USCGC *Healy* Arctic West Summer 2004 Cruise Summary: The Shelf-Basin Interactions mooring component

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The field phase of the Western Arctic Shelf-Basin Interactions Experiment (SBI) concluded in 2004 with a set of three cruises to the Chukchi and Beaufort Seas. SBI is a multi-institutional program investigating how the western Arctic shelves communicate with the interior of the Canada Basin, from a coupled physical-biochemical perspective. The primary aim of the physical oceanographic component is to identify and understand the water masses and mechanisms by which shelf waters ventilate the western Arctic halocline. The first two cruises in 2004—carried out in the spring and summer seasons—were the SBI Process cruises, consisting primarily of chemical and biological measurements. The third cruise was associated with the mooring component of SBI, and took place in late summer / early fall. This report presents a short summary of the 2004 mooring cruise, referred to as HLY04-04.

The primary goal of HLY04-04 was to recover the three SBI mooring arrays maintained by the University of Washington (UW), the University of Alaska–Fairbanks (UAF), and the Woods Hole Oceanographic Institution (WHOI). The first two arrays were designed to monitor the main outflow branches from the Chukchi shelf, and the third array was positioned to determine how these waters are fluxed into the interior Canada Basin. In addition to the mooring recoveries, the second goal of HLY04-04 was to occupy a set of hydrographic sections in the SBI study area, some of the sections being repeat occupations over the three year program. The final goal of the cruise was to locate and sample an eddy feature along the continental slope, since these features are thought to represent an important pathway by which shelf water is transferred into the interior basin.

For the hydrographic program on HLY04-04 we used a Seabird 911+ system along with a transmissometer, fluorometer, and oxygen sensor. Hydrostations included water sample measurements of salinity, dissolved oxygen, nutrients, and chlorophyll. Video Plankton Recorder casts were also carried out at select locations. In addition to these tasks, several new components were included in the hydrographic program this year. Dissolved Organic Carbon measurements were taken at numerous locations, multi-net casts were carried out (usually in conjunction with the video plankton recorder casts), and radium measurements were done at select locations. Finally, the vessel-mounted ADCP was used continuously throughout the cruise to measure currents in the upper 500 m.

Brief Synopsis

Healy departed Dutch Harbor, AK on 2 September and steamed to the WHOI array site in the southern Beaufort Sea. All 8 moorings were successfully recovered, in addition to two Acoustic Recording Packages (ARPs) that had been deployed the year before by the Pacific Marine Environmental Laboratory and the Scripps Institution of Oceanography. In addition to the mooring recoveries, a high-resolution hydrographic transect was carried out across the continental slope which included all of the biological and chemical quantities (Figure 1). Following this we steamed to Barrow Canyon and recovered the UAF mooring located at the head of the canyon, and then occupied two hydrographic lines. Next we headed to the western part of the study domain and recovered the two UW moorings located along 166°W, followed by a hydrographic transect. At this point we steamed north in order to turnaround a NOAA ice-monitoring mooring, after which we occupied a short section across the continental slope. This section represented the northern-most set of measurements in the SBI program, and provided an opportunity to sample the deep basin.

As we steamed south back towards the Chukchi shelf it was decided that this would be our best opportunity to try and find an eddy feature. During the previous SBI cruises numerous such features had been sampled, but the measurements were serendipitous and offered only partial views of these seemingly ubiquitous western Arctic eddies. Our plan was to locate an eddy and carry out a detailed three dimensional survey of the feature. Towards this end we first occupied a set of 5 expendable bathythermograph (XBT) sections across the shelfbreak and slope to look for evidence of eddy activity (Figure 1). At the conclusion of the survey only one of the sections looked promising (the western-most one), so we steamed to that area and dropped some additional XBTs in order to hone in on the feature. Once the location and scale of the eddy were roughly defined, we carried out a rapid high-resolution survey consisting of a mix of CTDS and XCTDs. The grid was roughly 30 km on a side with 5 km resolution (Figure 1). At the conclusion of the survey a final hydrographic line was placed through the center of the eddy allowing us to sample it with the full suite of physical, biological, and chemical measurements.

The final part of the cruise consisted of recovering the remaining UAF mooring in the Chukchi central channel, and occupying a hydrographic line extending eastward across the Alaskan coastal current. The cruise ended on 1 October in Nome, AK.

A few preliminary results

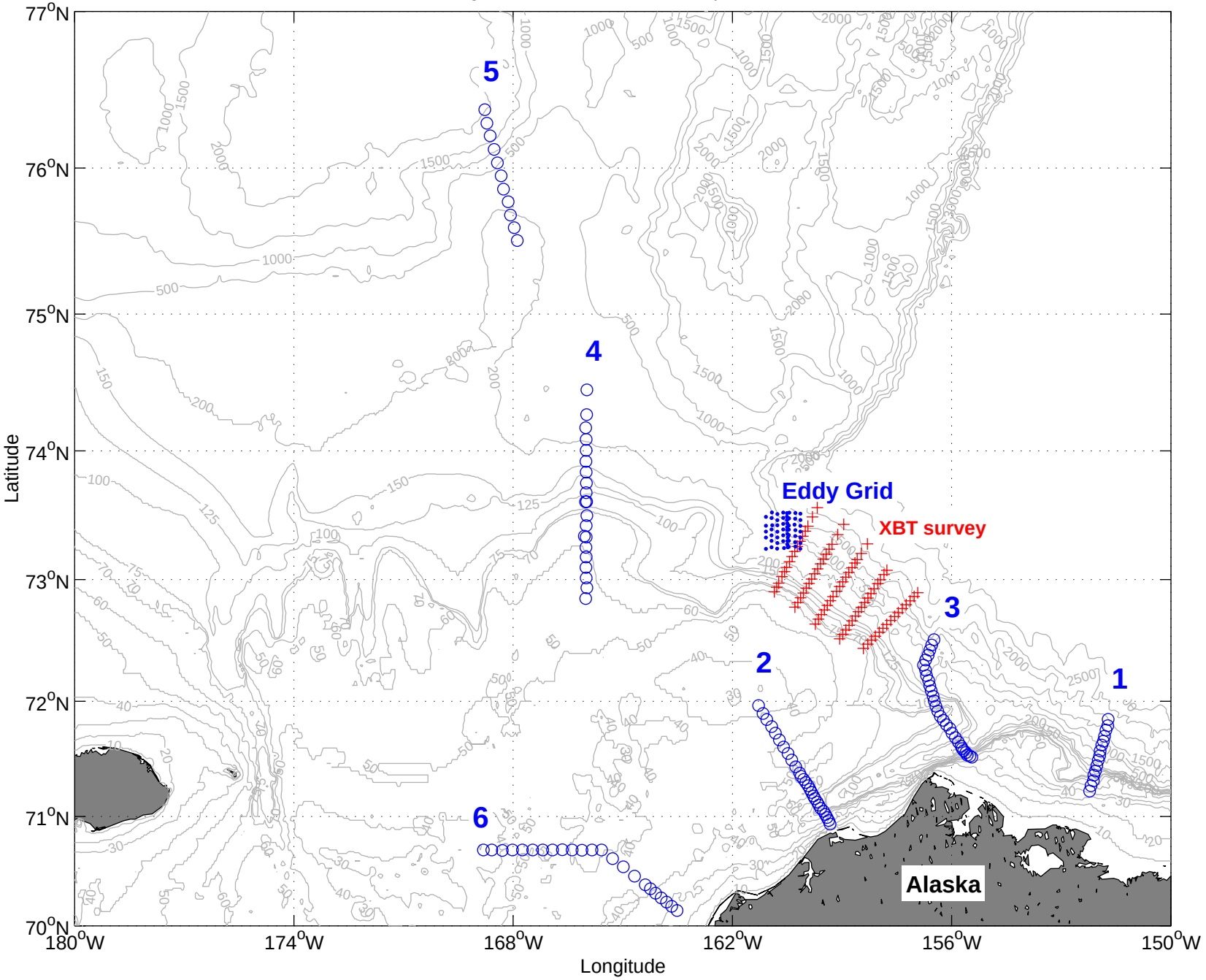
During the cruise we were able to start processing some of the moored data as the instruments were recovered. Figure 2a shows the timeseries of temperature and salinity for the month of January 2004 from the mooring at the head of Barrow Canyon. This provides a glance of some of the rich variability contained in these records. For instance, during the first part of the month (5-9 January) there was cold, uniform water present at the mooring, followed by a strong upwelling event that brought warm, salty Atlantic water to the head of the canyon. Both of these features were also observed downstream of Barrow Canyon on the Beaufort continental slope. This can be seen in the temperature timeseries from the upper part of the slope (Figure 2b). This two-year record shows the seasonal arrival of the Alaska coastal current water in the upper part of the water column, as well as the presence of the

denser winter-transformed Pacific water colder than -1.65°C. Especially noticeable in the record is the repeated occurrence of upwelling at the mooring site, indicated by the bottom-intensified warm events during the fall and winter (and into early spring). Focusing on January 2004, one sees a brief occurrence of winter water at the beginning of the month, followed immediately by a strong upwelling event, as was seen at Barrow Canyon. One of the many aims during the analysis of the SBI mooring data will be to investigate the connection between processes on the Chukchi shelf and Beaufort slope, and how this leads to shelf-basin exchange.

One exchange mechanism that has become apparent during the course of SBI is the formation and offshore migration of small-scale eddies. This was the motivation for finding and surveying a subsurface eddy during our cruise. A lateral view of the feature we found is presented in Figure 3. This shows the layer thickness between the bounding isopycnals of the eddy, revealing the anomalously thick center (more than 90 m thick). The swirl of the eddy was anti-cyclonic (this was verified by the vessel-mounted ADCP data), and the eddy contained water that was anomalously cold, turbid, and high in fluorescence, dissolved oxygen, and silicate. These characteristics indicate that the eddy was carrying winter-transformed water, most likely originating from the Herald Valley outflow. Interestingly, the feature was elongated zonally. Our three-dimensional view, along with the corresponding chemical and biological information contained in the transect through the center of the eddy, will shed light on how (and how quickly) these features are formed, how they decay, and what impact they might have on the ecosystem of the western Arctic.

For further information on this year's cruise, see www.whoi.edu/arcticedge.

Figure 1: SBI fall 2004 station positions.



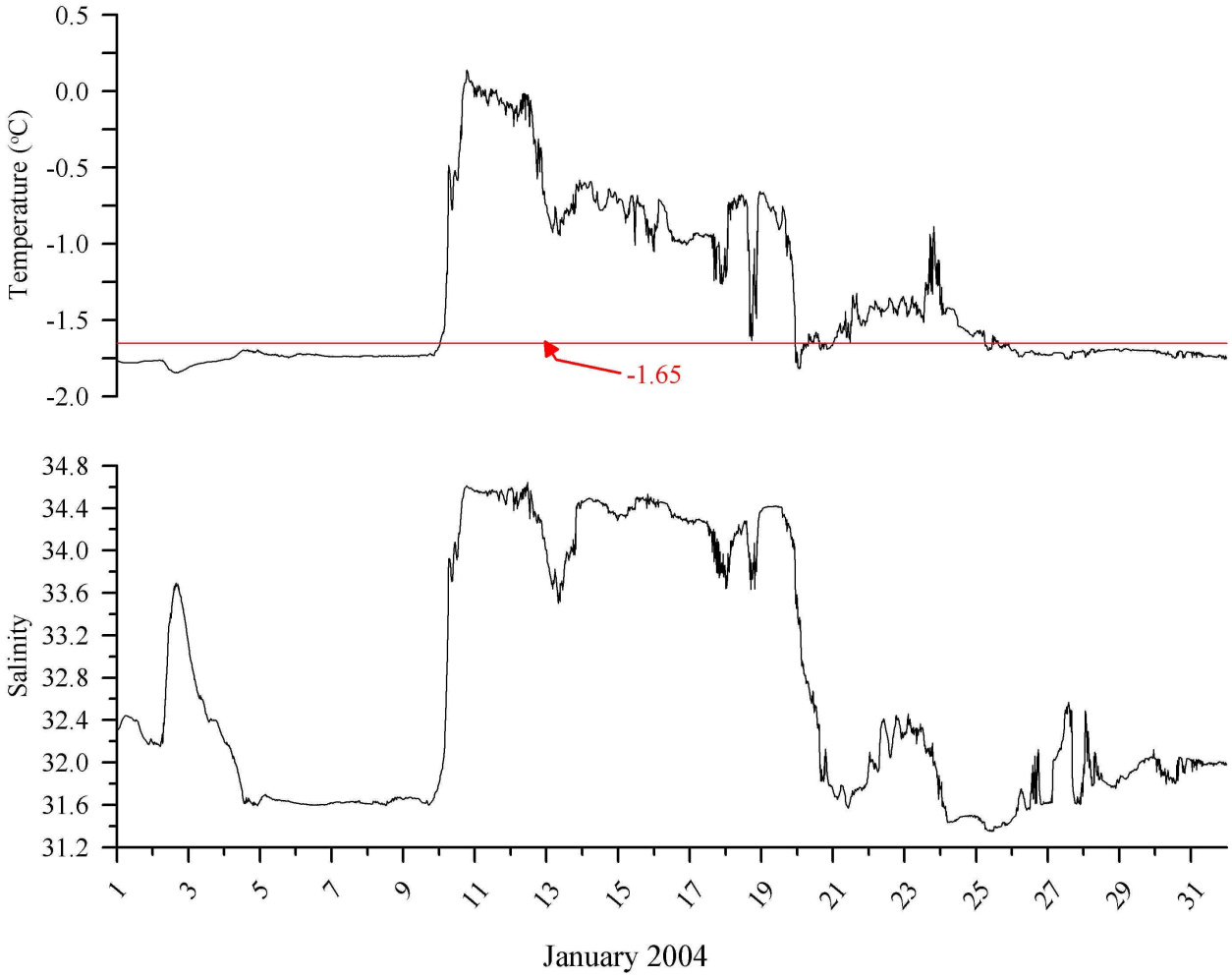


Figure 2a: The January 2004 time series of temperature and salinity from the UAF mooring at the head of Barrow Canyon.

Figure 2b: Two−year time series of potential temperature (C) on the Beaufort slope.

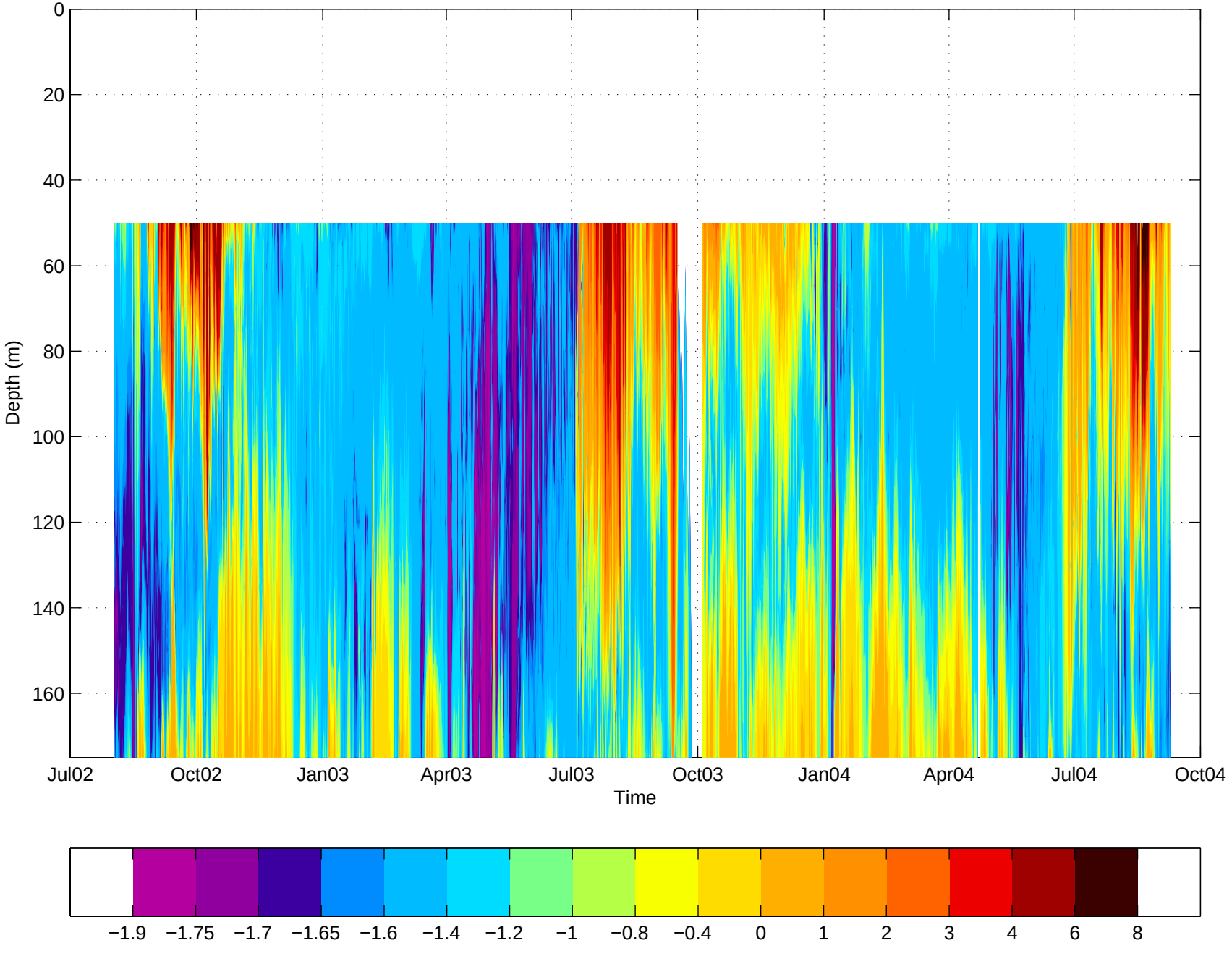


Figure 3: Eddy layer thickness (m) bewteen σ_θ = 26.4--26.8, overlaid on the bottom topography (m).