RRS James Clark Ross 105 Cruise Summary: Irminger Sea Circulation and Convection

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Voyage 105 of RRS James Clark Ross was carried out from 22 July to 11 August, 2004 in the Irminger Sea. This was the fourth and final cruise of the NSF-sponsored project entitled "Is Labrador Sea Water formed in the Irminger Basin?" The main objectives of the cruise were (1) to recover the two moored profilers (MPs) in the southern Irminger Sea; (2) to deploy a long-term subsurface mooring for a related project; (3) to deploy a meteorological buoy alongside this mooring; and (4) to carry out a hydrographic/velocity/tracer survey of the East Greenland coastal current on the inner shelf from Cape Farewell to Denmark Strait. All of these objectives were successfully met.

Brief Synopsis

The cruise began in Qaqortoq, Greenland and we reached our first work site in the southwest Irminger Sea shortly thereafter. Our goal here was to recover the MP at the offshore site (Figure 1), and replace it with a subsurface mooring called ULTRAMOOR (Nelson Hogg, PI). ULTRAMOOR is designed to be in the water for five years, and will allow for continued investigation of wintertime convection in the Irminger Sea. Because of the crucial role that the atmosphere plays in convection, and due to the lack of in-situ meteorological observations in this region, we also aimed to deploy a surface met buoy adjacent to ULTRAMOOR. All of these mooring operations were performed without incident. Following this we steamed to the onshore site. The MP at this location had a known release failure, and so our plan was to use an ROV to attach a line to the top float and pull the mooring up (anchor included). This turned out to be a challenging operation, due in part to the weather. In particular, the upper layer currents were highly variable and there was a significant swell from a storm that had passed by the area prior to our arrival. It took us numerous attempts, but on the second day we were successful in retrieving the MP (the anchor gave way roughly 800 m from the surface). We are thankful to Rob Morris of EG&G who deftly guided the ROV, and are indebted to captain Chris Elliot of the James Clark Ross whose expertise in maneuvering the vessel made this recovery possible.

After the mooring work was concluded we began our hydrographic survey of the East Greenland coastal current, beginning with a section near Cape Farewell (this section has been occupied four times over the course of our project). The instrumentation used during the survey consisted of a Seabird 911+ conductivity/temperature/depth (CTD) system with a SB43 oxygen sensor, transmissometer, and fluorometer, mounted on a 12-position rosette with 10 liter bottles. In addition to dissolved oxygen and salinity water samples, we measured nutrients, O-18, and alkalinity in association with P. Jones and K Azetsu-Scott of the Bedford Institute of Oceanography. Underway currents were measured using the vessel-mounted acoustic Doppler current profiler (ADCP). These data were processed, de-tided, and converted into stream coordinates in near-real time.

In order to carry out the hydrographic survey it was necessary to have an ice-strengthened vessel, since the inner shelf is often ice-covered in the summer months (this year was no exception). NSF and NERC kindly provided us the opportunity to use the British icebreaker James Clark Ross, which enabled us to take measurements to within three miles of the East Greenland coast, despite the presence of pack-ice and icebergs. Since section 4 was a repeat of the East Greenland spill jet section, we began this line on the upper continental slope and occupied stations at especially high resolution in the region of the shelfbreak. The spill jet was again present this year, implying that it is a permanent feature (at least during the summer season). In order to shed light on the origin of the East Greenland coastal current, we occupied section 5 north of Denmark Strait. We positioned this section to coincide with the Kogur section, which is one of the standard Icelandic hydrographic lines. At the end of the cruise we we occupied a final short transect in the vicinity of Denmark Strait. In all, 170 stations were occupied. The cruise terminated in Reykjavik, Iceland.

<u>A Few Results</u>

The potential temperature timeseries from the offshore MP that we recovered during the cruise is shown in Figure 2. We obtained an 8-month record that extended through the winter season, providing a vast amount of information on the seasonal evolution of this part of the Irminger Sea. Unfortunately the winter was not very robust so deep convection did not occur (this is undoubtedly true in the Labrador Sea as well), but one can see the erosion of the mixed-layer, which reached 400 m in early February. It will be interesting to relate this mixed layer evolution, which is recorded on a daily basis, to the passage of storms and the occurrence of the atmospheric Greenland tip jet, using the Prins Christian Sund met data at Cape Farewell. Interestingly the warmest water in the upper layer was found in late fall, which needs to be explained.

Our hydrographic survey of the East Greenland coastal current was very successful. We sampled the current multiple times at high resolution (Figure 1), including measurements of velocity and the full-suite of tracers. This data set represents the first comprehensive survey of this current system. Figure 3 shows our second crossing, near 63°N. One can see the large "wedge" of cold, fresh water (colder than -.5°C) and the corresponding isopycnal tilt. Coincident with the density front is a strong current with a peak speed > 90 cm/s. Surprisingly, the jet extends nearly to the bottom and is transporting more than 2 Sv. It is hard to believe that such a feature is due solely to coastal run off and ice-melt. Future work will be directed at exploring the origin of the coastal current (including how much Arctic water it carries), its kinematics and dynamics, as well as its role in the freshwater budget of the Nordic Seas.

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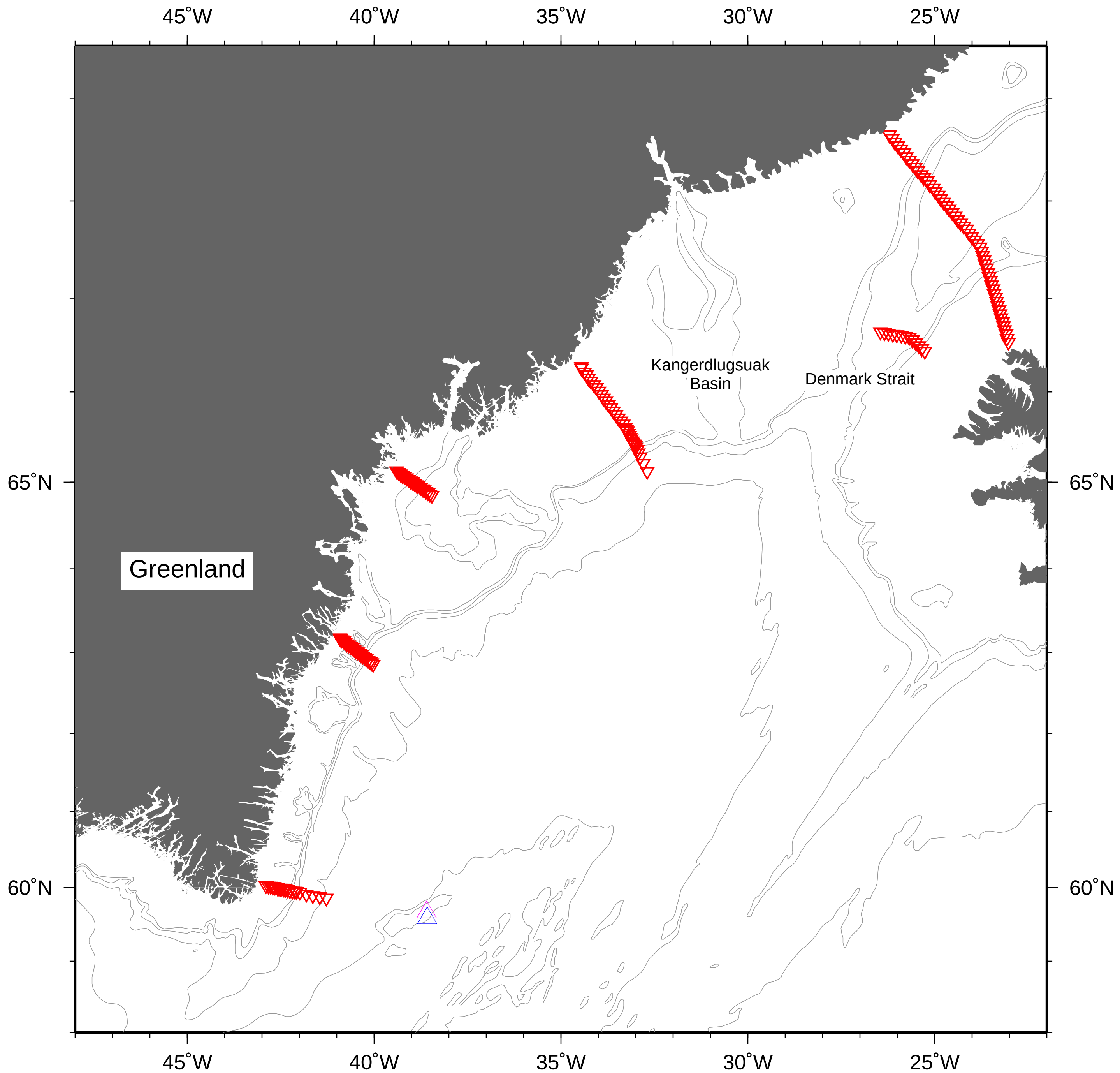
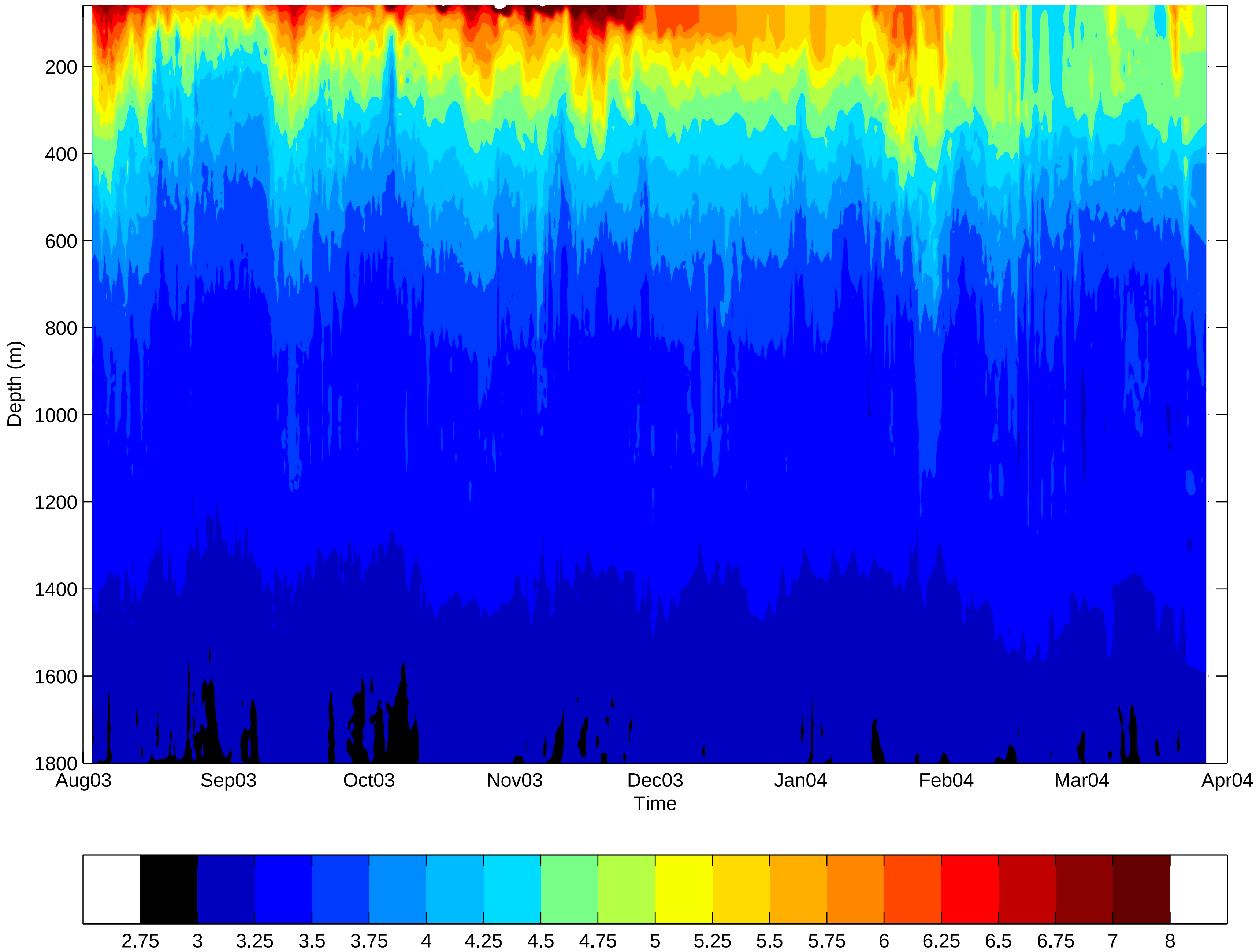


Figure 1: CTD stations (inverted red triangles) occupied by RRS James Clark Ross voyage 105 in July-August, 2004. The ULTRAMOOR mooring and meteorological buoy are denoted by the blue and magenta triangles, respectively. The isobaths are 200m, 500m, 1000m, 2000m, and 3000m.

Figure 2: Timeseries of potential temperature (C) from the moored profiler at the ULTRAMOOR site (Figure 1).



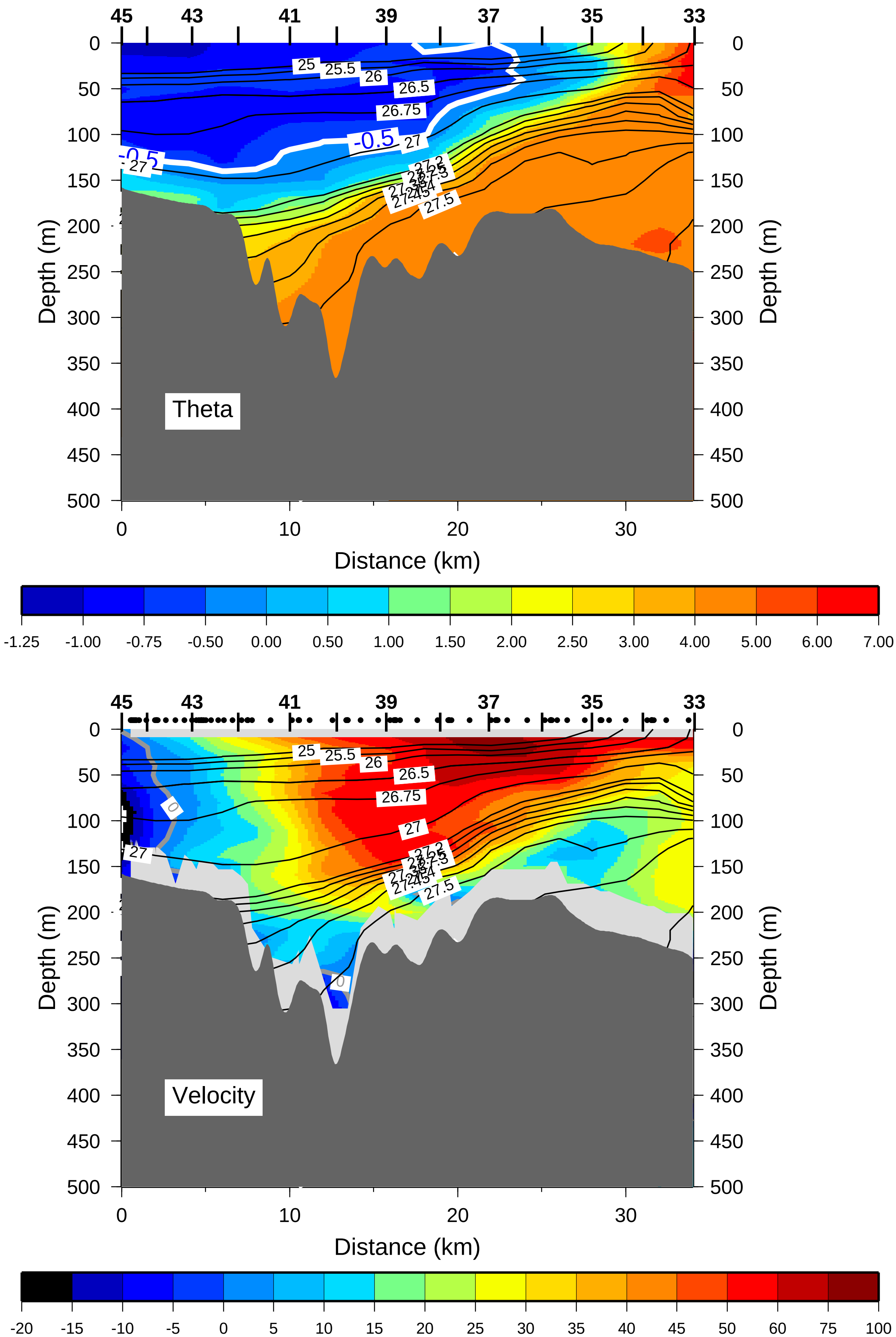


Figure 3: Vertical sections across the East Greenland coastal current near 63°N (Section 2, Figure 1). (a) Potential temperature (color, °C) overlaid on potential density (kg/m^3). The -.5°C contour is highlighted. (b) Alongstream velocity (color, cm/s). The ADCP ensemble locations are indicated by the dots.