Seasonal Changes of Nutrients on the Bering Sea Shelf: Primary Production and the Nitrogen Cycle

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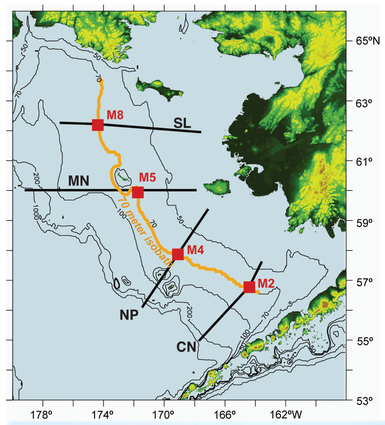
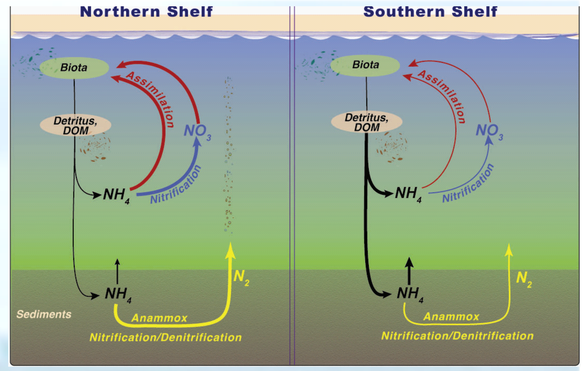


As part of the Bering Sea Ecosystem Study (BEST), alongshelf and cross-shelf transects were occupied multiple times in 2007, 2008 and 2009. The above map shows the location of repeat transects and mooring sites.

Season & Year	Ship, Cruise ID	Dates
Spring 2007	Healy 0701	Apr 10 - May 11
Summer 2007	Thompson TN211	Sep 24 - Oct 11
Spring 2008	Healy 0802	Mar 29 - May 6
Summer 2008	Healy 0803	Jul 3 - Jul 31
Late Summer 2008	Melville 0823	Aug 23 - Sep 11
Spring 2009	Healy 0902	Apr 3 - May 11
Summer 2009	Knorr 195-10	Jun 14 - Jul 15

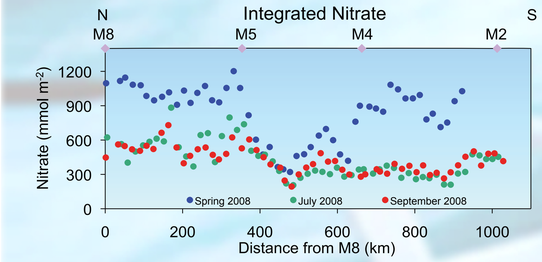
Results

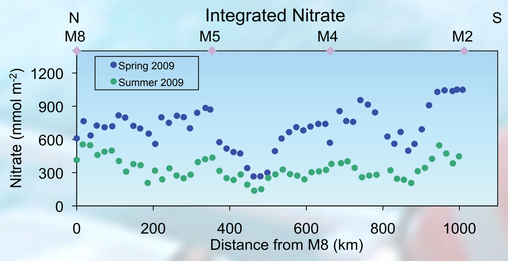
- Post-bloom conditions occurred over a large portion of the middle shelf in early spring:
  - Advection of post-bloom water from the inner shelf?
  - Early bloom associated with ice-melt event?
- Northern shelf dominated by processes that preclude the build-up of ammonium:
  - Production of phytoplankton /upper trophic levels
  - Denitrification and anammox
- Southern shelf dominated by ammonification
- Largest nitrogen deficit (denitrified water) was observed in spring

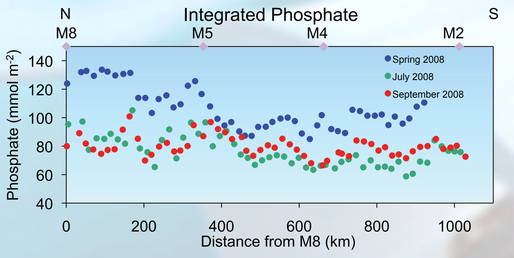


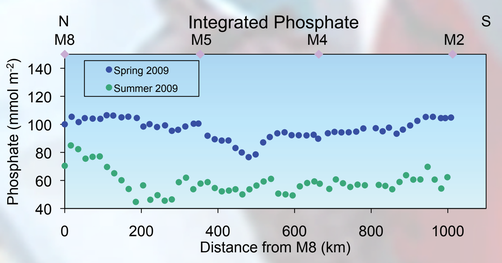
Estimates of New Primary Production in Spring

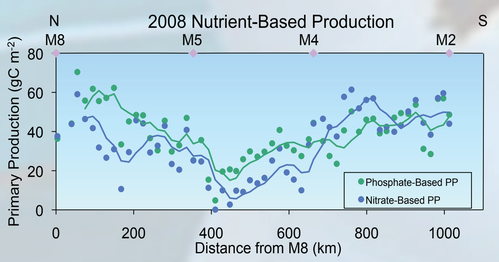
Estimates of primary production were made by (1) vertically integrating nitrate and phosphate at repeat hydrographic stations along the 70-m isobath in spring and summer, and (2) converting the seasonal drawdown of nutrients into carbon using a Redfield ratio of 1P-16N-106C. These estimates are valid for regions with low rates of advection. Pre-bloom conditions at the southernmost stations were established from bottom water concentrations

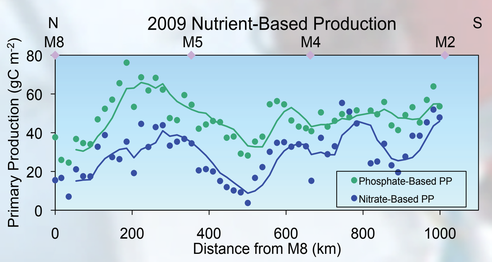






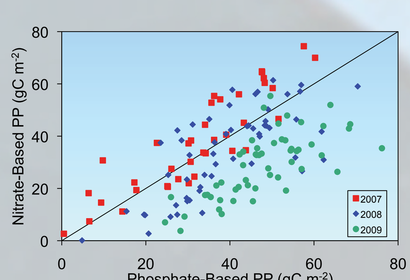






- Anomalous conditions were observed in the center of the transect (between M4 and M5) including:
  - Very low nutrient content in spring
  - Low seasonality of nutrients which suggests relatively low primary production
- In the north, nutrient concentrations in spring and estimates of primary production were higher in 2008 than in 2009.

Comparison of nutrient-based primary production estimates

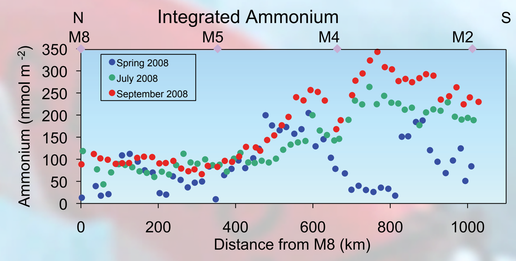


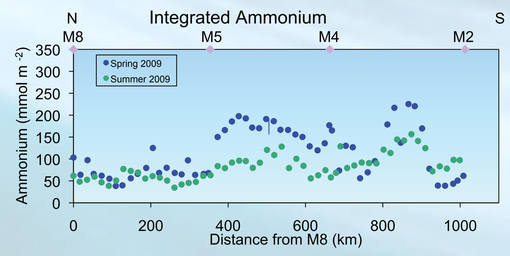
- Similar range of production for both nutrients
- Similar in range to historical measurements on the middle shelf
- Higher rates of phosphate-based production likely resulted from ammonium rather than nitrate being used as a primary nitrogen source, i.e. post-bloom production

Variability in the Marine Nitrogen Cycle

Subsequent to the seasonal drawdown of nitrate by phytoplankton, fixed nitrogen is distributed among phytoplankton, higher trophic levels, and pools of detrital and dissolved organic matter. Portions of these nitrogen pools may be converted into ammonium (ammonification), and thereafter into nitrate (nitrification) or lost as nitrogen gas (denitrification / anammox). In the Bering Sea, denitrification and anammox are restricted to the sediments; however, these processes impact the water column as remineralized nutrients with anomalous ratios diffuse out of the sediments. To gain a better understanding of the relative importance of these pathways, we examined the seasonal accumulation of ammonium (vertically integrated ammonium at each station on the 70-m isobath), and the extent to which nitrogen was "missing" from the water column.

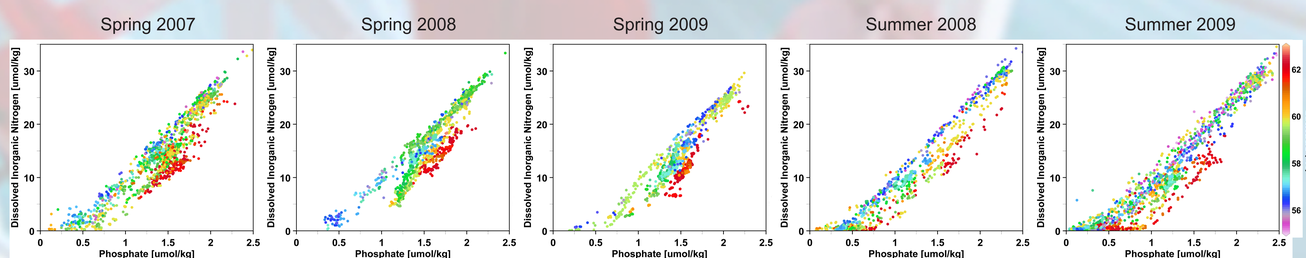
Seasonal Accumulation of Ammonium

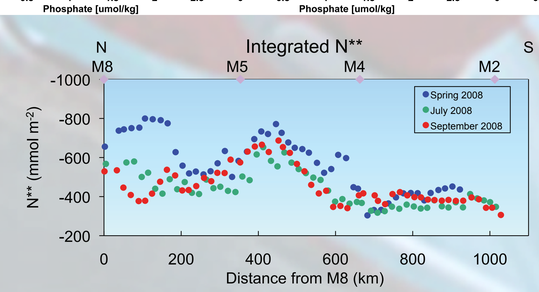


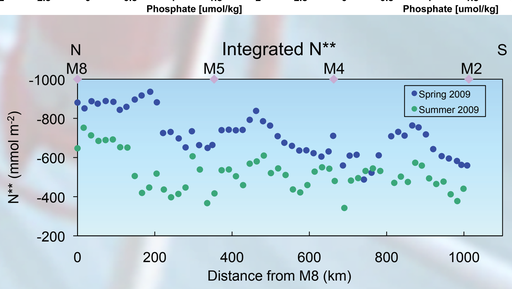


- In these years, highest ammonium was observed in the south
- In spring, high ammonium was observed in the center of the transect and at 850 km – post bloom conditions
- In the north, low seasonality and low interannual variability of ammonium

Examining Variability of Denitrification / Anammox Using Nutrient Relationships







- N** was lowest in the south in all years, and all seasons
- Greatest seasonal variability of N** observed in the north
- The seasonal trend everywhere was opposite of what we expected; it was higher in the spring!
- Was the shelf flushed with denitrified water in winter?

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