R/V Knorr Cruise KN194 Leg IV

Shelf-Basin Exchange South of Denmark Strait: Forcing, Dynamics, and Large-scale Impact

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Cruise KN194 Leg IV on the research vessel *Knorr* took place from 3-31 October, 2008 in the northern Irminger Sea and southern Iceland Sea. The main goals of the cruise were to recover a mooring array that was deployed the previous September on the Greenland shelf/slope south of Denmark Strait (Fig 1), and to carry out a hydrographic/velocity survey to shed light on the origin and fate of the dense water flowing through the strait. There are presently different explanations as to where this throughflow originates. One scenario is that the East Greenland Current advects both shelf water and dense overflow water through the Strait. A second idea, recently put forth by Jonsson and Valdimarsson (2004), argues that the majority of the overflow water enters the eastern side of the strait along the Iceland slope. It was our hope to assess the relative contributions of these two pathways.

An additional goal of the cruise was to investigate the source of the recently established East Greenland Coastal Current. This is a buoyancy-driven current located on the inner Greenland shelf. It has been measured south of Denmark strait, but it is uncertain if this current exists north of the Strait. Another goal was to investigate the amount and types of zooplankton advected southward from the Arctic domain via the East Greenland Current using a video plankton recorder (C. Ashjian, WHOI). The final goal of the cruise was to learn more about the nature of the storms that pass through this region, via radiosonde measurements (I. Renfrew, University of East Anglia; G.W.K. Moore, University of Toronto). The area of operations was along the North Atlantic storm track, and these storms are believed to influence the currents measured by the moorings. Despite significant weather delays during the course of the month-long cruise, the various goals were accomplished.

Brief Synopsis

The ship departed Reykjavik, Iceland on 3 October, and arrived at the East Greenland shelf/slope mooring array 24 hours later. Due to a good weather window, all 7 moorings were successfully recovered within two days, and the hydrographic survey was begun immediately afterwards. The overall plan was to work northward through Denmark Strait, occupying hydrographic/vessel-mounted ADCP sections to track the currents and water masses passing through the strait. Fig 1 shows the 13 CTD sections that were occupied during the cruise. Some of the features of note are as follows. Section 1 (where the moorings were located) was a repeat of a CTD line that has been occupied four times previously during this decade. Stations were occupied right up to the coast in order to sample the East Greenland Coastal Current (true as well for section 8). Sections 2 and 3 were designed to investigate the channeling of water into / out of the Kangerdlugsuak canyon and fjord, which is thought to influence the glacier activity in the fjord as well as modify the water masses that flow past the mooring array site. Sections 4-8 were positioned to sample the pathways immediately upstream and downstream of the Denmark Strait sill. All of the hydrographic sections were

done at high horizontal resolution (typically 5 km), and video plankton recorder casts were occupied in the vicinity of the Greenland shelfbreak on some of the sections.

On the northern side of the strait the sampling conditions became more difficult. Sections 9 and 10 were designed to be a single section spanning the strait, but the ship encountered pack-ice that had been carried southward by the strong northerly winds. We lost most of a day steaming around bands of ice extending far offshore. Shortly thereafter we encountered a "hurricane low" that forced us to seek shelter behind an island in a fjord on the north side of Iceland. Between the storm itself, and steaming to/from the work area, we lost 5 days. We then attempted to recover a mooring that had been deployed collaboratively between WHOI and the Marine Research Institute of Reykjavik (HAFRO) last September on the north Icelandic slope. Unfortunately, we could not communicate with the acoustic release, and dragging operations were unsuccessful. Plans are underway for a more thorough recovery attempt in the coming year when HAFRO carries out one of their seasonal fisheries surveys of the area. Science operations concluded on 29 October with the occupation of a final CTD section along the Kolbeinsey Ridge. The ship arrived in Reykjavik the morning of 31 October.

Some Preliminary Results

One of the hypotheses of the experiment is that some portion of the Denmark Strait overflow water does not enter the main plume south of the sill, but instead stays on the outer part of the shelf and subsequently "spills over" the shelfbreak—forming the intense gravity current known as the East Greenland Spill Jet (Pickart et al., 2005). The mooring array was designed to capture the spilling process, whether it be forced by downwelling storms or caused by baroclinic instability of the East Greenland/Irminger Current. The hydrographic survey revealed that some overflow water (i.e. denser than 27.8 kgm^{-3}) can indeed be found on the shelf south of the sill (Fig 2). The mooring timeseries data will elucidate how common this is and how much volume transport is involved.

North of the strait our measurements revealed the presence of the southward-flowing jet along the Iceland slope first reported by Jonsson and Valdimarsson (2004). An example is shown in Fig 3. This is further proof that the jet is a persistent feature (it was measured during a 2004 cruise as well). The hydrographic measurements will enable us quantify the water being advected by the jet and its contribution to the overflow water. We envision that the data analysis over the next couple of years, in conjunction with the modeling component of the program, will provide new insights into how dense waters enter and exit Denmark Strait, and the ramifications of this for the circulation of the sub-polar North Atlantic.

References

Jonsson S., H. Valdimarsson, 2004: A new path for the Denmark Strait overflow water from the Iceland Sea to Denmark Strait, *Geophys. Res. Lett.*, **31**, L03305, doi:10.1029/2003GL019214.

Pickart, R.S., D.J. Torres, P.S. Fratantoni, 2005: The East Greenland Spill Jet. *Journal of Physical Oceanography*, **35**, 1037-1053.

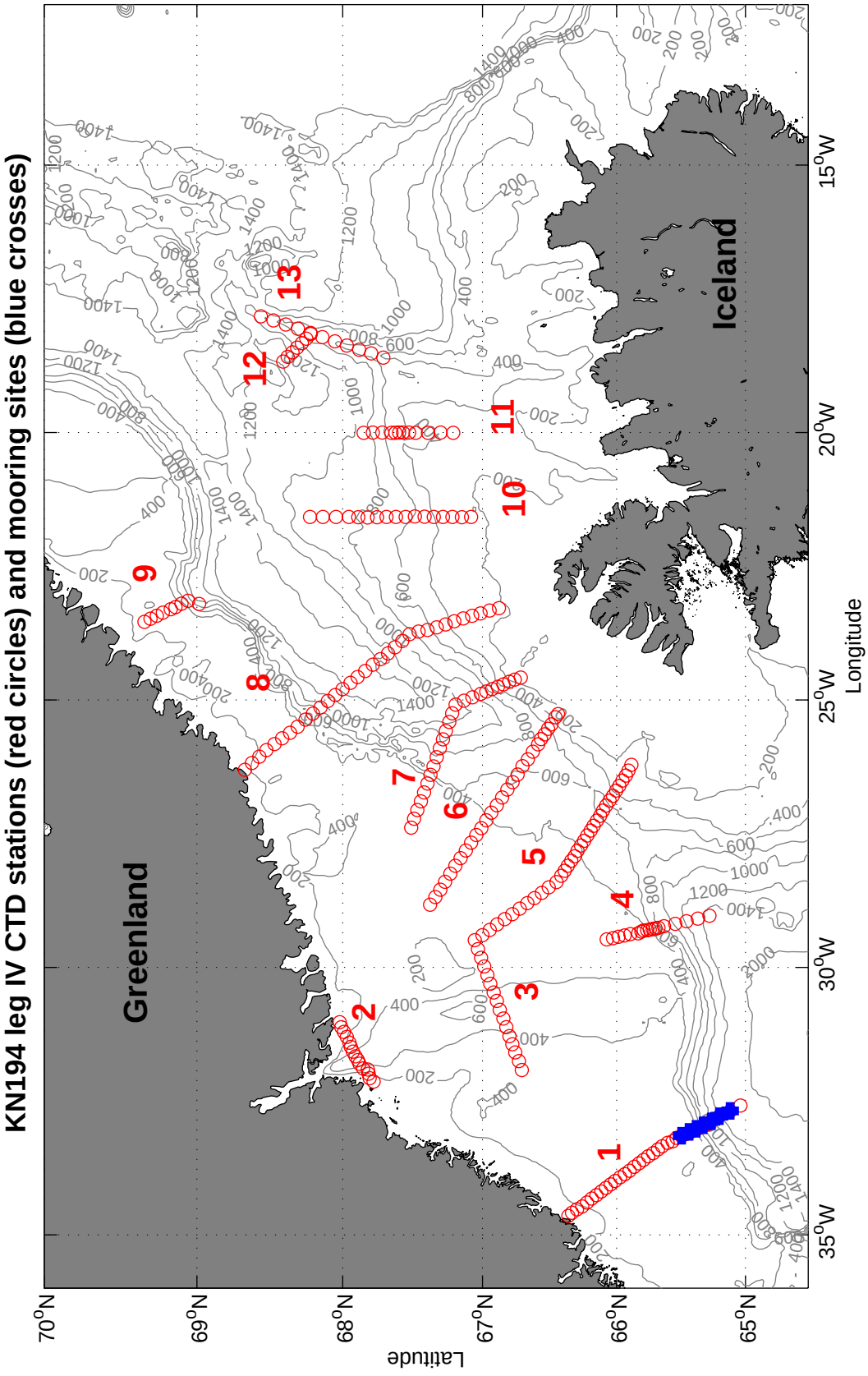

Figure 1: CTD sections occupied during KN194 leg IV (red circles). The moorings that were recovered are denoted by the blue crosses

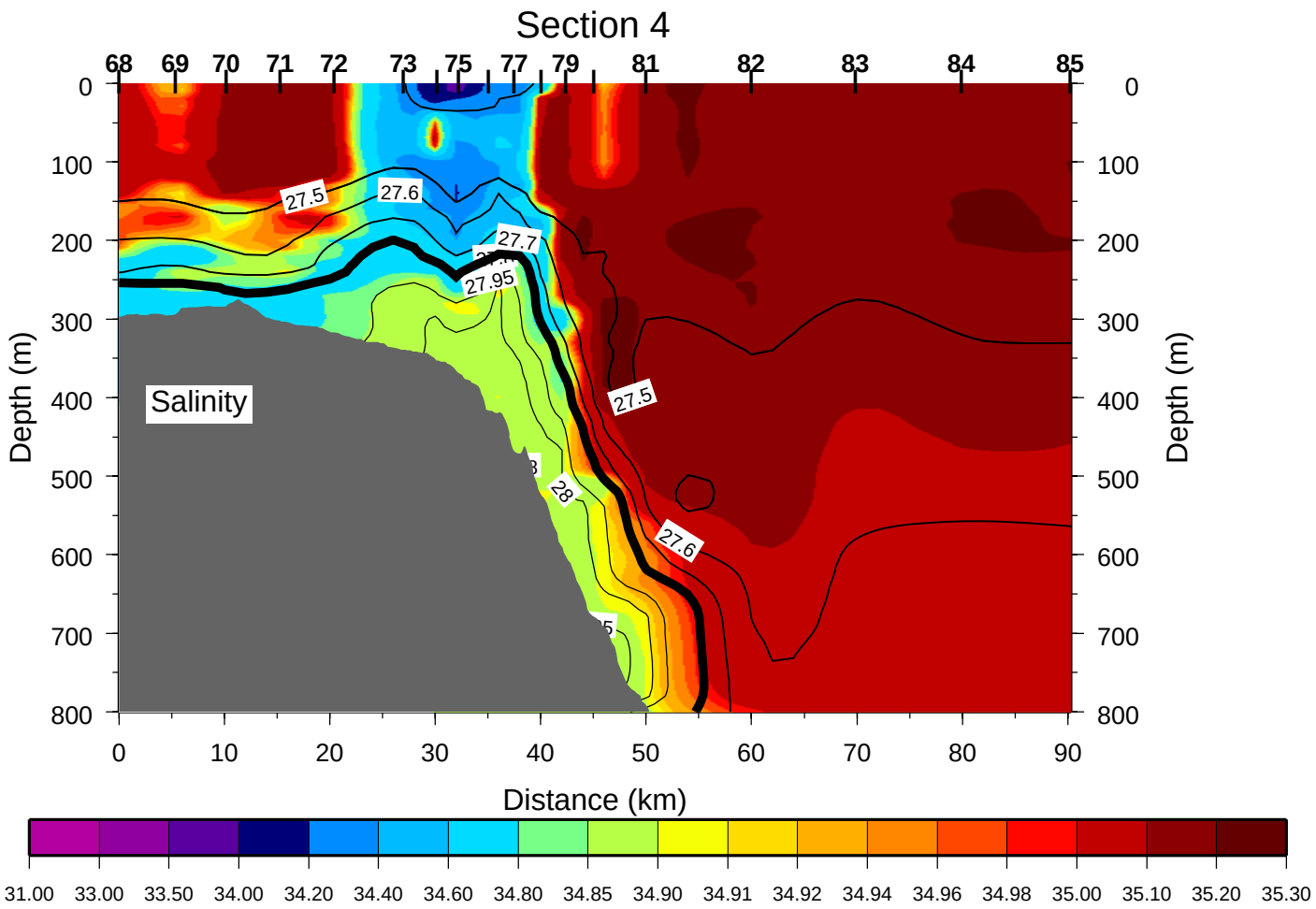

Figure 2: Salinity (color) at Section 4 overlain by potential density (contours, kgm^{-3}). The bold line is the 27.8 contour, which delimits the Denmark Strait overflow water.

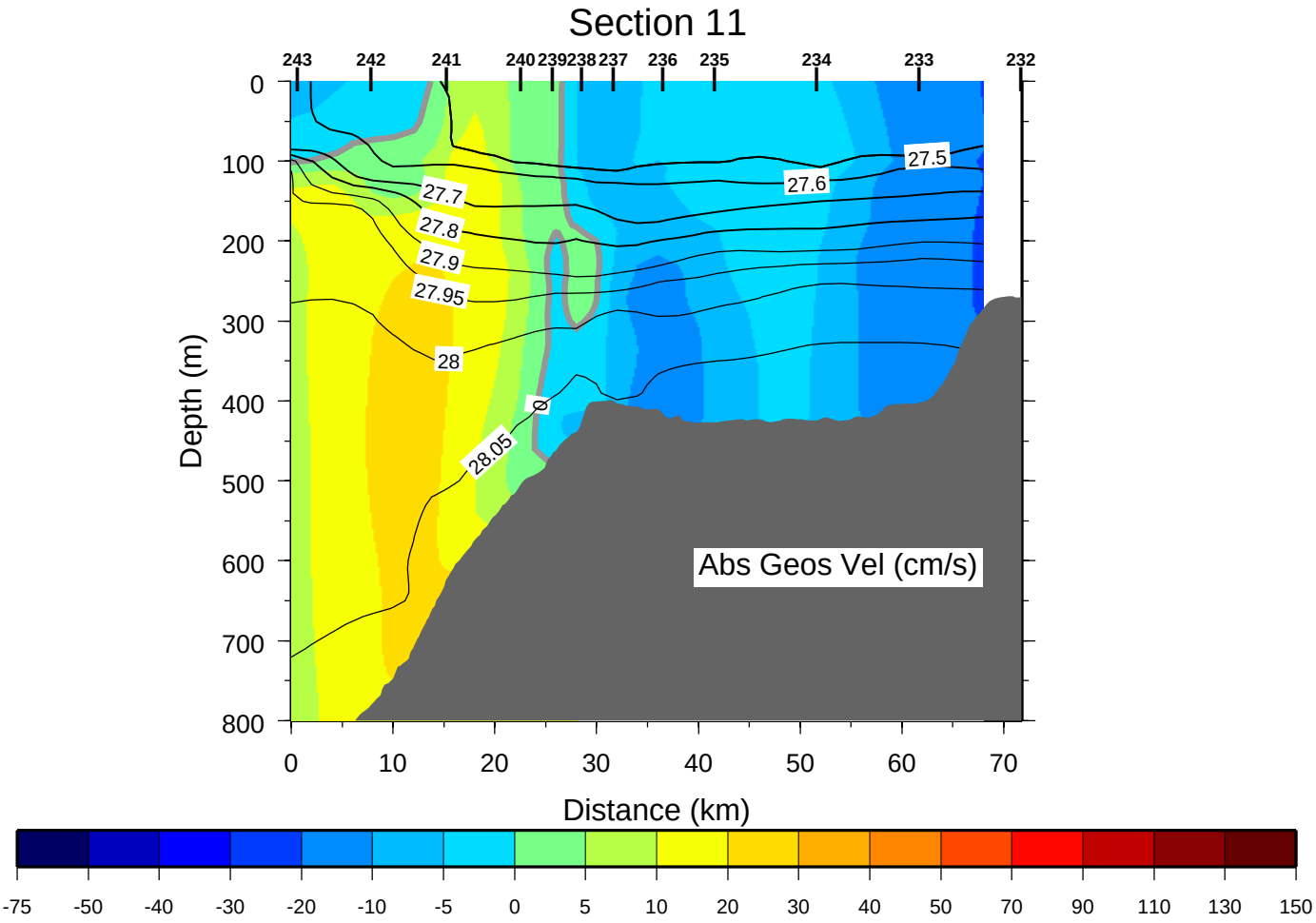

Figure 3: Absolute geostrophic velocity (color, cms^{-1}) at Section 11 overlain by potential density (contours, kgm^{-3}). The thermal wind shear was referenced using the de-tided vessel-mounted ADCP data. Positive values of velocity are equatorward. The jet carrying dense water toward Denmark Strait is centered near the 700 m isobath.