You are what (and even where) you eat

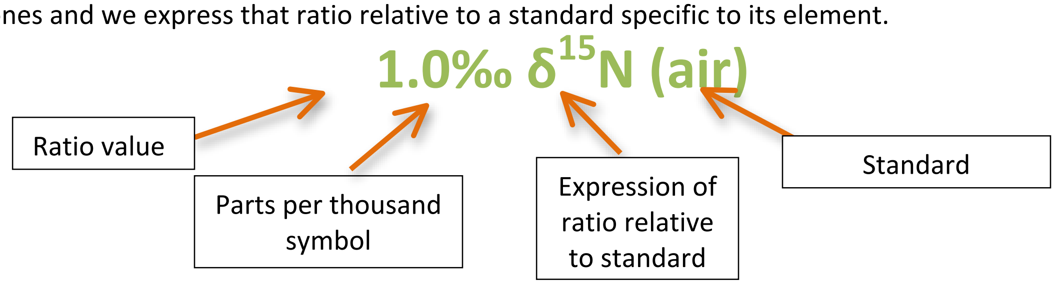
Archaeologists are often perceived of as a very different sort of scientist. After all, they dig through people's thousands-of-years-old garbage dumps (called middens) on a regular basis. I began my career as an archaeologist but then turned to marine science; mostly because I wanted to use what we can learn about the past to better understand our future. In my case this meant learning more about the marine ecosystems that humans living on the coast rely on day after day. I now combine my archaeological knowledge with marine science, but I am still studying other people's garbage; specifically the bones of creatures we find in middens and the soils they were buried in.

Available historic ecological data span periods too short to capture the large climatic changes the world-- and specifically the north-- is now experiencing. However, the past 4500 years experienced both warmer and cooler climate periods such as the Neoglacial (cool), the Pre-Medieval and Medieval Climate Anomaly (both warm), and the Little Ice Age (cool). The two warmer periods are more comparable to current and projected climate, and a better understanding of how important resources such as fish and marine mammals responded to those changes could help communities plan for a sustainable future. Coastal communities could be better able to both devise and advocate for plans that will allow for continued subsistence and economic reliance.

This summer I am participating in three projects; one in the western Aleutians and two on the western portion of the Alaska Peninsula. All of them involve stable isotopes, food webs, and productivity of important resources such as salmon, cod, sea lions and other pinnipeds, and birds. The samples will come from middens in archaeological sites and sediment cores from sockeye spawning lakes. For all of these projects my job will be to use chemistry to decipher past ecosystem change. I hope a better understanding of the past could help communities who are currently making decisions for a sustainable future.

I use stable isotope analysis of bone and soil that can, with certain limitations, help us understand changes in food webs, productivity, and even foraging location of marine species over long periods of time. Most ecologists think of a long-term study as something that has data for the past 20, 50, or at the most 100 years. Our models for fisheries management are often based on the knowledge we have from the last 50 years or so. However, we have climate data that spans thousands of years and now we need environmental and ecosystem data that are as long term as our climate models. Or at least as far back in time as we can retrieve good data. So far, that "good data" for stable isotope analysis of middens in coastal Alaska seems to stretch back about 4000-5000 years.

Isotopes are atoms of a single element that have different atomic weights and we can use stable carbon and nitrogen isotope ratios to place an organism into a food web. In nature lighter isotopes are more abundant than heavier ones and we express that ratio relative to a standard specific to its element.



(from Misarti in *Sanak Island, Alaska: A Natural and Cultural History*, eds. K. Reedy-Maschner and H. Maschner 2012)

Basically each step up the marine food chain increases your nitrogen isotope ratio ($\delta^{15}N$) by about 3.5‰ and carbon ratios ($\delta^{13}C$) by 0.5‰ to 1‰. The way organisms at the base of the food web uptake $\delta^{13}C$ during photosynthesis are different and can help determine the type of ecosystem we are looking at. For example, an urchin that feeds on kelp will have a different $\delta^{13}C$ than a fish that feeds on a copepod (that in turn fed on phytoplankton). It will also have a different nitrogen isotope ratio as the urchin is only two steps up the food chain and the fish is three steps up the food chain. Carbon isotopes can also be a marker of productivity because when productivity in the ocean increases so does $\delta^{13}C$. Overall if we see changes in carbon and nitrogen isotope values within a species over time it probably reflects changes within that organism's ecosystem. In other words, an organism's $\delta^{13}C$ and $\delta^{15}N$ tell us what they eat and where they eat.

This is true for muscle tissue, hair, bone, and pretty much any other part of the body. Each type of tissue has a slightly different ratio based on the amount of time that tissue takes to "turn over" the nutrients a body is taking in. This means that with a little study and laboratory preparation, scientists can compare bone from 4000 years ago to muscle tissue from today. In other words, we can compare food webs, specie's trophic position, productivity, and potentially the locations these animals were feeding over thousands of years. There are limitations of course, but these types of long term data can help us better understand how organisms might react to current and future change.