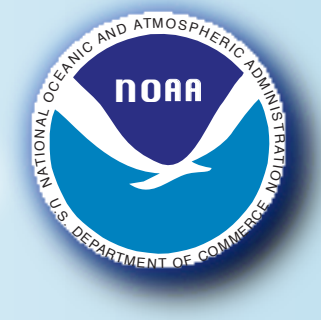




History of an Ecosystem Spring Setup as Seen in Annual Ice Cover

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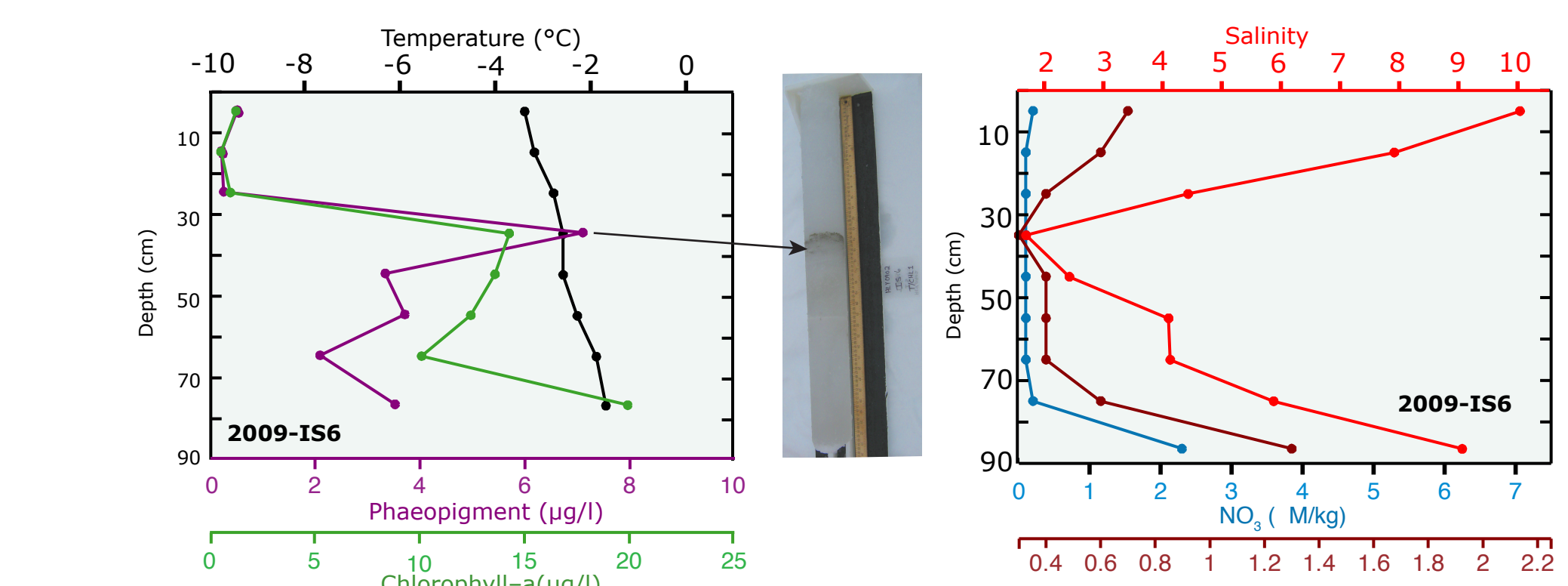
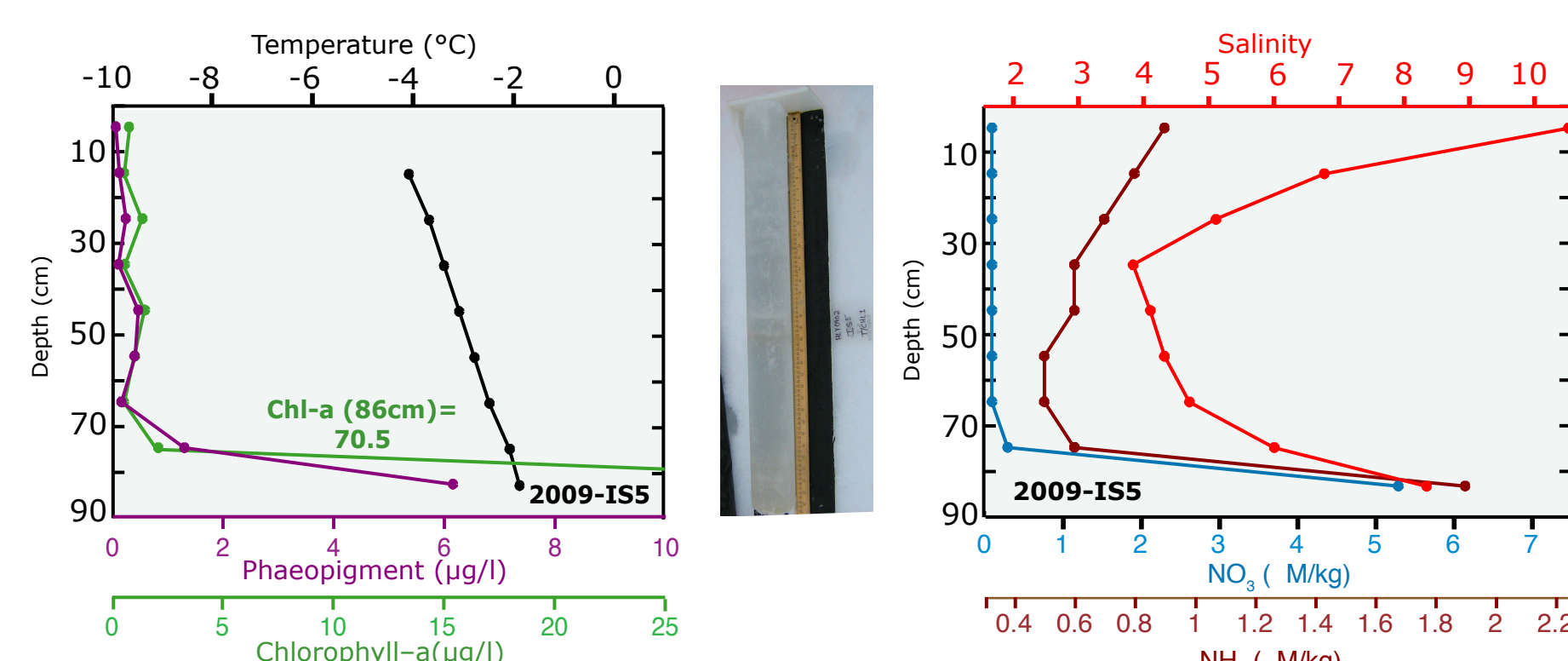
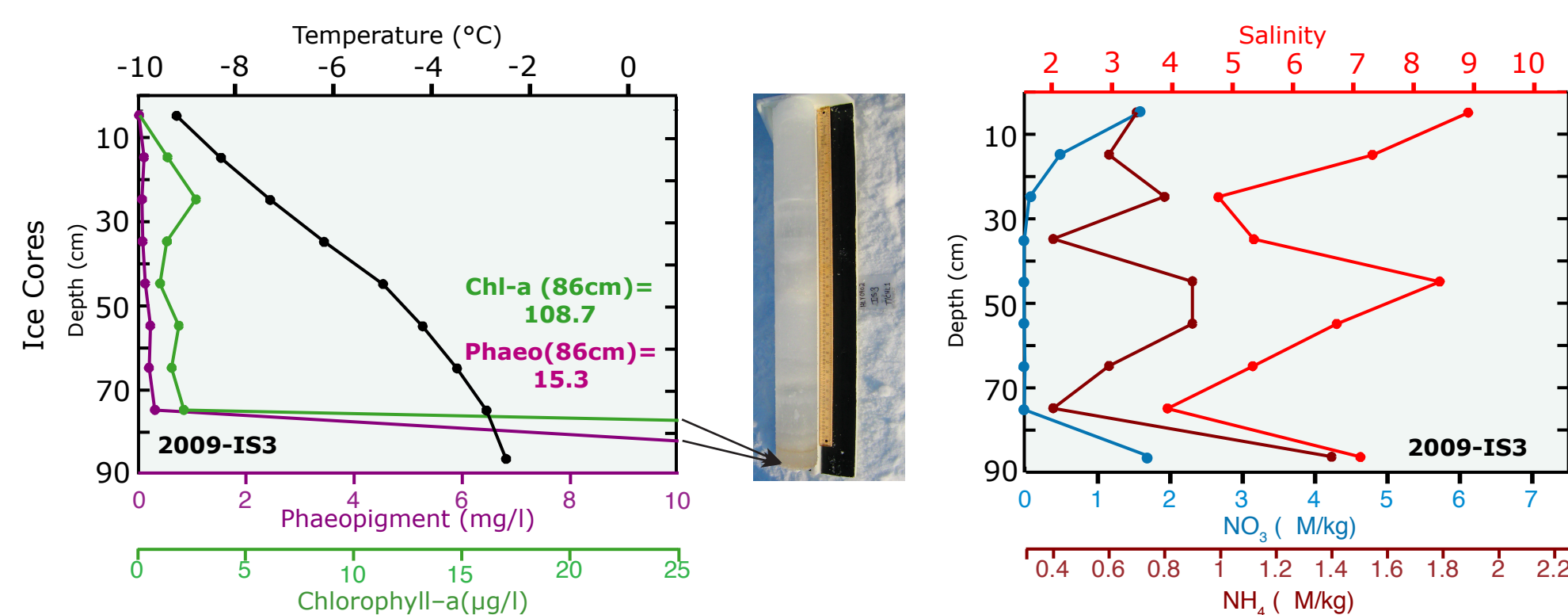
Introduction

Seasonal sea ice is a defining characteristic of the eastern Bering Sea shelf and plays a critical role in determining the timing of the spring phytoplankton bloom and temperature and salinity structure over this shallow, productive shelf. During four spring seasons, 2006-2009, sea-ice data were collected on the southeastern Bering Sea shelf. At thirty well-distributed sites in the seasonal ice, temperature, salinity, chlorophyll-a, nutrients and oxygen were measured in ice cores and brine wells. We show vertical structure of physical, chemical and biological data. We have integrated these data with weather, mooring and satellite ice data to examine set-up of the spring ecosystem, and illustrate ice thickness observations and brine well data.

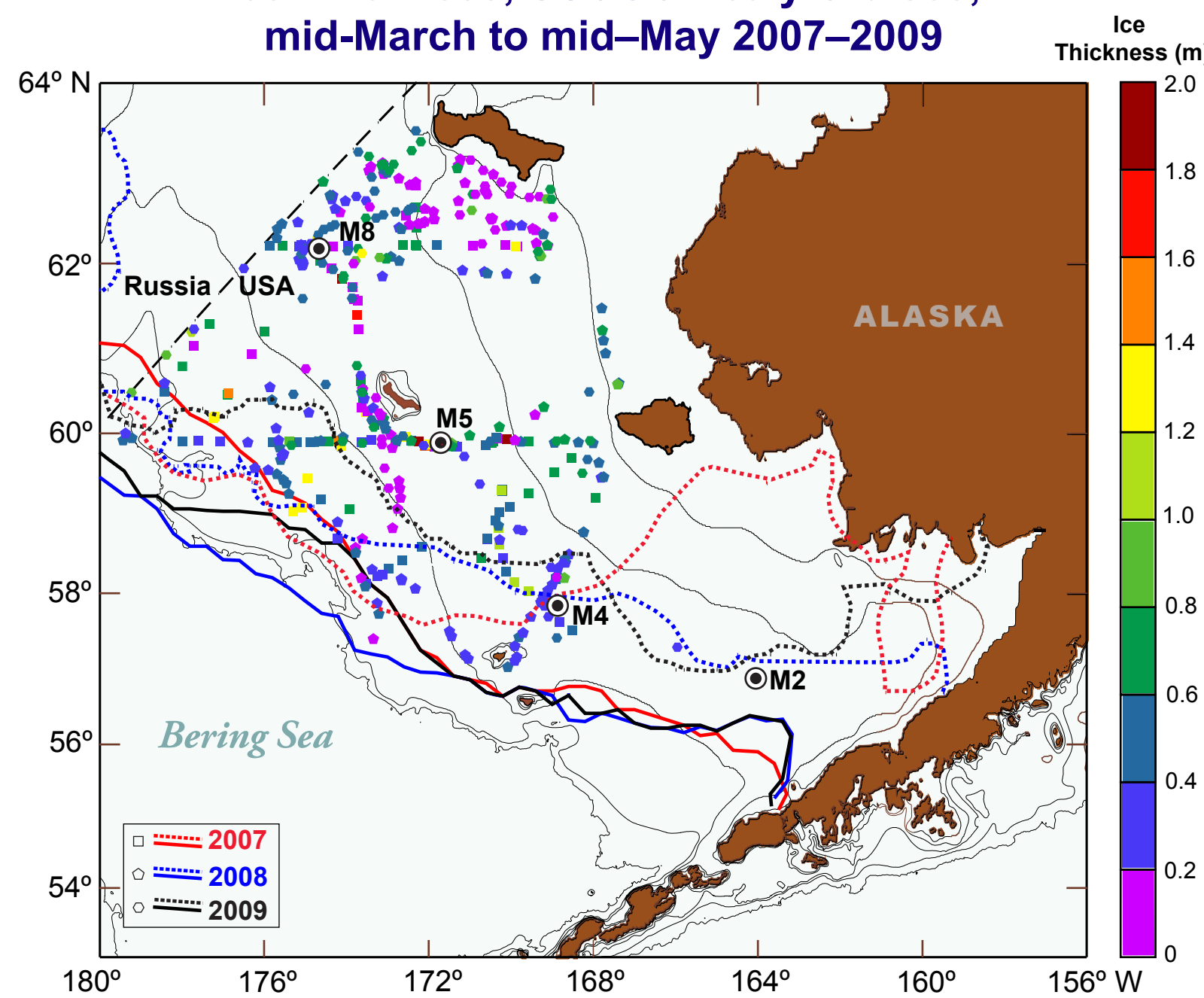
Variability in the various parameters is dependent upon the ice thickness, air and ocean temperatures, depth of snow cover, and state of the ice (e.g., melting, freezing). Few measurements have been made on the seasonal ice field in the Bering Sea since the 1970s and 1980s. With the predicted earlier retreat of sea ice due to climate change, a better understanding of how sea ice impacts the ecosystem is important for improving ecosystem models.

Ice core data profiles compared to photos, 3 ice stations.

Cores at three ice stations. Typically temperature increases with depth, chlorophyll is a maximum at the bottom, and salinity has a mid-depth minimum. Exceptions however are frequent and reflect the history of ice formation, usually indicating rafting of ice. Note the picture of the ice core (with banding) between profile pairs. Nitrate is often depleted at the top of core, while ammonium has a more complex structure.

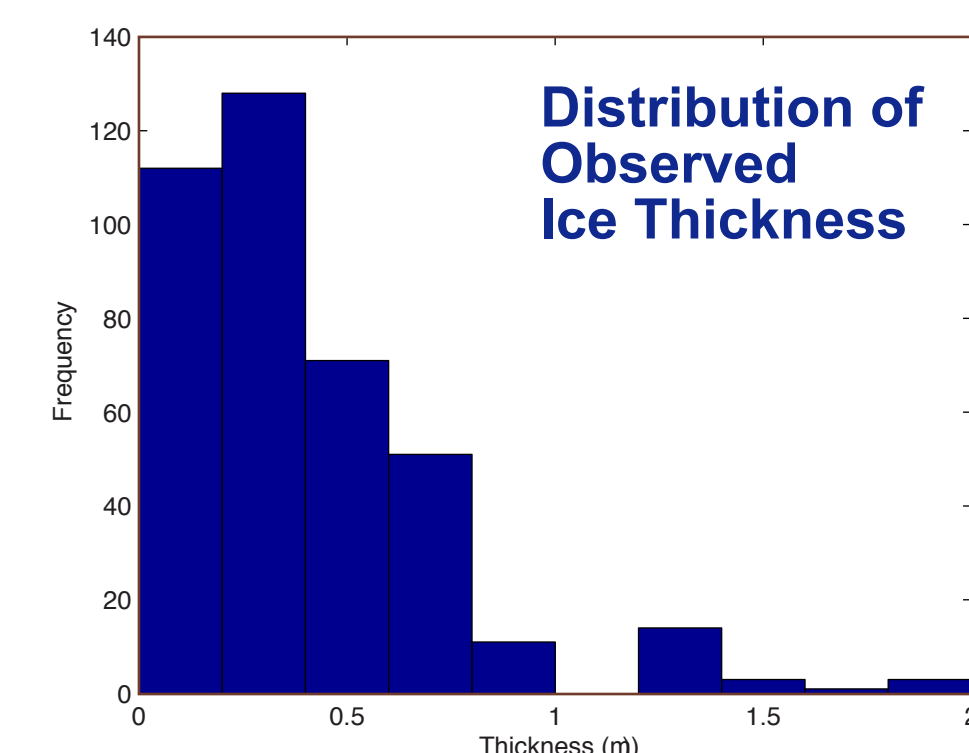


Ice Thickness, USCGC Healy Cruises, mid-March to mid-May 2007-2009



Ice thickness observations, mooring locations, and ice edges. Solid lines represent the maximum extent. Dashed lines show ice edge on May 1 of each year.

- Ice Thickness Observations: polynyas, thickness variability
- Ice Edges: variability in maximum extent of ice edge from year to year variation in extent of ice retreat from maximum to May 1

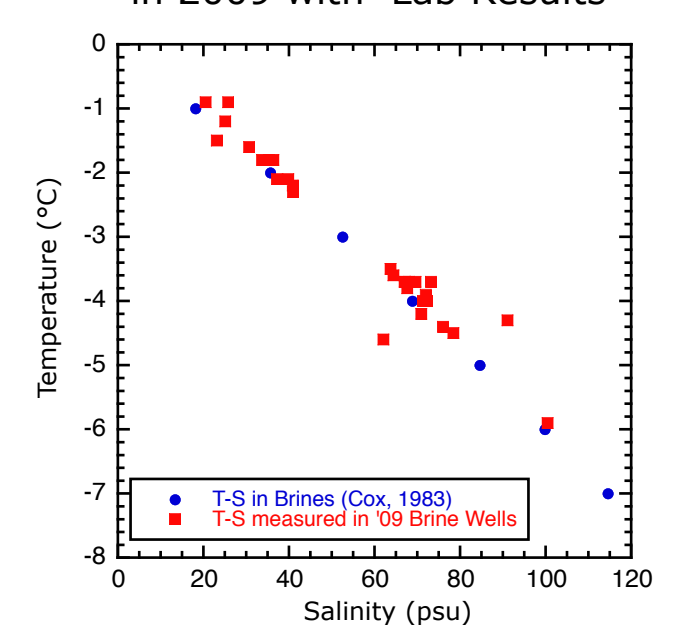


Salt Flux

Sea ice forms in polynyas and is advected southward where it melts, cooling and freshening the water column. If we consider two cold years, 2008 and 2009, and use an ice salinity of 5 psu the advancing ice will freshen the water column south of 60°N (excluding the polynyas) by 0.5 psu. This magnitude of change is seen in the salinity time series in the region (M5).

Brine

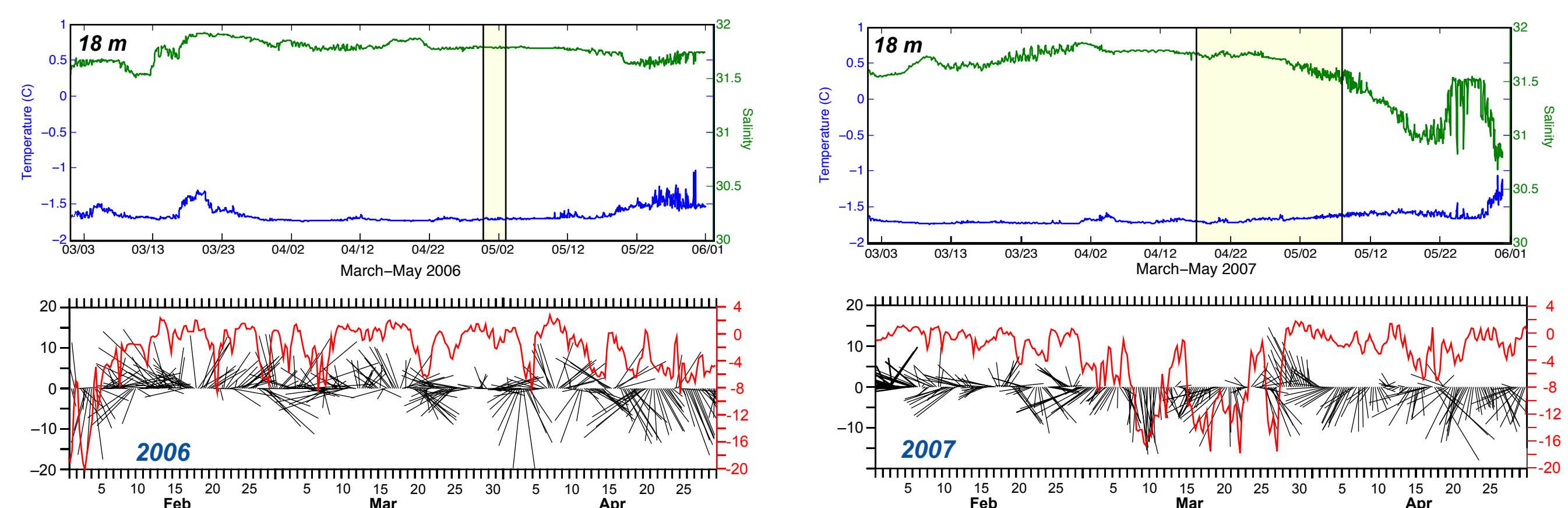
T-S Comparison of Brine Well in 2009 with Lab Results



To verify our methods and results, we have plotted temperature vs. salinity from our brine well sampling (red) compared to laboratory values (blue) (Cox, 1983*).

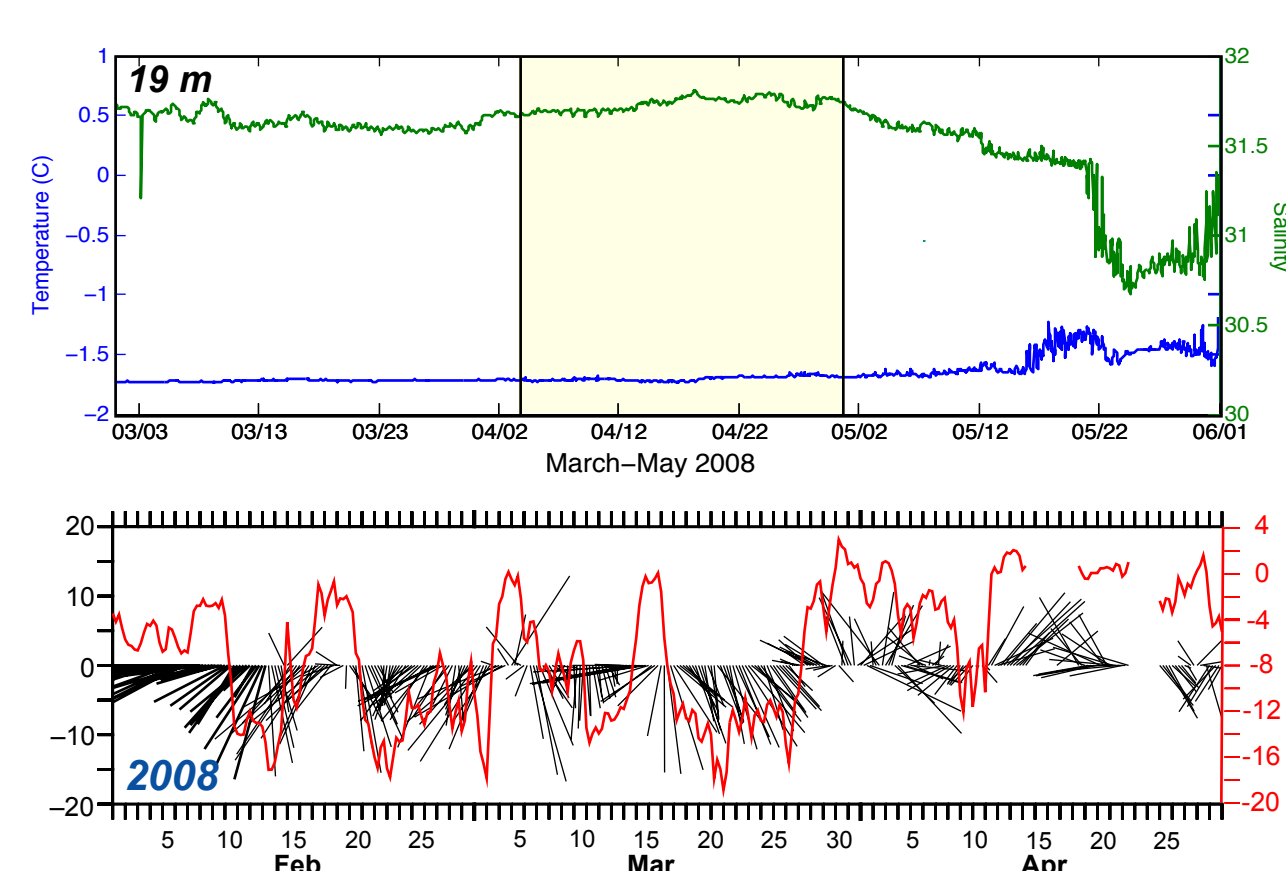
Spring Weather (St. Paul Island) and Water Column Patterns at Mooring 5

Ocean temperature and salinity are impacted by atmospheric forcing and sea ice. Warm ocean temperature during the prior late summer can influence the advance of sea ice. By mid April the ice is usually melting or retreating. Yellow bands encompass the time window of ice station work.

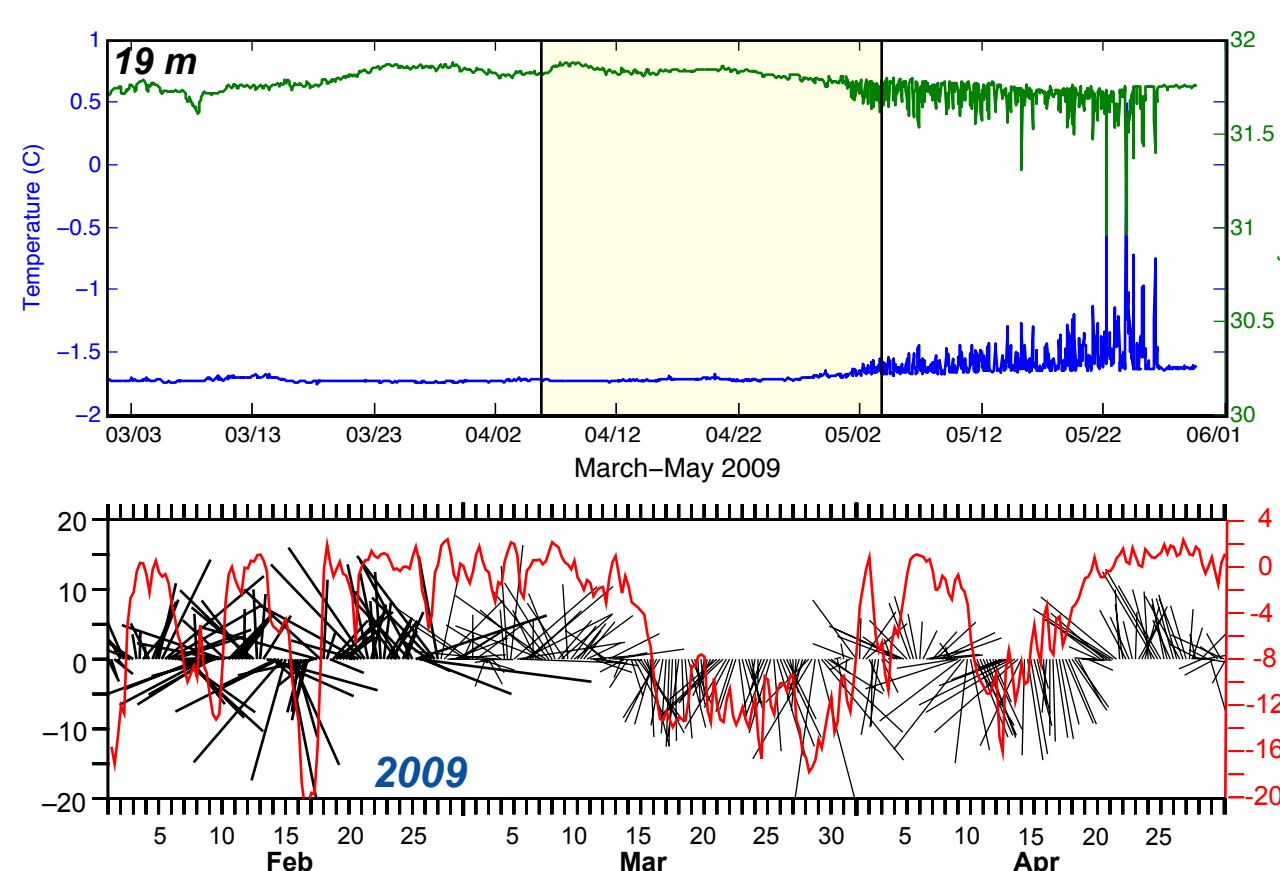


Prior year setup: September 2005 was very warm (~depth integrated temperature on the southern shelf ~8°C). Even with strong winds out of the north, air temperature remained above freezing. -Limited ice resulted in little freshening of the water column. -Mixed layer depth at ~20 m shows fluctuation between the upper and lower layers in temperature and salinity time series.

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-Prior year setup: September 2007 was average to cold (~4.5°C) -From Feb to March strong winds out of the north brought ice, resulting in very cold air temperatures -Ice melt began late April and an intrusion of warmer, fresher water occurred on May 18. -Intrusion of more saline water in late May.



Prior year setup: September 2008 was very cold (<4°C). These cold ocean temperatures permit the easy advection of ice into the region. -Northerly winds began in mid March bringing ice to area. -The range in temperature and salinity in May is a result of the instrument being at the thermocline, so it measures T and S in the upper and lower layer.

Ice station group, USCGC Healy in background. Photo by K. Mier

Ice core sliding onto sampling and cutting platform. Photo by M. Cameron

Melting ice. Photo by P. Sullivan

Launching a CTD. Each ice station has an associated CTD cast and all cruises covered similar CTD transects. Photo by J. Napp

Algae growth under ice. photo by Miller Freeman diver S. Cimilluca

Bering Sea ice edge, MODIS Terra satellite image, 1/16/2010, from NASA Earth Observatory.

Ice Coring. Photo by J. Napp