out of the fog
Emerging Science from California's Central Coast

Using body chemistry to track ocean predators

by **Leigh Cooper** on 12 November, 2014

Open-ocean predators, like tuna and sharks, don't settle down as happy homemakers, content to prowl amongst the corals of one reef. Instead, these hunters perform surprisingly long migrations, chomping on seafood from numerous marine ecosystems.

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The source of sashimi sushi, bluefin tuna can tantalize our taste buds. But, these tuna cost much more than our average can of albacore with a single 489-pound bluefin tuna pulling in $1.8 million in 2012 (Big Bluefin). With that monetary incentive, humans have overfished bluefin tuna, dropping their

populations by 96 percent. And yet, fisheries managers still lack sufficient data to track the migration of these predators.

For their June 2014 *Ecology* paper (esajournals), Daniel Madifan at Stanford University's Hopkins Marine Station (Hopkins) and his international colleagues turned to body chemistry to track the immigration of Pacific bluefin tuna (*Thunnus orientalis*) to the Baja California coast.

Pacific bluefin travel more than most fish. Born in the western Pacific near Japan, many young tuna journey to the western coast of North America and grow plump on resources supplied by the California Current. The team wanted to know at what age the tuna turn tail on Japan and how long they stay near North America before returning to Japan to breed.

Elements like carbon and uranium sometimes exist in unique forms that contain different numbers of neutrons. Madigan's team focused on the different forms, or isotopes, of nitrogen, a nutrient all organisms need to create proteins and DNA. Nitrogen exists as multiple isotopes including the most common form with 14 neutrons (^{14}N) and a very rare form with 15 neutrons (^{15}N).

Scientists can measure the nitrogen isotope ratio, ^{15}N:^{14}N, in an animal's muscle. Because a predator incorporates the nutrients from its prey into its body, a predator's ^{15}N:^{14}N ratio will reflect the ^{15}N:^{14}N ratio of its prey. And, often times, nitrogen ratios differ among prey species.

A Pacific bluefin living on anchovies off the coast of Japan will have a different nitrogen ratio than one munching on California squid, because their prey have different isotope ratios.

There is a challenge to using this method to track predators – animals also excrete nitrogen. We excrete ^{14}N at a faster rate than ^{15}N, altering our nitrogen ratio. Imagine looking squarely into a mirror, but your reflection stands off to the left. In the same way, a tuna's nitrogen ratio mirrors that of the squid it usually eats, but with a distinct and calculable shift.

This process magnifies with predators higher and higher on the food chain. The nitrogen ratio of an animal that eats the tuna will be another step removed from the original squid's nitrogen ratio. Basically, as the top predator excretes more nitrogen, their reflection slides another step to the left.

Madigan's team needed to make sure any differences in Pacific bluefin nitrogen ratios reflected whether a fish snacked on Japanese fare or California cuisine as opposed to moving up and down the food chain. They solved this by testing nitrogen ratios in different types of amino acids, the building blocks of a protein. They isolated amino acids that only changed when the primary food source changes – Japanese anchovy versus California squid.

All that chemistry paid off when Madigan's team began labeling each captured Pacific bluefin as a recent migrant – one who just entered the ocean near Baja Californian, or a resident – a fish who had puttering around the area for a while. To maintain a stable tuna population for fishing, fisheries managers desperately needed this information.

They found that most recent migrants had not reached their second birthday, but the surprised scientists found that even 33 percent of two to four year olds were new arrivals. The scientists even discovered a previously unknown pattern to the young tuna's migration; the adolescent tuna left the western Pacific in winter and arrived in late spring as they turned one year old.

After testing nitrogen ratios in muscle and amino acids, the team triple checked their findings. The scientists noted that the tuna designated "recent migrants" by the nitrogen isotope techniques also contained high concentrations of rediocesium in their bodies. Radiocesium, a radioactive version of the element cesium, gushed from the Fukushima Daiichi power plant after the 2011 tsunami and contaminated local fish. Only recent migrants would show high concentrations of the radioactive element.

With the application of a few inventive tools, Madigan and his researchers opened the door to understanding the movements of one of our ocean's predators – tools useful for tracking other ocean hunters as well. Troubled enough by these large fish gallivanting across international boundaries, California fisheries managers can now generate better estimates of Pacific bluefin migrations into the eastern Pacific.

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About Leigh Cooper

My professor advised me to become a science teacher after my partner and I, dressed as kangaroos, presented our kangaroo mating study as an episode of the radio call-in show "Loveline." Until then, I never thought to share my dizzying enthusiasm for the natural world through teaching. As I slogged through graduate school, drowning in freshwater nutrient cycles, the fun of learning science began to dissipate. My students were my salvation. They asked the most important

question: “Why should we care?” I had forgotten what I had once known instinctively: As a teacher, I needed to find that one story, study, or kangaroo costume that viscerally engaged my audience. Now, as a science writer, I will connect my readers with a world where each brook and beetle bursts with a captivating tale to tell.

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