BEST-BSIERP Bering Sea PROJECT

UNDERSTANDING ECOSYSTEM PROCESSES IN THE BERING SEA 2007–2013

The Impact of Changes in Sea Ice Extent in the Eastern Bering Sea

MODELING A LARGE-SCALE ECOSYSTEM RESPONSE TO GLOBAL OCEAN WARMING

Phytoplankton form the base of the food chain in the sunlit ocean and support higher trophic levels, such as fisheries. Previous studies have linked changes in phytoplankton community to indices of natural climate variability (e.g., El Niño), but little is known about ecosystem responses to ocean warming. We used a combination of new field measurements and an ecosystem model to estimate changes in phytoplankton production and removal under actual cold and simulated warm years over the southeastern Bering Sea shelf.

Using ecosystem model simulations, we observed that phytoplankton production over the Bering Sea shelf in warm years was only slightly higher than during cold years. Associated with this increased phytoplankton productivity was a simulated increase in export of phytoplankton material to the ocean floor (Figure 1). Simulated phytoplankton carbon export in both warm and cold years showed strong seasonal patterns; a result validated by direct observation in the cold years of the Bering Sea Project. Phytoplankton carbon export was low in the marginal ice zone (MIZ),

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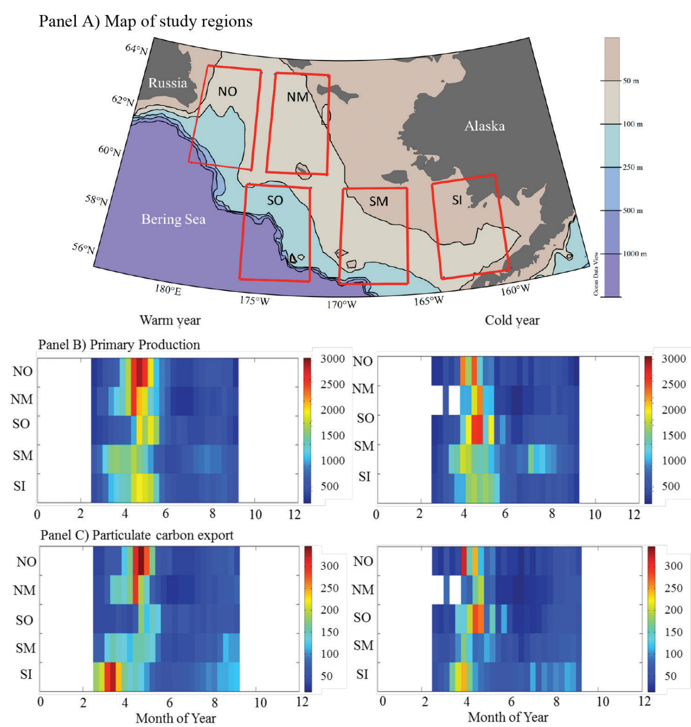
Fig. 1



Focus regions for our modeling simulations (panel A). Rates (mg C m-2 d-1) of phytoplankton primary production (panel B) and particulate carbon export flux (panel C) for warm (left plots) and cold (right plots) years in each study region and for each 8-day average time window.

The Big Picture

The Bering Sea supports one of the world's most productive ecosystems and sustains a large fraction of the total U.S. fisheries harvest. The Bering Sea is potentially susceptible to future climate change, but it is not known how, or to what extent, a warmer Bering Sea might alter the fate of phytoplankton production within the ecosystem and hence affect the yield of this important fishery. A key hypothesis of our Bering Sea Project is that climate change shifts the fate of organic matter from the pelagic to the benthic environment; and, further, that such external forcing on the ecosystem is highly dynamic, non-linear, and unpredictable.

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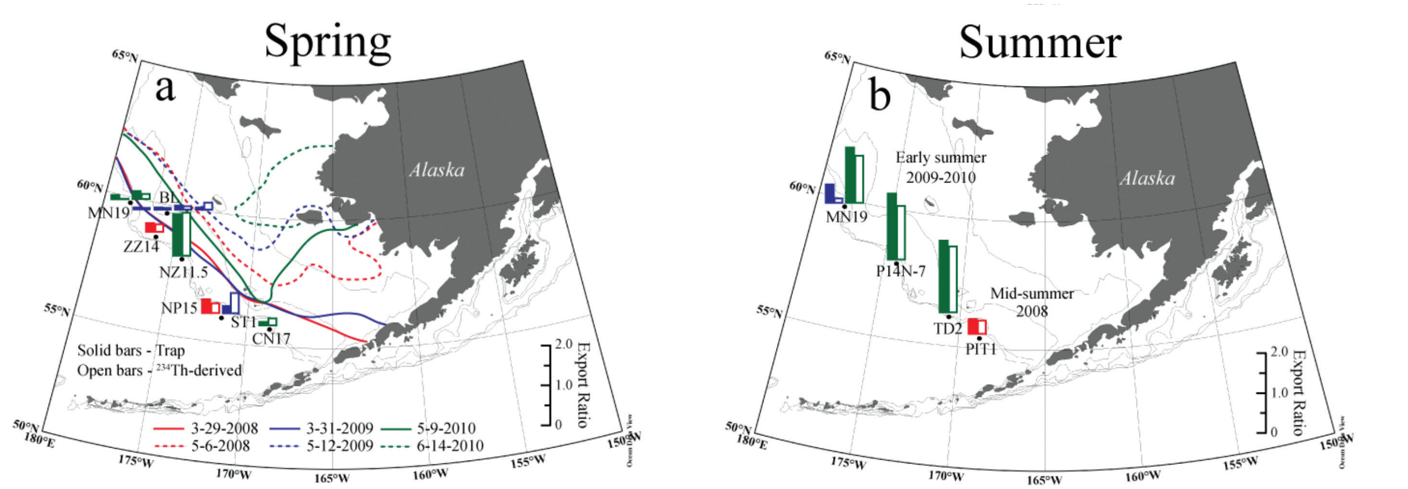
Fig. 2



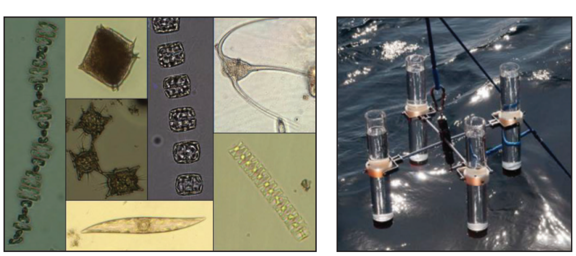
Spring (a) and summer (b) export ratios determined during 2008-2010. Solid and dashed lines represent ice-edge maximum and minimum during spring sampling periods. Solid bars indicate trap-derived and open bars represent Thorium-derived export ratios. Colors: red (2008), blue (2009), and green (2010).

unless the area was experiencing an active phytoplankton bloom, and increased through late spring and early summer. This phytoplankton carbon export to the benthos represented a significant fraction of primary production, i.e., the export ratio (Figure 2).

How We Did It

We conducted spatially extensive measurements of phytoplankton production, community structure, and associated particulate carbon export during spring and summer from 2008-2010. We supplemented this observational dataset with phytoplankton production model simulations derived from spatial distributions of remotely sensed phytoplankton biomass and knowledge of their physiology. Using sequential ocean color images and a mathematical model constraining the relationships between elements in the ecosystem model, we estimated the partitioning of organic carbon between higher trophic levels and the ocean floor (Figure 1). These ecosystem model simulations were validated for cold years by comparison to directly measured particulate carbon export derived from sediment traps (Figure 3). Other carbon fluxes are currently being compared to distributions of data collected by the Bering Sea Project to better understand the partitioning of carbon within the Bering Sea ecosystem so that the potential implications for the fishery may be assessed.

Fig. 3



Images of Eastern Bering Sea plankton, common diatoms and dinoflagellates, (left panel) and the sediment trap used to capture them as they sink from the surface ocean (right panel).

Why We Did It

The combination of field measurements and model analysis has led to an improved understanding of the regional and temporal (warm vs. cold periods) variability in the magnitude of phytoplankton production and its fate within the Bering Sea ecosystem. From this study, we are developing a more mechanistic understanding of how carbon and energy flow through the plankton community to commercially important species in a changing Bering Sea.

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