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

Organic Matter Mineralization in Bering Sea Sediments

WHAT THE SEAFLOOR TELLS US ABOUT CLIMATE-INDUCED CHANGES

The seafloor is the Bering Sea's recycling center. When food from surface waters hits the bottom, it is consumed by scavengers and bacteria that inhabit the seafloor. The biochemical processes (termed mineralization) that break down this organic carbon are much more complicated and more interesting than one might imagine. Microbial communities use a variety of biochemical processes to oxidize the food that hits the bottom. The oxidative pathways taken by the organic matter likely vary with the rate of food supply to the seafloor. Because much of the organic matter export to the Bering Sea floor occurs during seasonal sea ice melt, a warming climate would be expected to reduce the quantity of organic matter reaching the sediment, and this change could be observed by studying organic matter mineralization processes in Bering Sea sediments.

The most energy-efficient mechanism of organic matter mineralization is aerobic respiration. But, in the absence of dissolved oxygen, microbes use anaerobic respiration with different oxidants to break down organic carbon. The sequence of oxidants that we would expect to observe in Bering Sea sediments in order of decreasing efficiency is oxygen, nitrate, manganese oxide, iron oxide, and sulfate. This sequence produces vertical gradients in these chemicals within the sediment column. The various organic matter mineralization mechanisms follow different chemical reactions and produce different by-products.

We hypothesized that organic-carbon mineralization pathways would vary with food supply to the seafloor, and this would produce observable regional variation in the organic matter mineralization

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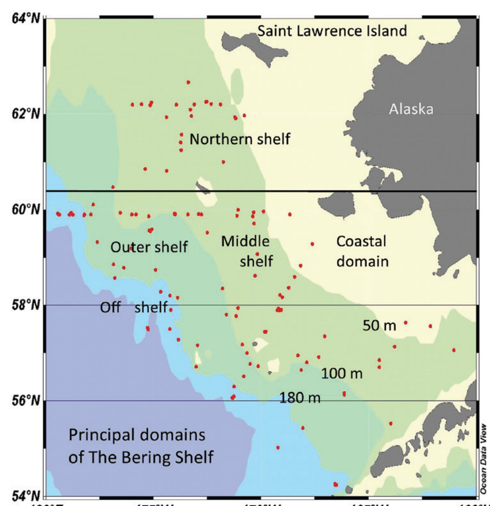
Fig. 1

Deploying a multi-corer.

Fig. 2



Red dots indicate locations of core samples taken from across the eastern Bering Sea over a four-year period.

The Big Picture

Organic matter production fuels the highly productive Bering Sea food web. The amount of organic matter exported to the seafloor varies spatially across the Bering Shelf, and may reflect longer-term changes in productivity related to the seasonal melting of sea ice and the development of nutrient limitation on the shelf. But, what happens to this material after it hits the bottom?

We quantified the fate of organic matter in Bering Sea sediments and discovered that the processes vary regionally, reflecting the export of organic matter from the water column. Because sedimentary processes tend to filter out short-term fluctuations, the variation in organic-matter mineralization in the sediments may be a useful indicator of climate-induced changes in ecosystem productivity that fuels the important Bering Sea fishery.

DENITRIFICATION AND GLOBAL CHANGE IN BERING SEA SHELF SEDIMENTS
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pathways. Specifically, we expected the proportion of organic matter mineralization due to aerobic respiration to increase from north to south on the Bering Shelf, and also increase from onshore to offshore. This pattern parallels independent estimates of organic matter export, which is largest in the northern shelf and drops to the south and offshore. We set out to test this hypothesis in order to better understand how organic matter is recycled in Bering Sea sediments and how it relates to the supply of food from overlying water.

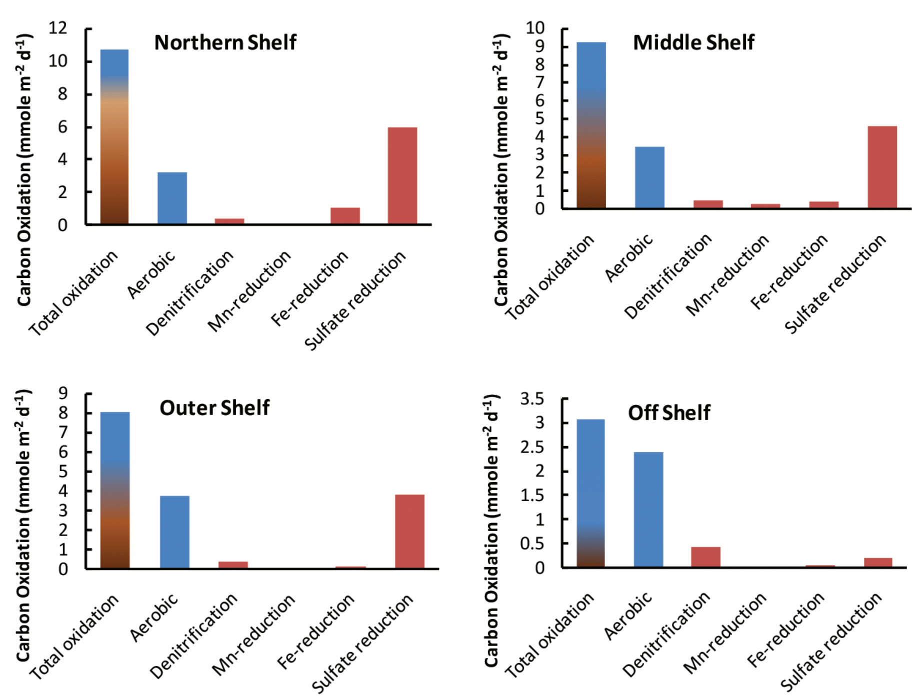
How We Did It

We deployed a hydraulically-damped "multi-corer" (Figure 1) which drops to the bottom, slowly plunges eight sampling tubes into the sediment, carefully withdraws and caps the tubes, and transports the intact section of seafloor back to the ship for analysis and experimentation. We collected sediment cores from approximately 125 locations on the Bering Shelf, slope and rise over four years (Figure 2). We incubated cores on the ship at near in situ temperatures and directly measured the rate of oxygen consumption and nitrogen gas production (to quantify denitrification) in the sediments. We measured the rate of sediment mixing (bioturbation) using the chemical tracer ^{234}Th and used that rate, along with profiles of manganese (Mn) and iron (Fe) oxides, to estimate the rates of Mn and Fe reduction. We also incubated sediment amended with radioactive sulfate to determine the rates of sulfate reduction. These measurements allowed us to determine how sedimentary organic matter was remineralized in different regions of the Bering Sea, and to test our hypothesis regarding its regional variation. Indeed, our results confirmed that food supplied from the overlying water takes different oxidative pathways in different regions of the Bering Sea in a manner that is consistent with its variation in supply from the water column (Figure 3).

Why We Did It

Sedimentary processes tend to reflect average conditions and filter out short-term fluctuations. Processes in overlying water are subject to considerable variation, even at small spatial and temporal scales. Thus, variation in sedimentary processes such as organic matter mineralization may indicate longer-term changes in conditions in the Bering Sea. Our results were consistent with our hypothesis that the proportion of organic matter mineralization due to aerobic respiration would increase from north to south on the Bering Shelf, and also increase from onshore to offshore. This pattern parallels independent estimates of organic matter export. As this ecosystem changes on decadal and longer time scales, these changes may be reflected in organic matter mineralization pathways revealed in the sediment.

Fig. 3



Moving from the Northern Bering Shelf toward the south (that is, toward the middle shelf at similar water depths), and from the middle shelf to deeper water, the relative importance of aerobic respiration increases and anaerobic respiration, especially sulfate reduction, decreases in importance.

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