USCGC *Healy* Arctic Summer 2003 Cruise Summary: Shelf-Basin Interactions

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The field phase of the Western Arctic Shelf-Basin Interactions Experiment (SBI) continued in 2003 with a set of two 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 cruise in 2003—the service measurement cruise—took place in July-August and consisted of an extensive hydrographic survey of the SBI study area. The second cruise—the mooring turnaround cruise—was carried out on the Coast Guard icebreaker *Healy* from early September to mid-October. This report presents a short summary of the *Healy* 2003 cruise (HLY03), focusing on the Woods Hole Oceanographic Institution (WHOI) moored array. The reader is referred to the report by R. Woodgate (chief scientist on HLY03) for a more thorough description of the cruise and a summary of the University of Washington-University of Alaska (UW-UAF) moored array.

The major goals of HLY03 were to recover, then re-set, the combined SBI moored arrays, and also carry out a hydrographic survey in the early fall season to compliment the summertime service measurement survey. The SBI mooring program has two components: (1) a system of moorings to monitor the main outflow branches from the Chukchi shelf (the UW-UAF component); and (2) a high-resolution moored array across the Beaufort slope, downstream of the outflows, to determine how these waters are fluxed into the interior (the WHOI component). A unique aspect of the WHOI array is that it consists predominantly of profiling instrumentation. The inshore moorings have an upward-looking Acoustic Doppler Current Profiler (ADCP) at the base, and a Coastal Moored Profiler (CMP) that climbs up and down the wire four times a day. The CMP contains a Falmouth Scientific Incorporated EMCTD that measures conductivity, temperature, and pressure. The offshore moorings contain a McLane Moored Profiler (MMP) that profiles the water column twice a day with an EMCTD and acoustic current meter.

For the hydrographic survey on HLY03 we used a Seabird 911+ system along with a transmissometer, fluorometer, and oxygen sensor. Many of the hydrostations included water sample measurements of salinity, dissolved oxygen, nutrients (carried out by the SBI service measurement team), and chlorophyll (carried out by D. Stockwell of UAF). The rosette package was outfitted with a dual Workhorse lowered ADCP system providing profiles of absolute horizontal velocity. The vessel-mounted ADCP was used continuously throughout the cruise to measure currents in the upper 500 m (A. Muenchow, University of Delaware). Finally, Video Plankton Recorder casts and vertical net tows were carried out along the Beaufort mooring line (C. Ashjian, WHOI).

Brief Synopsis

Healy embarked the science party in Barrow, AK on 11 September and soon thereafter turned around the UAF Barrow Canyon mooring, followed by a hydrographic section across the head of Barrow Canyon (Figure 1). Next we we proceeded to 166°W—site of the two UW moorings—which we refer to as the Herald Valley outflow site. (Herald Valley actually lies to the west of 166°W in the Russian EEZ. We were unable to obtain clearance to work in Russian waters; however, we believe that the measurements along 166°W will capture at least a portion of the outflow of Pacific-origin water from Herald Valley.) Both UW moorings were turned around successfully (although one of them had to be dragged for), and two CTD lines were done. Following some additional hydrographic work, the UAF central channel mooring was turned around and a CTD line was occupied across the channel.

At this point our mooring work in the Chukchi Sea was complete, and we steamed to the Beaufort line and commenced turning around the WHOI array. This was a time consuming process because of the number and length of the moorings, and because much of the instrumentation had to be recycled at sea. The routine that we developed before the cruise for calibrating and refurbishing the CMPs and EMCTDs worked extremely well. All of the EMCTDs were benchmarked against the SBE9 T/C sensors (which in turn were calibrated using bottles) by systematically attaching the EMCTDs to the rosette frame and doing a series of casts in deep water. This enabled us to calibrate the moored profiler temperature and salinity data, and allowed us to choose the most stable set of sensors to put back in the water. It took roughly 10 days to turnaround the entire WHOI array, during which time we did 7 CTD crossings of the Beaufort Sea boundary current system. This included one net tow section, one VPR section, and one section with full water sample coverage. Two upwelling storm events occurred during this time that were nicely sampled by our repeat CTD and velocity sections.

Also at the Beaufort site we recovered the Acoustic Recording Package (ARP) that was deployed last year, then put out three additional ARPs for another year (two along the WHOI array line, and one roughly 10 miles to the west). The ARP project is being done by J. Hildebrand (Scripps) and S. Moore (PMEL). These instruments will record marine mammal calls that we hope to interpret within the context of the physical data.

After completing the Beaufort mooring work we steamed back to the Chukchi Sea and spent the remainder of the cruise completing our broad hydrographic survey. Due in part to the lack of ice in our working area, and the impressive stability of the Healy in rough seas, we were able to do many more CTD stations than originally planned. In all, 321 CTD stations were occupied at high spatial resolution. This will allow for a detailed comparison of the state of the Chukchi Sea with the summertime realization obtained during the service cruise. Our cruise ended on 18 October when the science party was disembarked at Nome, AK.

Some Preliminary Results

During last year's mooring cruise in July-August the shelf-edge boundary current was carrying cold, dense winter-transformed water from the Chukchi Sea (presumably formed the previous winter). This year, in September-October, the cold Chukchi water mass was absent. This was replaced instead by a moderately cold product (likely emanating from the Chukchi Sea after winter's end), and then,

later in the cruise, by an anomalously warm water mass. The warm water mass is likely the ambient summertime water in the Chukchi Sea, which also gets flushed from the shelf. Another difference from last year was the predominance of very warm and fresh water that we observed on the Beaufort shelf and shelfbreak. The origin of this water is the Alaskan coastal current, which likely turns east after flowing past Barrow Canyon.

These different water masses, and the timing of their arrival along the slope of the Beaufort Sea, can be seen in the mooring records from the WHOI array. All 7 profilers returned 14+ months of data, along with the corresponding ADCPs at the bases of the moorings. This translates into more than 800 high resolution synoptic CTD sections across the Beaufort Sea boundary current system over the course of the year. The temperature timeseries from the shelfbreak moored profiler is shown in Figure 2. One sees the Alaskan coastal current water (red) pass by the array in late summer/early fall. In late spring/early summer the cold, dense winter-transformed water (purple) appears at this site, present (somewhat intermittently) over a two month period.

Like last year, our hydrographic sections revealed active eddy formation in the shelfbreak current. It has become quite clear that this boundary current system is highly unstable and can readily form subsurface anti-cyclones. Last year these anti-cyclones contained cold, winter-transformed water. This year we saw both moderately cold core eddies, as well as warm core eddies (Figure 3). These features contained shelf-origin water high in fluorescence and high in sediment content. This strongly suggests that boundary current instability is a dominant mechanism for shelf-basin transport, and that both warm and cold features are being spawned by a similar dynamical process. Analysis of our collective data sets will shed more light on this in the coming months.

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

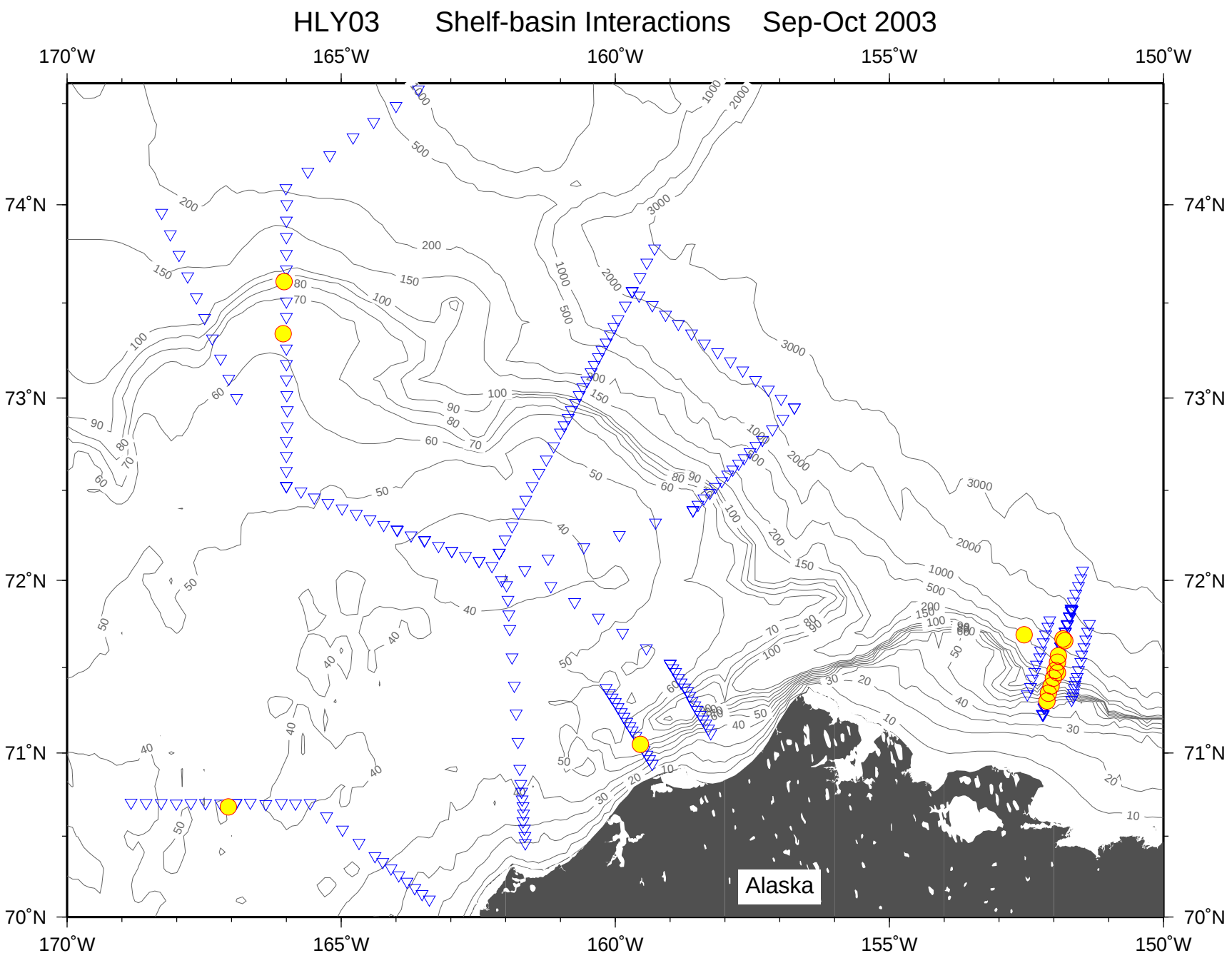

Figure 1: HLY03 CTD stations (inverted blue triangles) and moorings (yellow circles).

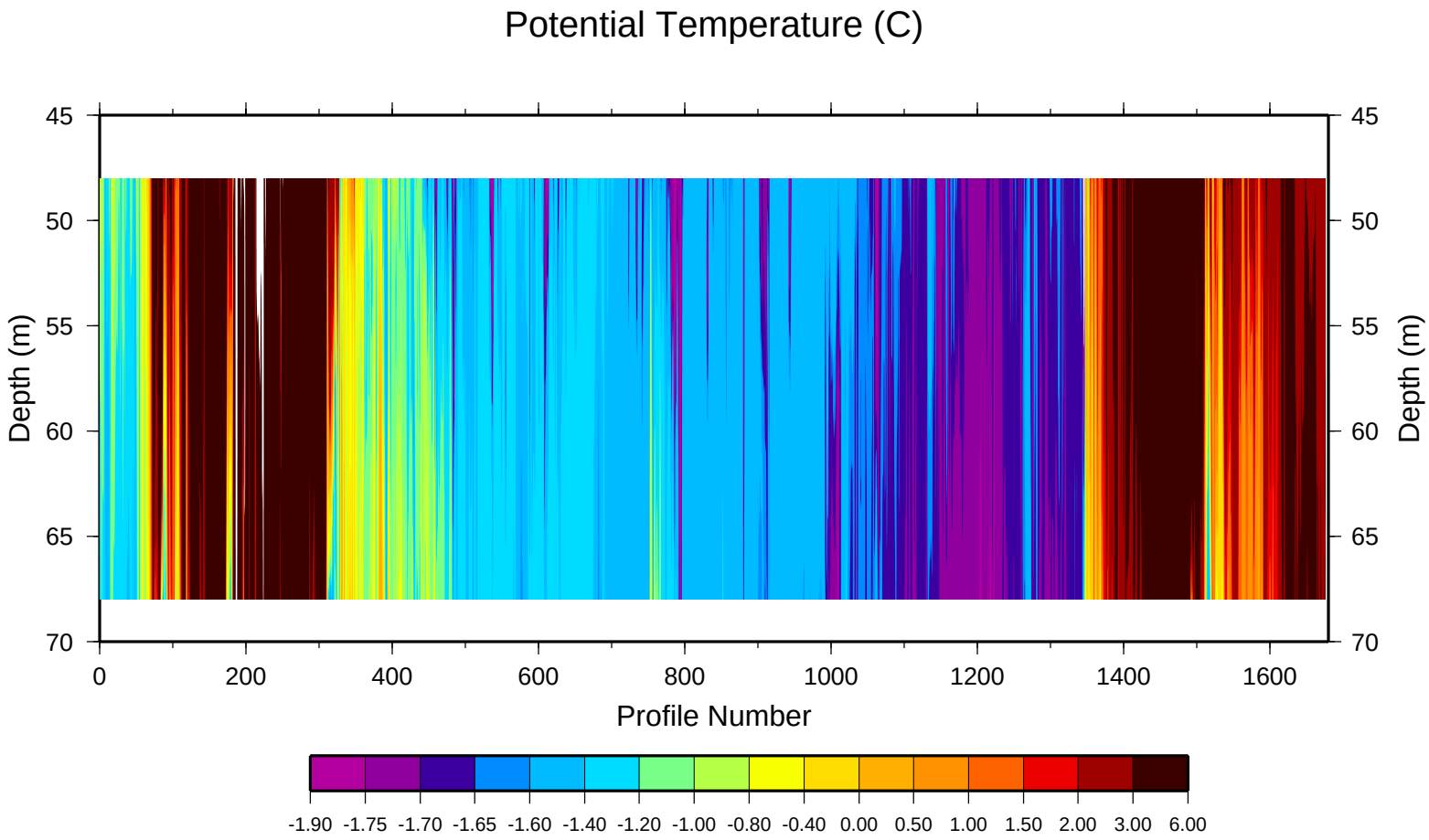

Figure 2: Time series of potential temperature from the moored profiler at the Beaufort shelfbreak.

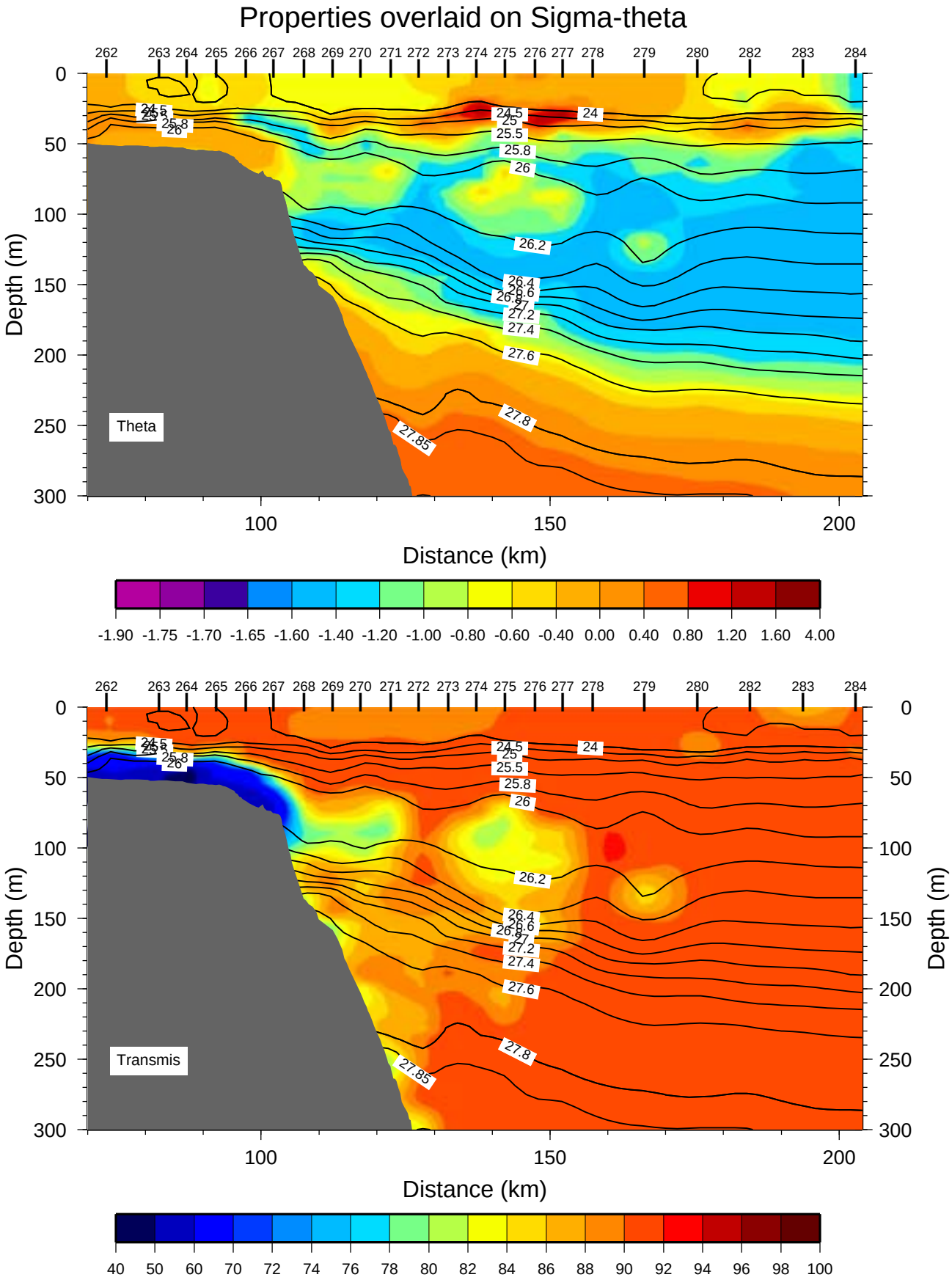

Figure 3: Vertical sections of potential temperature and transmissivity, overlaid on potential density, across the Chukchi shelfbreak near 161W. Three warm-core eddies are present offshore of the shelfbreak between 50-100m depth.