BEST-BSIERP
Bering Sea PROJECT
UNDERSTANDING ECOSYSTEM PROCESSES IN THE BERING SEA 2007–2013

Protists - Tiny Predators of Phytoplankton

AN AMAZING ARRAY OF ONE-CELLED ORGANISMS FEED IN THE BERING SEA

While copepods are small, about the size of grains of rice, microzooplankton protists are even tinier, less than 200 microns in size, smaller than poppy seeds. How are such miniscule predators able to feed on diatoms, single-celled algae that are often as big, or even bigger, in size than the protist themselves? It turns out that these protists have many, often surprising, ways to prey on diatoms.

How We Did It

During spring (March-June) Bering Sea cruises in sea ice, we studied the importance of microzooplankton protists as consumers of algae, predominately diatoms, in the Bering Sea. Experiments were done in on-deck incubators to measure growth of algae in seawater with and without the presence of microzooplankton predators. The difference in algal growth, measured by change in amount of chlorophyll during the incubations, showed how much algal production was eaten by the microzooplankton. Using a microscope, we inspected water samples that we had preserved at sea to determine the biomass and types of predatory microzooplankton. In these samples, we took photographs of protists that were caught in the act of feeding on diatoms.

The results of the experimental incubations showed that the microzooplankton protists were important consumers of diatoms. We found a positive relationship between the biomass of these predatory protists and phytoplankton stocks as measured by the concentration of chlorophyll in the water (Figure 1). At some sites, we measured a high amount of protist grazing on intense

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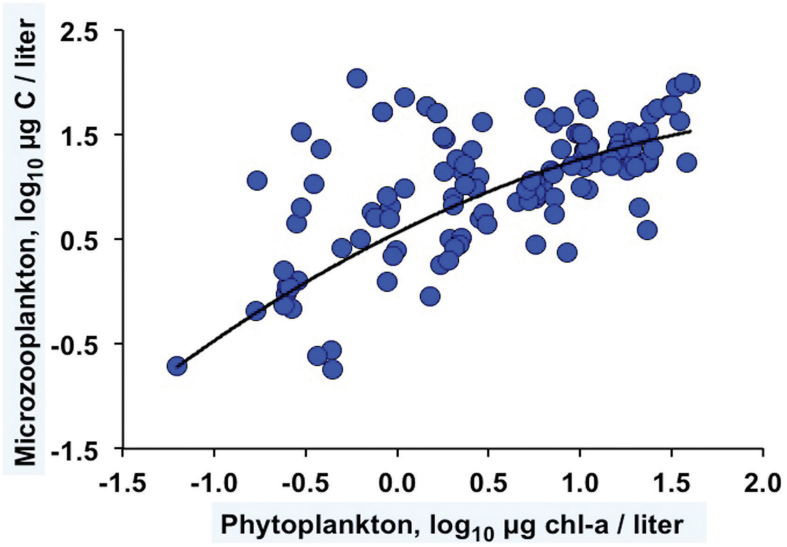
Fig. 1



Log-log relationship between biomass of microzooplankton (µg C/liter) and concentration of phytoplankton (µg chl-a/liter) in the Bering Sea during spring (March-June). Chlorophyll ranged from 0.2 to 38 µg/liter, and microzooplankton biomass from 2 to 72 µg C/liter.

The Big Picture

When ocean ecologists say, "all fish is diatom," they mean that the annual blooms of these large, lipid-filled algae support major marine fisheries. Diatoms, which grow both in sea ice and in the water, are known to form the base of food webs in the Bering Sea. Yet, exactly how the production of diatoms moves through the food chain to fish, seabirds, seals, and whales is still debated. The standard concept is that diatoms are eaten by crustacean zooplankton such as copepods and krill, which are then consumed by higher predators. However, this view of a straight-line food chain is giving way to evidence that much of the diatom production is instead consumed by unicellular predators, protists in the microzooplankton.

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diatom blooms. Our most surprising finding was the varied ways that protists fed on diatoms.

The most common types of protist predators of diatoms were large-sized dinoflagellates. Common species of marine dinoflagellates use only organic materials as a source of food, and make their living by feeding on other cells. Abundant *Gyrodinium* dinoflagellates in the Bering Sea were able to engulf large diatom cells and chains (Figures 2-A, 2-B, 2-C). In some cases, the dinoflagellate cell was so distended to accommodate a long diatom chain that it appeared about to pop (Figure 2-C). Other types of predatory dinoflagellates are encased in rigid armor plates, called a theca. These thecate dinoflagellates cannot change their shape to surround a diatom chain as do their *Gyrodinium* cousins. Instead, the dinoflagellates extrude an amoeba-like blob of protoplasm that attaches to a diatom chain. The protoplasm surrounds the diatoms, and then enzymes are released to digest the algae and slurp the food back into the dinoflagellate cell (Figure 2-D).

Some types of protists feeding on diatoms were unexpected. Shelled amoebae that sucked out the protoplasm of centric diatoms (Figures 3-A, 3-B) were among the most curious predators. In one shipboard experiment, these amoebae dramatically increased in abundance, which showed that they were able to rapidly grow on diatom food. Even smaller protists prey on diatoms by attaching to the silica shell and injecting enzymes to digest the cell contents. Parasitic flagellates have been previously observed preying on centric diatoms during summer in the Bering Sea. Similar flagellates infested chains of pennate diatoms during our spring study (Figure 3-C). We don't yet know how important these diatom parasites are in the Bering Sea; although parasitic flagellates have been reported to crash a diatom bloom in a European coastal system.

Why We Did It

We hope that future studies will discover the true significance of these varied protists as consumers of diatoms, and whether their feeding impact in Bering Sea food webs might dramatically increase as a result of global warming.

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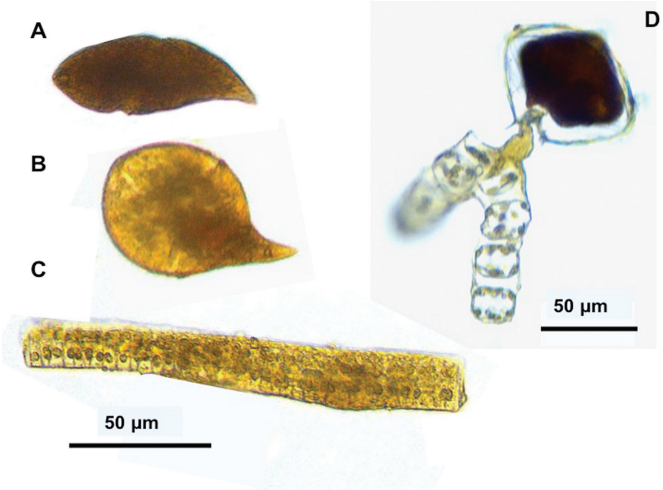
The Bering Sea Project is a partnership between the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Project and the National Science Foundation's Bering Ecosystem Study. **www.nprb.org/beringseaproject**

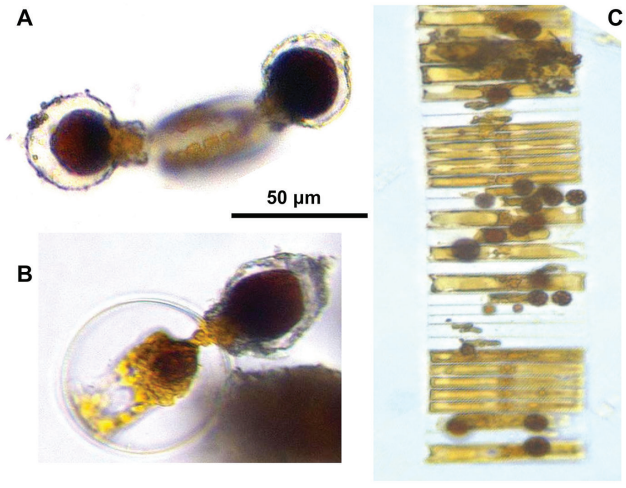
Fig. 2



A, B, C: Evelyn Sherr; D: Celia Ross

Dinoflagellates are well known as predators of large diatom cells and chains. ***A.*** Gyrodinium *sp. dinoflagellate without ingested prey.* ***B.*** Gyrodinium *dinoflagellate cell distended with an engulfed single centric diatom cell.* ***C.*** Gyrodinium *dinoflagellate cell grossly distended with an engulfed pennate diatom chain about 40 cells in length.* ***D.*** *Thecate dinoflagellate feeding on a diatom chain by attachment of an extruded blob of protoplasm containing digestive enzymes. The brown color of the cells is from the iodine fixative used in preservation.*

Fig. 3



Evelyn Sherr

Other types of protists found feeding on diatoms included shelled amoebae and parasitic flagellates. ***A.*** *Two amoebae attached to one diatom cell.* ***B.*** *Single amoeba feeding on a diatom cell.* ***C.*** Fragillariopsis *diatom chain infested with parasitic flagellates.*