Biologist gets a squid's eye view (w/ video)

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(Phys.org) —Pursuing the misunderstood Humboldt squid, Hopkins Marine Station's William Gilly has strapped video cameras and electronic sensors to the animals, exhaustively analyzed their habitats, tracked them with sonar and raised their eggs.

As far as invertebrates go, the Humboldt squid is something of a media star. December's reports of hundreds of squids beaching themselves along the Santa Cruz, Calif., coastline in a "frenzy of suicide" are only the latest examples of the animal's odd celebrity. With popularity rare

for a mollusk, the squid is a frequent guest on adventure-themed TV shows and regularly featured in sport-fishing articles described in frightening terms like "cannibal" and "invader."

This morbid attention makes sense – the squid, *Dosidicus gigas*, with a razor-sharp beak and hooks on its suckers, can reach the size of a grown man. But the squid's horror-movie image isn't based on much concrete evidence at all.

For an animal that constitutes the largest invertebrate fishery in the world, we know surprisingly little about the most basic features of squid behavior. Now that the animal appears poised to be a resident of the California coast – traveling far north of its "traditional" habitat off the Peruvian coast to the Gulf of California – study of the creature is more relevant than ever.

For the past decade, Stanford biology Professor William Gilly – the go-to expert for those who are seeking to understand the mass beaching at Santa Cruz – has been learning everything he can about the Humboldt squid. Members of the Gilly Lab at Stanford's Hopkins Marine Station have strapped video cameras and electronic sensors to the animals, exhaustively analyzed their habitats, tracked them with sonar and raised their eggs.

The fruits of their labor? An unprecedentedly detailed view of life as a squid.

Home movies

The National Geographic Society's Crittercam has been invading the animal kingdom's privacy for over two decades. A quart-sized low-light camera equipped with an array of sensitive instruments for measuring everything from water temperature to acceleration in three dimensions,

the device has been strapped to penguins, sea turtles, hyenas and a host of other animals.

Attaching it to Dosidicus, however, took some finagling.

"A squid is a very flexible platform for a camera," Gilly said. The device simply wasn't designed to latch onto a slippery, boneless creature, and the team was forced to attach it with the help of a child's bathing suit, cut to act as an elastic sleeve.

Six years ago, Gilly discovered that Humboldt squid undertake daily vertical migrations in the water column, spending the days at depth and popping up to the shallows at night to feed. Crittercam footage and data, along with echosounding studies conducted with Kelly Benoit-Bird of Oregon State University, have filled in many of the blanks in that picture.

Humboldt squid, it turns out, are capable of remarkable bursts of speed. By squeezing their sac-like bodies and forcing the water through a siphon just underneath their heads, the animals can jet-propel themselves in brief spurts up to 20 meters per second, or nearly 45 miles per hour – comparable to the fastest ocean fish.

The hunting itself involves tight coordination within large groups of squid – behavior thought to be more typical of fish than invertebrates.

Dosidicus' coordinated hunting is complicated by another factor as well. Gilly and Benoit-Bird found that smaller squid maintained large buffers between themselves and larger squids – presumably because of the animals' much-reported propensity for cannibalism.

Seasoned travelers

But while the kind of jet propulsion squid use during hunting is fast, it's inefficient. Dosidicus is known for traveling long distances – tagging studies by the Gilly Lab along the California coast show that the squid frequently travel more than 30 kilometers a day, logging migrations as long as 600 kilometers in a bit over two weeks.

"They undergo big migrations for such a short-lived animal," said former Stanford undergraduate Lauren Bell, who coauthored the Crittercam study. "It was a mystery how they were able to satisfy energy demands that allow for both growth and travel."

Data from the video package show that squid spend about 90 percent of their time not sprinting, but doing something called "climb-and-glide" – jetting upward briefly and then coasting forward as they sink – thereby saving the squid a great deal of energy.

Much of the squid's vertical travel time is spent passing through the oxygen-minimum zone, or OMZ – a midwater layer of extremely low-oxygen water that's at the heart of a number of Dosidicus questions.

It's certainly at the heart of the squid's world: Scattered just above is a smorgasbord of prey, squeezed between the OMZ's upper boundary and the sunny surface waters, crawling with visually oriented predators. Gilly's group has called this region the "oxygen-limited zone," or OLZ.

The squid seems to do well in these punishing environments. Former Gilly Lab graduate student Julie Stewart has found that the animals spend up to a third of their time in the OMZ, and collaborators at the University of Rhode Island have shown that the squid can suppress its metabolism under low-oxygen conditions.

This ability gives the squid an advantage over both its competitors and its own predators – most notably sperm whales. Fish and marine mammals

can dive to oxygen-limited depths, but can't stay long.

"The squid can stay in the OLZ permanently for all we know," Gilly said.

Although it has often been assumed that the squid only hunt at night when they and their prey migrate into near-surface waters, research by former Gilly postdoctoral scholar Louis Zeidberg suggests that Dosidicus may forage in and above the OMZ as well.

"[The Monterey Bay Aquarium Research Institute] has videos of them just gliding along with their arms out, shoveling krill in," Gilly said. "It's like raking in potato chips." Whether these videos taken by a submersible vehicle with bright lights represent natural behavior is still unknown.

Low-oxygen layers

Perhaps the single most mysterious question surrounding the squid – why they're moving north at all – may also be tied to the OMZ. For the past few decades, low-oxygen zones have been becoming larger and shallower across a vast area of the eastern Pacific – from Chile to Alaska.

Why? The phenomenon seems to be tied to warming oceans. As surface waters heat up, oxygen solubility goes down. And, as the surface layer warms and becomes less dense, it mixes less with the layers of colder, denser water beneath it, greatly reducing the transfer of oxygen to deep waters.

Monterey, where Hopkins Marine Station is located, often sees pulses of low-oxygen water. Gilly lab technician Ashley Booth has identified these as rolling in from the deep waters off the central California coast,

including the Grand Canyon-sized Monterey Submarine Canyon.

This situation is likely to benefit creatures who can stand that kind of cold, hypoxic water, like squid.

According to Gilly, ongoing changes to the OMZ could have major biological consequences. As the layer moves upward, the animals that live just above in the OLZ lose habitat. They're forced to crowd into a space that gets shallower by the year, even as OMZ-loving animals like the squid expand their range as far north as Sitka, Alaska.

Territorial dispute

Although relatively little is known about Dosidicus development, research from former Gilly graduate student Danna Staaf on squid embryos suggests they can only survive in a narrow temperature range.

Which, Staaf said, raises the question: "Here's this squid that has this enormous range. But can they really spawn in that whole territory?"

In the lab, Staaf began to raise Dosidicus eggs into hatchlings – an arduous task, involving the liberal application of squid oviducal gland extract. She found that squid hatchlings wouldn't develop unless the temperature was higher than 59 degrees Fahrenheit.

This means that squid should be able to lay eggs in one of two places: waters south of the United States, including the Gulf of California and Pacific waters off the Baja Peninsula, or in postulated seasonal spawning grounds hundreds of miles offshore of California and Oregon. Given Dosidicus' talent for feats of endurance, a squid born in either of these distant locales could easily migrate to the shore of British Columbia and back in a single season.

And Dosidicus has already proven an unwelcome visitor in Monterey Bay, where it arrives sporadically to eat market squid, anchovies, sardines and other ecologically and commercially important species. Further to the north off Washington and British Columbia, Dosidicus also consumes salmon smolts, ling cod, flounder and hake – the largest Pacific fishery in the lower 48.

"This has always been thought to be a species that's going to benefit from global warming," said Bell. "And it seems to be taking advantage of it already."

Whether the Humboldt squid will continue its northward expansion and what effect that will have if it does remain open questions. For now, Dosidicus is keeping its secrets tightly under tentacled wraps.

Provided by Stanford University