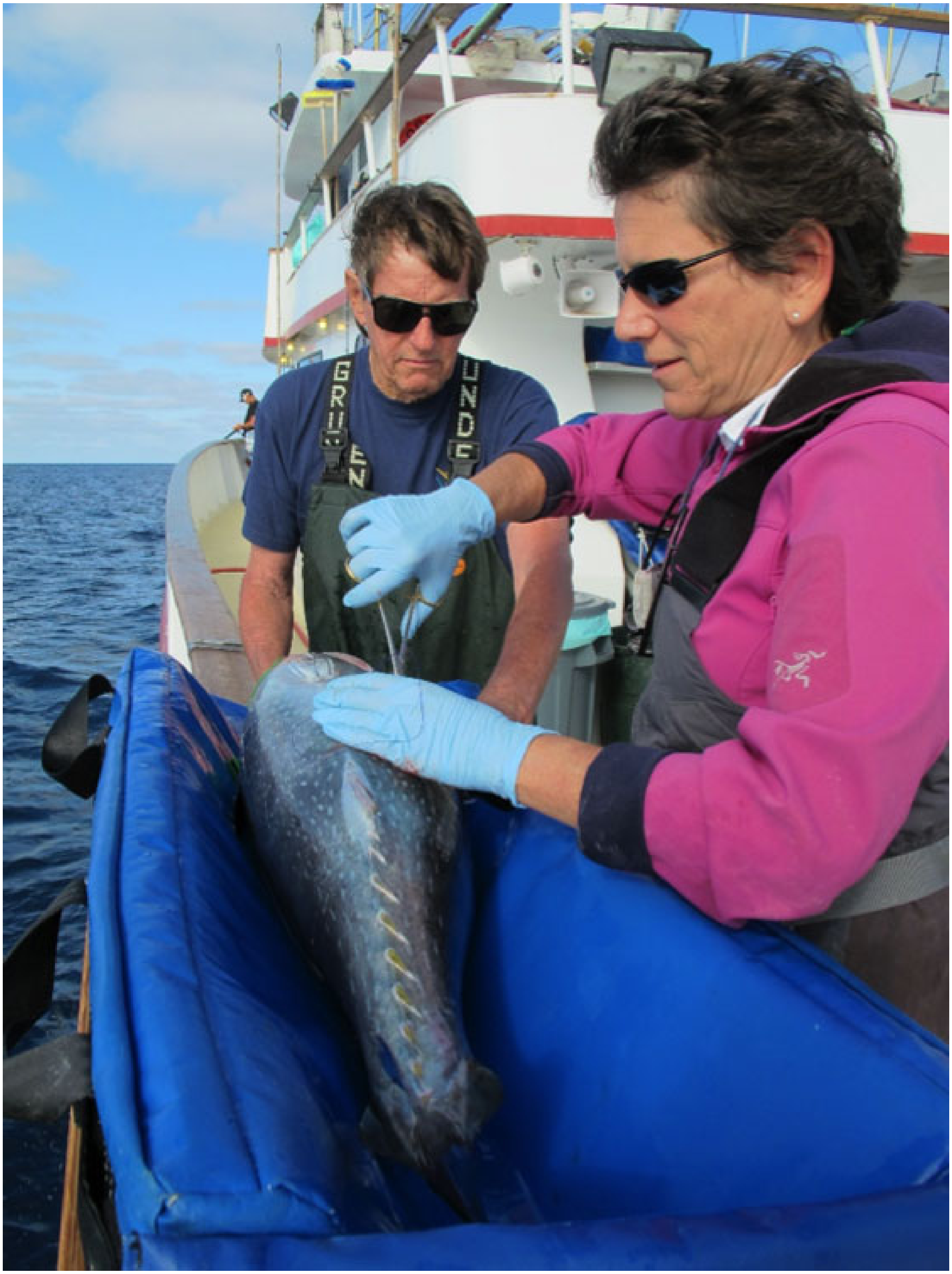
Stanford scientists help discover Pacific bluefin tunas' favorite feeding spots

September 25 2015



Marine sciences Professor Barbara Block of Stanford and Charles Farwell of the Monterey Bay Aquarium tag a Pacific bluefin tuna. (Photo: Courtesy Barbara

Block)

After chowing down a big meal, you might feel your belly warm as your stomach muscles and digestive organs set to work breaking your food into smaller and smaller pieces rich in nutrients. A bluefin tuna's stomach experiences a similar spike in temperature when it gulps down a mouthful of juicy sardines.

Now, scientists at Stanford, Monterey Bay Aquarium and the National Oceanic and Atmospheric Administration (NOAA) have devised a way to measure that internal temperature increase in the fish. This is the first work to measure how much energy an aquatic animal consumes in the wild, and has allowed the researchers to identify the bluefin's favorite dining spots along the North American coastline. The findings are published online in *Science Advances*, and could help design better conservation policies to help a species in steep decline.

Pacific bluefin tuna are superbly streamlined, bullet-shaped fish, with powerful swimming muscles capable of powering transoceanic travels. Unlike most other bony fish, they are warm bodied, elevating their internal tissue temperatures above that of the surrounding water.

"Bluefin tuna are the pinnacle of bony fish evolution, endothermic or warm-bodied in a manner that rivals the metabolic performances of birds and mammals," said senior author Barbara Block, a professor of marine sciences at Stanford's Hopkins Marine Station and a senior fellow at the Stanford Woods Institute for the Environment.

Following the fish

Bluefin tuna remain warm by capturing the metabolic heat produced as their swimming muscles contract with every tailbeat. This is made possible via specialized net-like blood vessels, called counter-current heat exchangers, in their muscles and digestive organs that prevent heat loss through their gills. Maintaining warmer-than-water body temperatures allows the fish to swim more efficiently and spend less energy digesting food, and enables them to thrive in a wide range of ecological niches.

The researchers homed in on this thermal characteristic in order to measure energy intake, and from that surmise the animals' daily foraging habits. The researchers implanted small data-logging tags in more than 500 tunas off the coast of Southern California and Mexico, and recorded the fishes' body temperature and ambient water temperature, as well as their locations and diving patterns as they searched for prey. With the help of fishers, the researchers recovered more than one-third of the tags, containing data records as long as three years as the fish made seasonal migrations from the waters off Mexico to Oregon.

Previously, observations led by Rebecca Whitlock, a postdoctoral scholar at Stanford, made at the Tuna Research and Conservation Center, had created a model for translating the change in tuna heat signatures into their caloric intake. Inside the center, which is operated by Stanford and the Monterey Bay Aquarium, researchers could count single sardines or squid consumed by individual tunas and match the warming signal to the energetic value of the prey item digested.

The thermal data showed exactly when the tunas ate a meal, and the researchers estimated how much energy a free swimming bluefin receives per unit of time, as well as how temperature changes impact that energy intake.

"We've been able to follow what Pacific bluefin tuna do in the open sea and record their feeding and meal size, every day for up to three years," said Whitlock, the lead author of the new paper. "Combining laboratory observations with electronic tagging can provide amazingly rich data and insights into the life of a wild marine predator."

A roadmap in the ocean

The wild tunas consumed prey on 90 percent of the days observed during the study, and the empirical data analyses and energetic model output allowed the scientists to chart precisely how much the fish ate - typically sardines and squid - and the total energy they consumed as they journeyed through the ocean.

From this, the scientists mapped the position data from the tags to satellite observations of sea temperature, chlorophyll levels and ocean currents - all factors that can combine to create nutrient-rich feeding grounds. These coincided well with successful tuna feedings, though interestingly the fish didn't always camp out in the locations with the best conditions to take advantage of the buffet.

"Foraging success was correlated to environmental features," said co-author Elliott Hazen, a research ecologist with NOAA's Southwest Fisheries Science Center. "Tuna may use the oceanography as a roadmap to move from hotspot to hotspot, and temperature appears to be the most important environmental cue."

Interestingly, the study showed that there was a potential tradeoff between feeding in the richest areas and avoiding the physiological constraints associated with feeding in very cold (which slows the heart) or warm (energetically taxing) waters. This answered a long-standing question about the species' traditional limits in range, from north of Oregon to south of the Baja Peninsula, despite the fact that close relatives of bluefin (yellowfin and albacore tuna) thrive outside of those latitudes.

Whenever the bluefin digests a meal, the fish tends to stay in waters that allowed it to remain at an optimum temperature to promote rapid digestion of the meal. Too high or too low an environmental temperature, and the increased demands of digestion can strain the cardiovascular system.

"We found the key to their energetics," Block said. "Our results suggest that physiological constraints on the tunas' whole organismal performance constrain their thermal distribution, and thus the latitudinal distribution of the fish. Digestion is metabolically costly, and the bluefin are doing it most efficiently."

Block calls this portion of the ocean the "Blue Serengeti," an open ocean ecospace where currents concentrate nutrients and plankton, attracting forage fish such as sardines or anchovy, which in turn lure larger fish such as bluefin tuna.

Understanding the locations of these "watering holes" for these large migratory fish remains largely a mystery, but is a key part in planning better conservation efforts. Linking the regions both physiologically and to environmental correlates has been an objective of this team.

The new work helps close that gap by identifying feeding hotspots (areas of highly successful feeding) for Pacific bluefin tuna along the Baja Peninsula in June and July, off Northern California from October to November and near Central California in January and February.

"Our results add to our understanding of predator-prey dynamics in the California Current," Block said. "By understanding where bluefin forage most, we can help protect these places and improve efforts to rebuild Pacific bluefin tuna stocks."

Provided by Stanford University

Citation: Stanford scientists help discover Pacific bluefin tunas' favorite feeding spots (2015, September 25) retrieved 18 April 2024 from https://phys.org/news/2015-09-stanford-scientists-pacific-bluefin-tunas.html