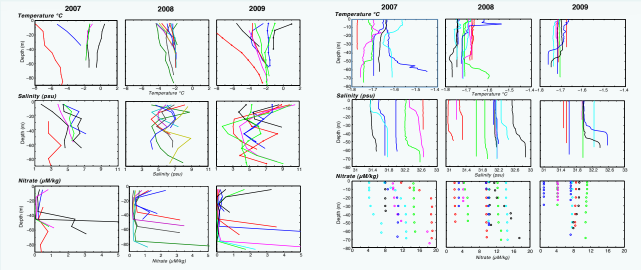
Spring Ice and Salt Flux in the Eastern Bering Sea Marginal Ice Zone

Margaret E. Sullivan[1], Sigrid A. Salo[2], Phyllis J. Stabeno[2], Calvin W. Mordy[1]
[1]JISAO, University of Washington, Seattle, WA, USA. [2]Pacific Marine Environmental Laboratory, NOAA, Seattle, WA, USA.
peggy.sullivan@noaa.gov

In the Marginal Ice Zone of the Eastern Bering Sea, sea ice can reach as far south as the shelf break. Annual ice extent varies. In late autumn and winter, persistent northerly winds mix and cool the water column to 1-2°C. Ice forms, mainly in the north, and is advected south, further cooling the water column to -1.7 to -1.8°C. Spring brings weaker, more southerly winds, more daylight, and ice melt, which sets up a two-layered water column while jump-starting the ecosystem production cycle. The sea ice is usually completely melted by June.

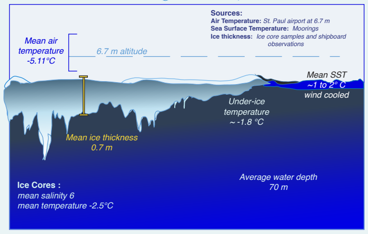
Ice Environment & Data

Ice Core Data — CTD Profiles Near Cores



Comparison of temperature, salinity and nitrate (NO_3) values from ice cores (left) and nearby CTD casts (right). Core temperatures are at the freezing point at the surface. CTD temperatures and salinities show well-mixed column. Ice-core NO_3 values are extremely low, with higher values at air and water interfaces. CTD nitrate values are low, but uniform through the water column.

Eastern Bering Sea Shelf, *variables*

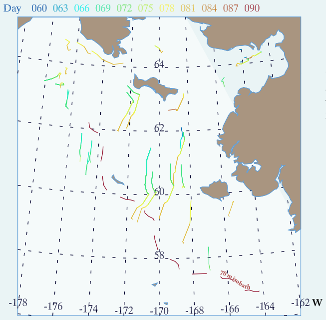


Data were collected in spring, 2007-2009 between April 2 and May 7 at 26 stations.

- Ice thickness range: 23 to ~329cm (mean 70 cm)
- Ice salinity range: 2.5 to 10.5 (mean 6)
- Ice temperature range: -9.5 to 1.0°C (mean -2.5°C)
- Ice NO_3 range: 0 - 13.23 μM (mean 0.88 μM)

Satellites, Ice Motion, Ice Concentration

Days 60- 90(March 1-31,2007)
Day 060 063 066 069 072 075 078 081 084 087 090

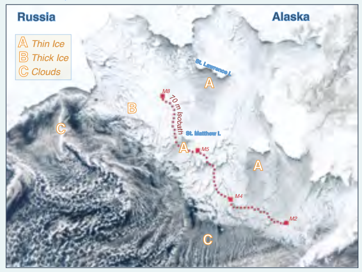


Ice Motion: We tracked individual ice floes in sequential Modis True-Color images until they disappeared at the ice edge or were deformed beyond recognition.

- A corridor of floes occupies the eastern Bering Sea shelf. Many floes in this corridor moved south >100 km in 2 weeks.
- Recently-formed ice is hard to track, since it doesn't have an easily recognizable shape, or deforms quickly. Therefore, we do not have long-lasting tracks from the St. Lawrence polynya for comparison.

March 9, 2007

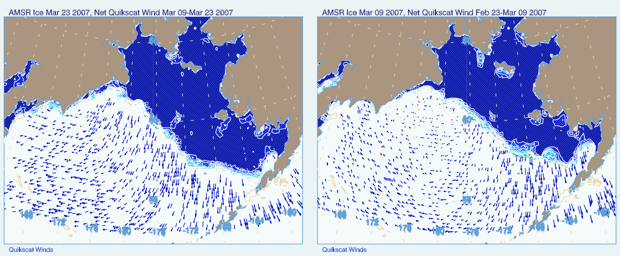
March 22, 2007



Sea ice covers much of the Bering Sea shelf in winter.

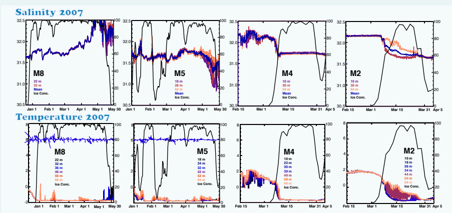
- Most ice forms in the northern Bering Sea and is advected south by northerly winds. Polynyas – regions of thin ice or open water on the downwind side of islands, where ice is pushed away from the coast as it forms – are important sources of ice.
- The location of islands and polynyas affects the amount and type of ice which reaches the ice edge. In these Modis True-Color images, thicker ice in larger floes is seen east of St. Lawrence Island and west of Nunivak Island.

Winds



In March 2007, vector-mean winds in the eastern Bering Sea were more strongly northerly, and ice advection was greater than farther west. The shelf break crosses the Bering Sea from southeast to northwest. This limits the extension of western ice, since it encounters deep water farther north. In the east, the shelf break – and therefore the ice edge limit – is farther south, in closer contact with water entering through the Aleutian Passes from the Pacific Ocean.

Ice Concentration vs Salinity and Temperature



These figures present the change in salinity and temperature at the four long-term Bering Sea moorings while the moorings were covered by ice.

- The salinity at M8 increased throughout the winter, which indicates that ice was formed at or near the site. The salinity change would suggest that about 2m of ice was formed in the vicinity. The daily-mean currents were consistently from the north during the greatest increases, suggesting advection of saline water from the St. Lawrence polynya.
- The water column at M5 was already near 0°C when the ice arrived, and the salinity change implies that about 0.5 m of ice (with a salinity of 6) was melted. Later (May) about 1.5 m of ice was melted – but not by water, which was at the freezing point.
- When the ice arrived at the two southern moorings, surface temperature and salinity decreased as heat was extracted from the water column to melt ice. The water column then rapidly mixed at M4, but took several weeks at M2.
- If the ice salinity was 6 (mean observed in ice-cores), then the salinity change at the moorings suggests that 1.2 to 1.5 m of ice was melted. Changes in water temperature are consistent with the volumes of ice melt calculated from salinity.

Acknowledgements: Modis satellite data were downloaded from NASA's Ocean Color website oceancolor.gsfc.nasa.gov and processed with their SeaDAS programs. We obtained the AMSR ice data files from the National Snow and Ice Data Center, and the Quikscat wind data files from the Jet Propulsion Laboratory DAAC: podaac.jpl.nasa.gov. This research is supported by grants from NSF and NPRB. We thank the crew and officers of USCGC Healy.