Plankton Mysteries along the Northern California Coast

by Michael Bailey

San Francisco State University's Toby Garfield, Associate Professor of Geosciences, and a group of Bay Area researchers, have discovered that in Bodega Bay, which experiences rapid and constant movement of its surface water out to sea, plankton somehow manage to thrive along the coast. Plankton, which are further subdivided into phytoplankton (plants) and zooplankton (animals), are the microscopic animals and plants that form the base of the food chain.

Upwelling, the process by which nutrient- and mineral-rich water is brought to the ocean's surface by variations in wind patterns, controls whether and how rapidly the phytoplankton will grow, or "bloom." In order for phytoplankton to grow, the nutrients brought to the surface by upwelling must remain at the ocean's surface for a certain period of time (exactly how long is not known). Coastal surface waters characteristically have very low phytoplankton growth because the wind blows the nutrients on which they feed out to sea. But some phytoplankton have developed strategies that enable them (or at least their seeds) to remain in that region offshore and wait for more nutrients to be upwelled to them.

Upwelling is also responsible for the fog and cool summers of northern California. It is caused by a combination of winds blowing across the surface water and the spinning of the earth. The earth's winds push ocean water around; in the northern hemisphere, simply put, "slabs" of water move to the right of the wind direction in circular patterns in the open ocean. At the coast, however, because the land presents a boundary, the water's movement is stopped by the land, and either moves parallel, or into or away from the coastline. When the water moves away from the coast, upwelling occurs, because the slab of water at the top is moved toward the open ocean and is replaced by water from underneath.

The interdisciplinary study that Garfield and colleagues are conducting is set in the Bodega Bay region because there is an enhanced, upwelling-driven offshore flow there. The researchers' approach is comprised of two main observation components. The first uses four stationary devices (on buoys) that are moored near the coast over the continental shelf (the shallow coastal underwater area). The devices record information year round as the water column moves past them (like a weather vane, influenced by wind moving past it). The second approach, in which Garfield is most directly involved, uses a ship to survey a large area of water. Garfield and his colleagues take the boat out twice a year (summer and winter) to observe the evolution of different "pieces" of water. The summer cruise usually lasts about a month; the winter cruise, a couple of weeks.

The study (which is focused on creatures only up to the zooplankton trophic level), encompasses a vast array of measurements. The group is gathering information on

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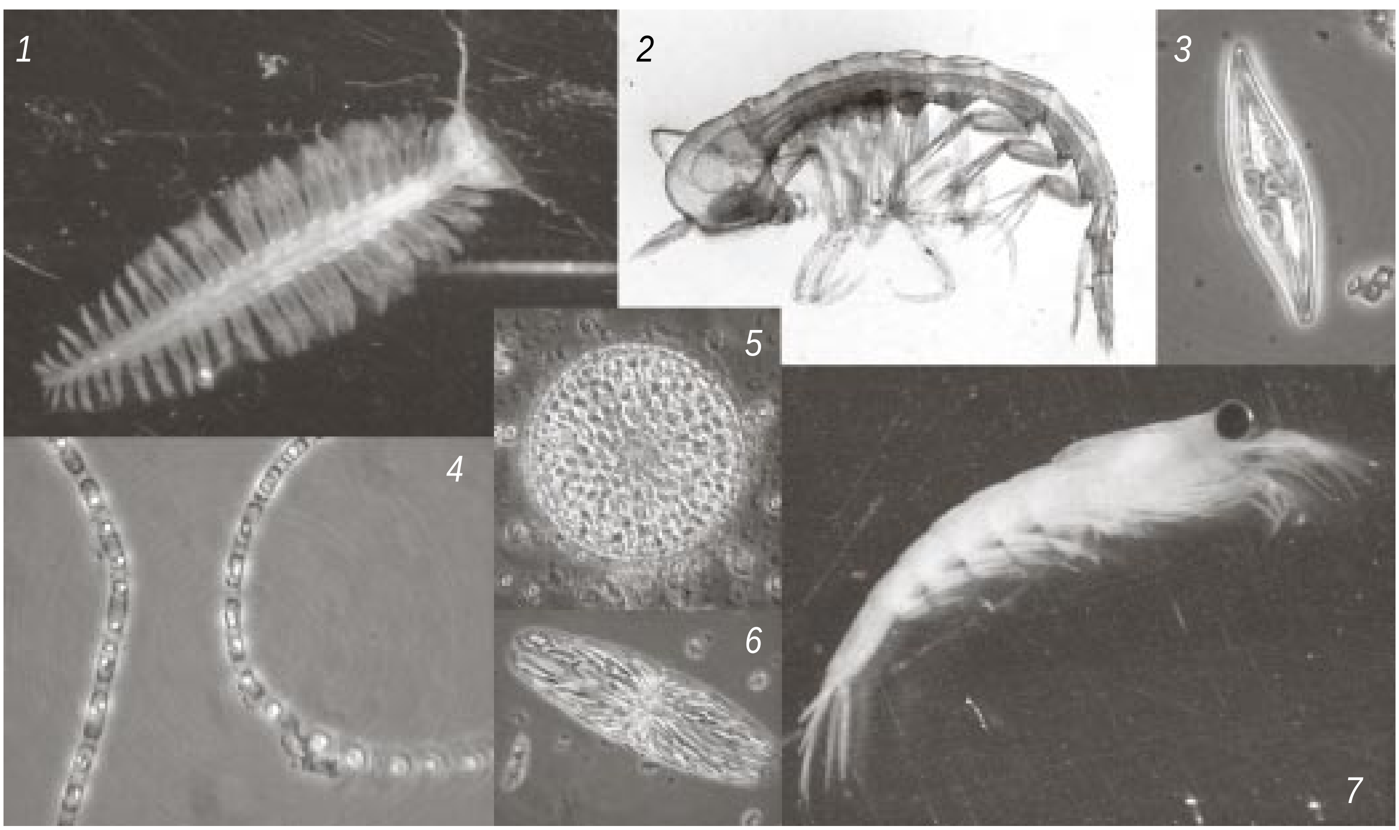

Some of the plankton observed for this study: *1. Tomopteris septentrionalis, 2.* Phronimid amphipod, *3. Pleurosigma spp., 4. Skeletonema costatum, 5. Coscinodiscus spp., 6. Tropidoneis antartica, 7. Euphausia pacifica.*

Photos 1, 2, and 7 courtesy of Anne Slaughter. Photos 3, 4, 5, and 6 courtesy of Adria Lassiter. Both at RTC.

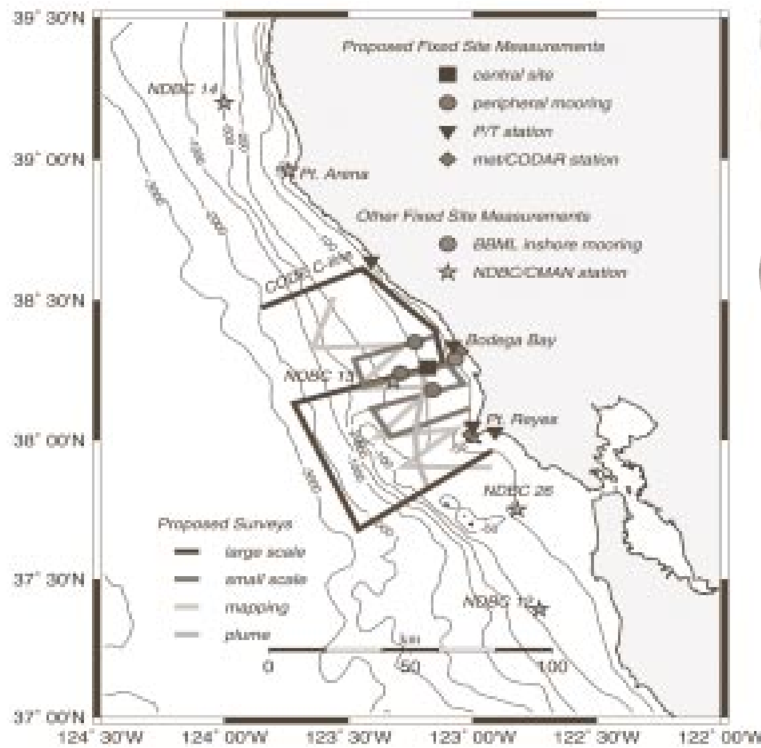

Figure 1. Area map showing proposed fixed site and survey measurements.

Area map showing proposed site and survey measurements.

Map courtesy of Dr. Garfield

seawater properties, nutrients, light, phytoplankton, and zooplankton. Ultimately, the information will be used, along with principles based in physics, to build a computer model. Garfield explains that if one can produce a computer model that reproduces observed conditions, the processes must be well understood (although a fair number of assumptions must also be included in any model created). Says Garfield, "I read somewhere that the process of science is 90 percent beating your head against the wall and 10 percent understanding. That's what happens: you go out and study something and get a little bit of understanding, but you end up bringing up so many other questions that you redefine the problem and approach it again."

During their first summer cruise, the team observed a two-week period with no wind at all. Then, during another two-week period, the wind had been blowing very hard just before the team arrived, which produced an abundance of nutrient-rich water right at the surface. When the team arrived, the winds subsided. They were able to measure that windless condition, which produced high phytoplankton values and an incredibly large jellyfish bloom. The jellyfish bloom was likely caused by the rapid growth of phytoplankton, which produced food for the zooplankton on which the jellyfish feed. The Bodega Bay region is known for having large jellyfish blooms in August; however, this one was occurring in June. The team quickly realized that, contrary to local legend, the jellyfish blooms are not seasonal after all; they occur when conditions are favorable, no matter what time of year it is. The following year produced "normal" conditions, with strong upwelling-favorable winds and breaks in between them. In the summer of 2002, conditions were abnormally windy, and the waters were rich in upwelled nutrients. The high winds, however, kept washing the nutrients out to deep water, and the phytoplankton never really had time to take hold and bloom. The team observed that a bloom had occurred just before they arrived, but was swept out to sea, and thus "lost" to the local system.

In the summer, the wind generally produces long periods of upwelling-favorable conditions, interspersed with short periods when the wind stops (or reverses direction). The phytoplankton bloom when the wind stops blowing because the nutrients on which they feed are able to stay in the area. In the winter, the winds are not as strong or frequent, producing more favorable conditions for the phytoplankton. However, the sunlight, another component necessary for growth, is not as intense.

One surprising observation the team made is that when the winds decrease for as little as an hour or two, the phytoplankton grow rapidly. Therefore, theorizes Garfield, they must be able to somehow respond quickly to wind reductions and seize the opportunity to grow. Says Garfield, "The phytoplankton are always there, ready to start growing, but the questions [for researchers] are: Where? How do they remain there? Where do they come from? The easy answer is to say that they come from upstream, but that begs the question, 'What is happening upstream so that those seeds are there?'"

Most of the equipment Garfield's team uses is automated, and the team receives their data quickly. The team that uses the moored equipment, however, recovers their data only when the team takes the instruments out of the water and collects samples. Therefore, that team's data is a year or two behind. According to Garfield, it will take a couple of years before the data from the two components can be put together and analyzed.

Garfield predicts that the most valuable information that the study will provide relates to time. Does the wind have to blow for a certain period of time for the system to become efficient? Is there a maximum time beyond which the system's efficiency decreases? For how long does the wind have to stop blowing before the system becomes stable enough for the phytoplankton to start growing? What is the mechanism by which the phytoplankton are cued to start growing? Can this information be used by environmentalists or the fishing industry to help predict phytoplankton growth, and therefore help support the overtaxed fish population? All of these and more questions are being brought up by the study.

Like all studies, this one raises as many (or more) questions than it answers. One theory is that the phytoplankton seeds remain *somewhere*, waiting for an environmental cue that tells them when to come to the surface. Garfield compares this quandary to the chicken and the egg question. It will take much more research and work to answer this and all of the other questions that have arisen from the study.