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DURHAM, N.H. - It should be simple: Little fish eat plankton. Big fish eat little fish. Big fish go home happy.

However, marine food webs are much more complex than that, making them very difficult to study and understand. Recent concerns about the Atlantic bluefin tuna populations have caused researchers to take a closer look at their diet and migration patterns.

"Subtle changes in the climate may cause subsequent changes in the condition and distribution of the prey items for bluefin tuna, and this could ultimately impact the tuna populations," explains John Logan, a Ph.D. candidate at the University of New Hampshire who works with the Large Pelagics Research Laboratory under the direction of Molly Lutcavage. "Diet studies can help to trace such ecosystem-level changes."

Researchers have spent years using electronic tags to track tuna and other large fish in the open ocean and examine their stomach contents to study diets. However, there are still plenty of questions to answer about where they migrate, where and how often they spawn, what they eat and how they fit in to the overall food web of the Atlantic Ocean.

"We'd ultimately like to predict changes in the tuna populations that might occur in response to ecosystem perturbations," Logan adds. "We're trying to get the broader ecosystem-wide picture of food web dynamics for a system that's somewhat difficult to study."

Through a combination of analyzing the bluefin tuna stomach contents and using natural biological tracers called stable isotopes, Logan is hoping to learn about how their diets change with their size, geographic location, and the season.

Stable isotopes are found in the food animals eat and can be measured in their tissues, Logan explains. Isotopes are atoms of an element, such as carbon or nitrogen, that have the same number of protons and electrons as the original element but have a different number of neutrons. Stable isotopes, unlike their radioactive relatives, contain combinations of protons and neutrons that are resistant to decay over time. The isotopes of different elements move up the trophic levels in a consistent manner, allowing researchers to naturally trace the links in the food web.

"The general concept is that an organism will inherit its isotope ratio values based on what it's eating," Logan says. "Ultimately, the idea of 'you are what you eat' can be seen all the way from top to bottom of the food web, from bluefin tuna to phytoplankton."

Logan is also looking at bluefin stomach contents whenever possible to augment the stable isotope data. Bluefin typically digest their prey within 18-20 hours of consumption, so anything found in the stomach contents is representative of what it has eaten recently. The benefit of using stable isotope analysis, Logan says, is that the isotope ratios represent a longer time frame of food consumption. Depending on which tissue type is sampled from an organism, the isotopes can describe the diet from the previous few weeks to a few months.

A second component of Logan's research involves learning about the bluefin tuna's migration and how that might impact their stable isotope ratios. And although "you are what you swim in" doesn't roll off the tongue easily, Logan says that's the basic concept.

"Often times, for an animal that is highly migratory like tuna, either its diet changes as it moves into a different area, or the overall isotope values for given areas might be spatially distinct," Logan says. "It all goes back to whatever the primary source of production is. If your baseline isotope ratio is totally different in different geographic areas, it's going to propagate up the food web. Then you get these nice spatial gradients in the isotopes that can be used to figure out where tuna and other migrating animals traveled from."

Determining if the isotope ratios are impacted by diet, migration or a combination of the two is where Logan's research can get a little tricky.

"Looking at the stable isotope analyses and comparing those to the stomach contents will help tease that apart," Logan says. "Whenever possible, if we can compare stable isotopes with some other technique like electronic tagging or stomach content analysis, it really strengthens your argument."

Many of the samples used for stomach content and stable isotope analyses are collected by recreational and commercial fishermen from both the western and eastern Atlantic, Logan explains.

Samples of the muscle tissue and organs from hundreds of bluefin brought into the Yankee Fishermen's Co-Op in Seabrook were frozen for subsequent isotope and stomach content analyses by Logan and other collaborators.

"What we're seeing in recent samples confirms previous studies that show no huge ecological shifts in the food web thus far," Logan says. "It seems like the bluefin tuna in the Gulf of Maine are still eating what they've been eating previously, which includes small schooling fishes like herring and mackerel."

With regards to the bluefin's migration patterns, Logan says the data collected from the stable isotope analyses supports the findings from electronic tagging data.

"The preliminary data suggest that fish are utilizing the continental shelf waters in the fall and winter for their forage grounds, and going offshore into the Gulf of Mexico in the spring for spawning," Logan says.

"We're getting a more complete picture about their movements with these data," he adds.

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Photograph available to download: http://www.unh.edu/news/cj_nr/2008/oct/tuna2.jpg

Caption: Atlantic bluefin tuna migration patterns and diets are the focus of a study conducted by researchers at the UNH Large Pelagics Research Lab. Stomach content and stable isotope analyses are helping scientists obtain more accurate data about this species.

Credit: Gilad Heinisch, UNH Large Pelagics Research Lab