Biological responses: plankton and foraminifera
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*Ocean acidification is consequence of changing ocean chemistry, but what really worries researchers are the negative effects it could have on life in the ocean.*

Though they might be invisible to the casual observer, marine plankton are much more important than their small size would suggest. These microscopic animals, algae, and other protists form the base of the marine food web, harnessing energy from the sun and moving it up the food chain, all the way to birds and marine mammals. Plankton play a foundational role in marine systems and can serve as sentinels of a changing ocean.

The Washington Ocean Acidification Center (WOAC) is eager to understand the status of plankton communities in Washington waters and how these communities might respond to future changes in ocean chemistry. To address these questions, investigators are monitoring plankton communities to determine which species live in Washington waters and what conditions these organisms are exposed to throughout the year.

Changes in the presence and abundance of different plankton species can reflect changes in water quality and provide insights into changing ocean conditions. “Sometimes species composition is a more subtle indicator because organisms integrate all kinds of different conditions,” said UW zooplankton ecologist Julie Keister. “So if there are changes in chlorophyll and temperature and circulation and salinity, they may all be fairly small changes, but the biological effects of all those changes added together could be really big.”

The biological plankton monitoring funded by WOAC focuses on three major taxonomic groups:

- **Phytoplankton & Microplankton** – these single-celled organisms comprise the lowest levels of the marine food web. Phytoplankton serve as a food source for microplankton, which then act as a food source for larger organisms.
- **Mesoplankton** – these slightly larger multicellular organisms such as copepods and krill prey mostly on microplankton. Plankton of this size class are one of the biggest food sources for suspension-feeders like mussels, oysters, and some juvenile fish.
- **Calcareous pteropods** – these are a type of mesoplankton that has been shown to be especially vulnerable to ocean acidification. Pteropods are being monitored for their shell dissolution, as an indicator of corrosive conditions.

These monitoring efforts serve as a mini-census of microscopic life at various sites throughout Puget Sound, the Strait of Juan de Fuca, and along Washington’s outer coast. Plankton samples are collected on three annual WOAC cruises in Puget Sound and the Strait, with additional semi-annual cruises to La Push on the outer coast. Identifying all the organisms collected takes a large amount of time from highly trained taxonomists.
“There are all sorts of things we look at,” Keister said of zooplankton identification. “Overall is it big, is it small, is it roundish or pointy, does it have lots of legs? It’s easy to quickly know whether it’s in a particular family, it’s just getting it to the species level that is very hard.”

The plankton data series is still too short to make any definitive connections between marine conditions and plankton community structure. So far, the three years of data show high levels of variability in species composition and abundance. This is the very first study in the region to analyze plankton communities in the context of physical parameters such as pH, temperature, and salinity, and it will take some time before researchers can start to discern how different environmental factors influence the community.

“What we need is enough observations over enough different conditions that we can start to separate out these factors,” Keister said. “So if one year has very high temperature and very low phytoplankton and the next year has high temperature and high phytoplankton, then that gives us a contrast.”

That contrast can help pinpoint specific conditions that caused a change in the plankton community. Even without long-term data, these surveys are informative on their own because they can give us clues about small-scale changes in the environment. For example, when a large mass of warmer than average seawater called “the blob” was evident off the Northwest coast, researchers observed plankton species that had never before been seen in the region. Similarly, increases in local species that are typically rare can indicate that the environment has changed to favor some species over others.

In addition to freely drifting plankton, the biological monitoring funded by WOAC also focuses on benthic (bottom-dwelling) organisms. Foraminifera can be thought of as benthic counterparts to plankton. Often referred to as ‘forams’, these organisms can be very abundant, serving as an important food source for small fish and invertebrates. Forams have been used as indicators of pollution and they may also serve as an indicator of ocean acidification. Because some forams make their shells out of calcium carbonate, they are susceptible to dissolution in the same way as the planktonic pteropods.

The Washington Department of Ecology has collected annual samples marine sediments containing forams since 1997. Some of these samples are shared with investigators at UW. In the foraminifera lab, researchers Ruth Martin and Liz Nesbitt, along with a dedicated group of student volunteers, comb through sediment samples under a microscope looking for tiny foram shells the size of a grain of sand, and picking out each individual with a fine paintbrush. Most samples contain thousands of forams, and they aim to identify a subset of 300 from each sample. With data going back 20 years, Martin estimates they will have analyzed close to 200,000 individual forams once their study is complete.

“We have the most wonderful students who come because they’re so interested in our work,” Martin said. “You don’t sit with a paintbrush and pick out grains of sand if you’re not really interested in the research.”
Martin and Nesbitt have identified areas in Bellingham Bay and Sinclair Inlet where foram abundance and diversity have shown large changes over the last decade. These changes could be a sign of environmental stress. To investigate the effects of ocean acidification, they categorize individual forams based on the condition of their shell. By distinguishing between shells considered pristine and those with mild, moderate or severe dissolution, they can assess how shell condition has changed over the last 20 years in parallel with the increasingly corrosive water conditions.

The WOAC-funded plankton and foram monitoring studies will allow researchers to detect and understand changing ocean conditions in Washington. In the meantime, information from these studies helps us understand short-term changes in biological response to environmental conditions. Preserving economically and culturally valuable marine resources in Washington, and adapting to the changes that lie ahead, requires that we understand changes among even the smallest organisms in ocean.