the deep and shallow water habitats.

"This was a complete surprise," said Mark Royer, lead author and researcher with the Shark Research Group at the Hawai'i Institute of Marine Biology (HIMB) in the UH Mānoa School of Ocean and Earth Science and Technology. "It was unexpected for sharks to hold their breath to hunt like a diving marine mammal. It is an extraordinary behavior from an incredible animal."

Shark gills are natural radiators that would rapidly cool the blood, muscles, and organs if scalloped hammerhead sharks did not close their gill slits during deep dives into cold water. These sharks are warm water animals but feed at depths where seawater temperatures are similar to those found in Kodiak Alaska (around 5ºC/ 40ºF), yet they need to keep their bodies warm in order to hunt effectively.

"Although it is obvious that air-breathing marine mammals hold their breath while diving, we did not expect to see sharks exhibiting similar behavior," said Royer. "This previously unobserved behavior reveals that scalloped hammerhead sharks have feeding strategies that are broadly similar to those of some marine mammals, like pilot whales. Both have evolved to exploit deep dwelling prey and do so by holding their breath to access these physically challenging environments for short periods."

The research team discovered this unexpected phenomenon by equipping deep-diving scalloped hammerhead sharks with devices that simultaneously measured their muscle temperature, depth, body orientation, and activity levels.

They saw that their muscles stayed warm throughout their dive into deep

cold water but suddenly cooled as the sharks approached the surface toward the end of each dive. Computer modeling suggested that hammerhead sharks must be preventing heat loss from their gills to keep their bodies warm during these deep-dives into cold water.

Scalloped hammerhead sharks off the Kona coast of the Big Island of Hawai'i. Credit: Deron Verbeck

Additionally, video of a scalloped hammerhead shark swimming along the seabed at a depth of 1,044 meters (more than 3,400 feet) showed its gill slits tightly closed, whereas similar images from surface waters show

these sharks swimming with their gill slits wide open. A sudden cooling in muscle temperature as scalloped hammerhead sharks approach the surface at the end of each dive suggests that they opened their gill slits to resume breathing while still in relatively cool water.

"Holding their breath keeps scalloped hammerhead sharks warm but also shuts off their oxygen supply," said Royer. "So, although these sharks hold their breath for an average of 17 minutes, they only spend an average of four minutes at the bottom of their dives at extreme depths before quickly returning to warmer, well-oxygenated surface waters where breathing resumes."

"This discovery fundamentally advances our understanding of how scalloped hammerhead sharks are able to dive to great depths and withstand frigid temperatures in order to capture prey," said Royer. "It also demonstrates the delicate physiological balance that scalloped hammerhead sharks must strike in order to forage successfully."

Scalloped hammerhead sharks are not listed as threatened in Hawai‘i but are regionally endangered in other parts of the world due to overfishing, bycatch, and nursery habitat loss.

"This new and detailed understanding of scalloped hammerhead physiology and ecology enhances our ability to effectively manage and conserve this iconic species by revealing potential vulnerabilities associated with changing ocean conditions or future human exploitation of these deep foraging habitats, such as deep-sea mining or large-scale fishing in the mesopelagic 'twilight zone', both of which might make it harder or more dangerous for these sharks to hunt their natural prey," said Royer.

"This extraordinary physiological feat that allows scalloped hammerhead sharks to expand their ecological niche into the deep sea could very well

make them vulnerable to additional human impacts."

More information: Mark Royer, "Breath holding" as a thermoregulation strategy in the scalloped hammerhead, *Science* (2023). DOI: 10.1126/science.add4445. www.science.org/doi/10.1126/science.add4445

Mark Meekan et al, Free-diving sharks, *Science* (2023). DOI: 10.1126/science.adg8452 , www.science.org/doi/10.1126/science.adg8452

Provided by University of Hawaii at Manoa