A Monitoring Mooring in the Western Arctic Boundary Current

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Background

It is commonly believed that the response to climate change will be experienced first, and be most-pronounced, at high latitudes. Indeed, there is compelling evidence of such change happening in the Arctic domain—from vanishing sea ice, to thawing permafrost, to increasing numbers of Arctic storms. Because the Arctic Ocean is the "head waters" of the meridional overturning circulation, climate-driven changes in this high-latitude ocean will likely have global impacts. Hence, it is essential for us as a community to establish a monitoring system in the Arctic, not only to detect climate variability, but ultimately to understand the mechanisms and causes behind it.

One of the unique and most important aspects of the Arctic Ocean is the presence of the "cold halocline". This feature is characterized by a sharp interface (gradient) in salinity, near 150m depth, that separates the near-surface cold layer from the warmer sub-surface Atlantic-origin waters. Among other things, the halocline acts as a shield that isolates the Atlantic layer from the surface sea-ice. Since there is more than enough heat stored at depth to melt the polar ice cap, the disappearance, or even weakening of the halocline due to climate change could have far-reaching consequences. At present, we do not fully understand why the halocline exists in the Arctic Ocean. The most popular belief is that it is maintained by lateral processes. The idea is that during winter the near-surface water on the shelves is made more dense by the cold air temperatures, and then spreads outward at the depth of the halocline. However, the precise mechanisms by which this spreading occurs are not understood. Hence, in order for us to determine how the cold halocline is ventilated, and how this process might vary during an altered climate, we must determine the basic physical mechanisms by which the lateral transfer of water occurs across the edge of the shelf. This means that we need to make observations in the shelf-edge boundary current of the Arctic Ocean.

In the western Arctic, Pacific-origin water is known to ventilate the interior halocline. However, we know very little about the characteristics and behavior of the boundary current that transports Pacific water in this region. Therefore, an important place to monitor the Arctic—and also determine how the ventilation of the halocline might be influenced by climate change—is the western Arctic boundary current. With funds from the Comer Foundation we now have in place a unique "monitoring mooring" north of Alaska, in the center of this boundary current.

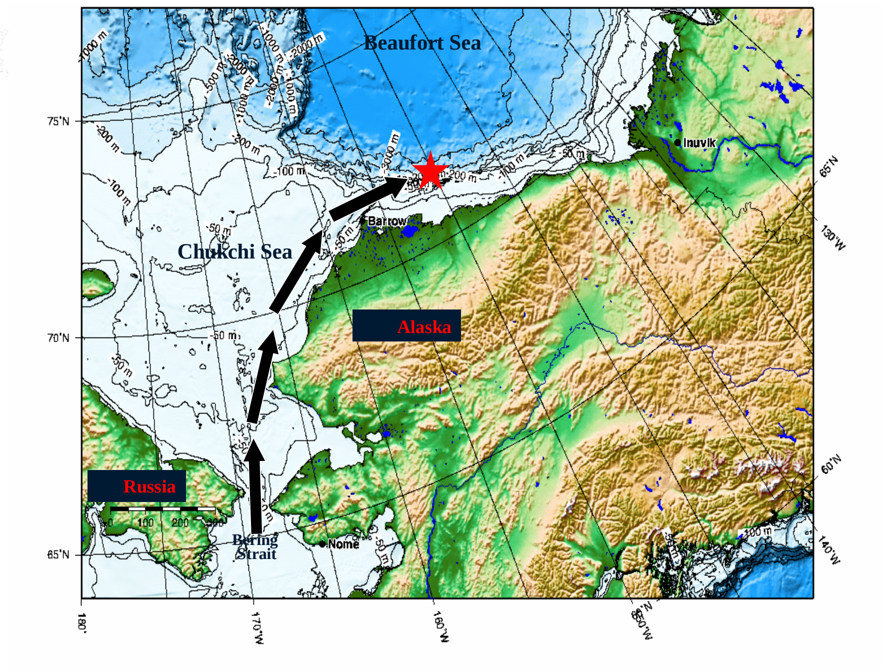

Figure 1: Study domain in the Western Arctic Ocean. Pacific water (denoted by the black arrows) enters through Bering Strait and flows to the shelfbreak of the Beaufort Sea where it forms a boundary current. The location of the monitoring mooring is denoted by the red star.

Monitoring Mooring

Motivation and Objectives

Based on results from recent measurements in the Chukchi and Beaufort Seas of the western Arctic (Figure 1), we now know that the Pacific water entering through Bering Strait forms an eastward-flowing boundary current when it reaches the shelfbreak. Since the current is so narrow there (Figure 2) it is possible to monitor this flow with a single mooring. In July 2005, using funds from the Comer Foundation, a mooring was deployed in the core of the boundary current. The main objectives of this study are (1) to measure the strength of the current and characterize its transport fluctuations in terms of the large-scale mass budget of the western Arctic (for instance compared to what enters the Arctic through Bering Strait); (2) to identify internal mechanisms by which Pacific water escapes from the current (for instance via the formation of eddies); and (3) to determine the response of the boundary current to wind events (for instance the upwelling of Atlantic water due to Arctic storms). The overall goal is understand how the dynamics of the boundary current dictate the flux of Pacific water into the interior halocline, and how this might change in an altered climate. To address this we need measurements over many years. It is hoped that the results from this study will help jump-start a long-term monitoring effort sponsored by the National Science Foundation. We will pursue this possibility in the International Polar Year (2007).

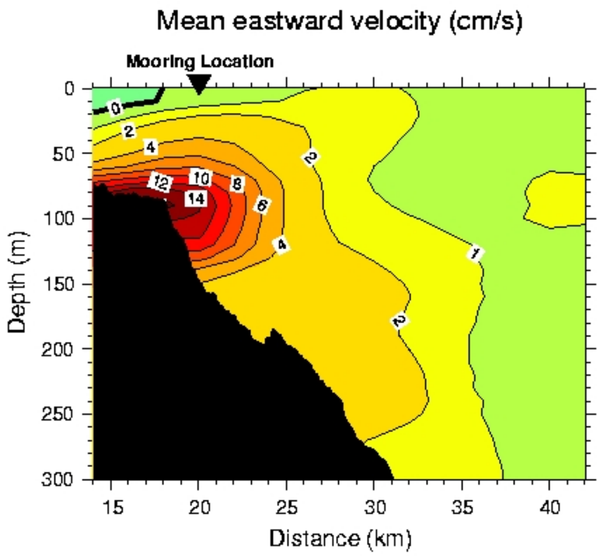

Figure 2: Cross-section of the western Arctic Boundary Current at the site of the monitoring mooring (see Figure 1), averaged over one year from recent measurements. The location of the mooring in the cross-stream plane is indicated by the inverted triangle.

Mooring Design and Deployment

The mooring that was deployed in July has a unique design that makes use of new technology developed at WHOI. Traditionally, sub-surface moorings in the Arctic (i.e. moorings anchored to the bottom) can only extend to approximately 40m beneath the surface; otherwise they stand the chance of getting knocked down and destroyed by ridging of the ice. To overcome this problem, the upper part of the water column is sampled by a profiling device called the "Arctic Winch" (Figure 3). This is a sensor suite that is mounted in a buoyant sphere and attached, via a small winch, to the subsurface part of the mooring with a nylon line. Once a day the buoyant sphere is released and travels either to the sea surface (when there is no ice) or to the underside of the pack ice. When the winch detects that the sphere has stopped moving it immediately pulls the sphere back down. Deeper than 40m the subsurface mooring uses a separate, more conventional profiling device that measures down to the sea floor. This way, the entire water column is sampled at high vertical resolution. This will be the first time that such bottom to top coverage will be attained by a mooring in the Arctic Ocean.

The deployment of the mooring from the Canadian Icebreaker *Louis St-Laurent* turned out to be very challenging. The pack ice in the Beaufort Sea last July was full of tall ridges and contained lots of "rotten" ice. WHOI's technician in charge of the deployment said it was some of the worst conditions he's encountered for such work in his 28 years of experience. Thanks in part to the "bubblers" on the *St-Laurent*—which squirted subsurface jets of air to keep the ice open—the mooring was deployed successfully (Figure 3). It is due to be recovered in the summer of 2006, at which point the data will be used to address some of the scientific issues described above.

Figure 3: The top section of the monitoring mooring enters the water upon deployment. The frothing water is due to the ship's underwater bubblers that keep the area free of ice. The photograph was taken moments before the heavy rope (in green, attached to the ship's crane) released the large yellow top float of the mooring. Once deployed, the top float resides at 40m depth, with the "Arctic Winch" (on the left-hand side) attached to it. The sensor suite of the Arctic Winch is contained inside the small yellow sphere, adjacent to the spool of nylon line (see text for details). The photograph was taken by C.A. Linder, who was the photo-journalist during the cruise (see www.whoi.edu/beaufortgyre for further information).