R/V Oceanus 395 Cruise Summary: Irminger Sea Circulation and Convection

Robert S. Pickart
Woods Hole Oceanographic Institution

Voyage 395 (leg III) of R/V Oceanus was carried out from 27 July–10 August, 2003 in the Irminger Sea. This was the third cruise in the collaborative projects "Is LSW formed in the Irminger Basin?" (WHOI) and "LSW formation and variability in transport and mixing of ISOW and DSOW in the Irminger Basin" (LDEO). The main objectives of the cruise were (1) to turn around the two moored profilers (MPs) in the southern Irminger Sea; (2) to occupy the western end of the WOCE A1E hydrographic line; and (3) do a high-resolution hydrographic/tracer/velocity survey of the East Greenland shelfbreak current system, downstream of Denmark Strait. All of these objectives were successfully met.

Brief Synopsis

The ship departed St. Johns Newfoundland and steamed for three days to the offshore mooring location. Unfortunately, rough weather prohibited us from commencing operations for nearly a day (although this would be the only weather-related work stoppage on the cruise, which is quite good for this area of the North Atlantic). Both of the MPs were turned around without incident thanks to the excellent efforts by our mooring technicians and the crew of the ship. After the mooring operations were completed, we worked our way towards Cape Farewell repeating the western end of the A1E line with conductivity/temperature/depth (CTD) stations. These included measurement of dissolved oxygen and CFCs. Stations were taken well onto the shelf in order to sample both the inner and outer branches of the East Greenland Current. Figure 1 shows the locations of the two MPs (blue squares) as well as the CTD stations (yellow inverted triangles) occupied on the cruise.

After completion of the Cape Farewell CTD line, we steamed north to the area immediately downstream of Denmark Strait and did a concentrated CTD/XCTD survey in the vicinity of the shelfbreak (Figure 1). The central CTD line of the survey, which was done first, was a repeat of stations we did in summer 2001. That year we observed evidence of dense shelf water "spilling" onto the upper slope, and our aim this summer was to determine if this process occurred regularly in the region. The repeat line indicated that this is the case, hence we did two additional short CTD transects upstream and downstream, separated by 45 km (which is somewhat larger than the deformation radius). The station spacing on the upstream line was less than 1.5 km, which was necessary to capture the complex spilling process at the shelfbreak.

The final task on the cruise was to conduct an underway XCTD survey (cyan inverted triangles in Figure 1) that cut across Kangerdlugsuak Basin, then doglegged across the shelfbreak. The purpose here was to look for evidence of flow along the edges of the basin. A high-resolution numerical model of the Irminger Sea was being run on the cruise (T. Haine, Johns Hopkins University) and the model suggested that a large portion of the shelf flow out of Denmark Strait is diverted around the canyon. Our tracer measurements hinted at this as well, so we decided to position the XCTD line in order to

shed light on this. The shipboard ADCP was running during this survey, as well as throughout the cruise.

During the cruise we constantly exchanged information between the ship and our respective labs back home. Each of the shelfbreak ADCP crossings was de-tided onboard (using a 1/12 degree satellite model) and then e-mailed ashore for transformation into stream coordinates using a set of processing routines. This enabled us to verify the features of interest and adjust our sampling scheme accordingly. Subsets of the velocity and hydrographic data were also e-mailed to Johns Hopkins for inclusion in a near real-time data assimilation numerical modeling run. While this did not impact the sampling on this cruise, it helped us to flesh out what is needed to perform this kind of assimilation on our 2004 cruise.

A Few Results

After experiencing an instrument failure in the initial deployment (in 2001-2) of the offshore MP, we were pleased to retrieve a full data set for the 2002-3 deployment. While we were unable to process the data at sea (hence no results can be shown here), it was verified that we acquired daily profiles of temperature, salinity, and absolute velocity to 1800 m. These will be analyzed over the coming year to look for evidence of wintertime mixing.

During the cruise we processed the CTD data, paying particular attention to the shelfbreak survey occupied downstream of Denmark Strait (Figure 1). The eastern-most CTD line is shown in Figure 2, which plots Sigma-theta (contours) overlaid on alongstream velocity (color). Note the descent of isopycnals above the bottom from the shelf to the slope, coinciding with the increased equatorward velocity near the shelfbreak. This feature has been dubbed the East Greenland spill jet. It has now been observed in multiple sections over two different years. In the example shown the velocity of the jet exceeds 85 cm/s, which is approaching speeds observed in Denmark Strait (corresponding to the denser overflow water). The spilled water in Figure 2 is nearly identical in properties to that residing on the outer shelf. We suspect that at the time of occupation of the section the water had recently descended off the shelf. We say this in part because the lens of water on the upper slope (denoted by the thick contour in Figure 2) is neutrally stable to the accuracy of the CTD, suggesting adjustment via mixing. Investigation of the spill jet using these data will occupy much of our efforts during the analysis phase of the experiment.

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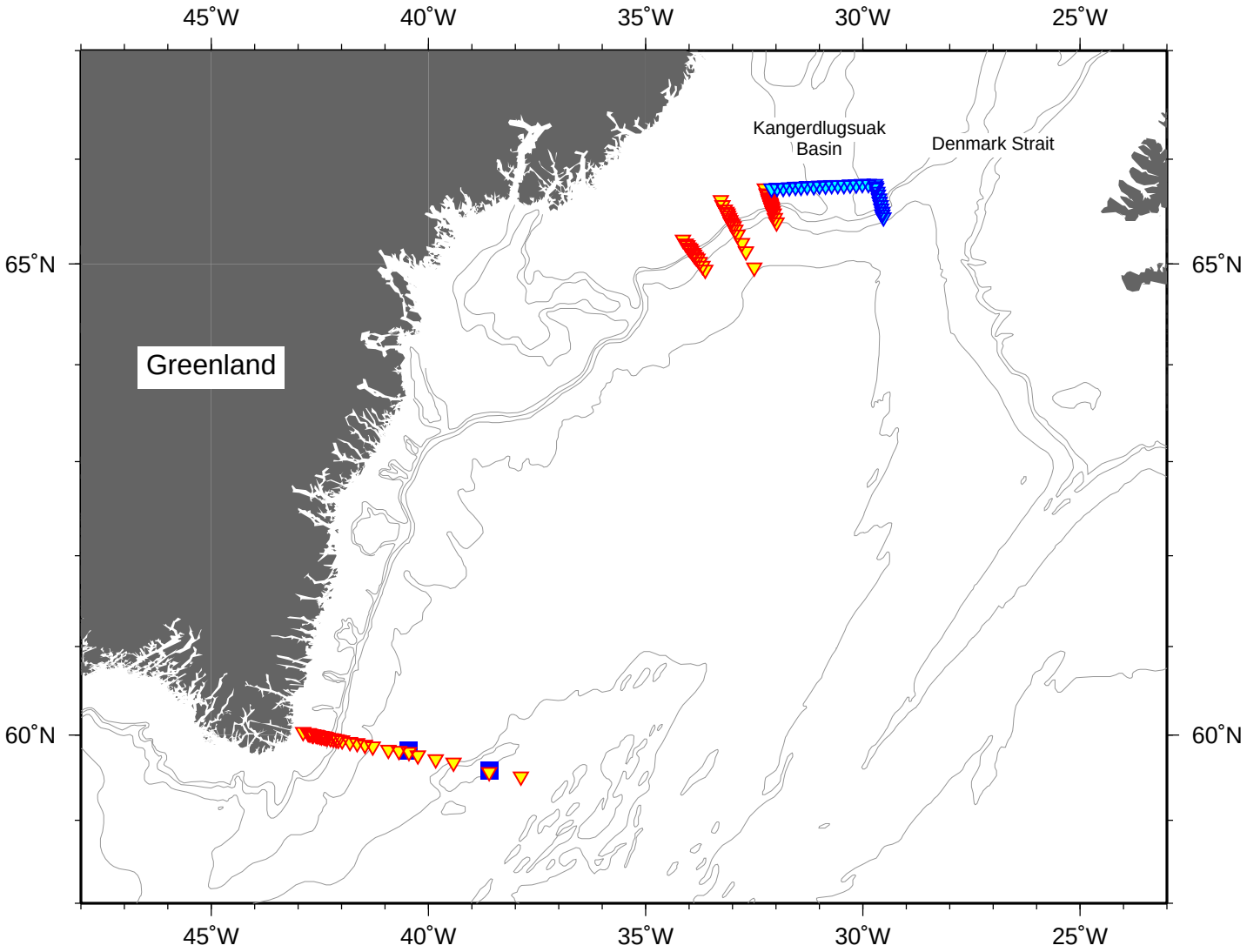

Figure 1: CTD stations (inverted yellow triangles) and XCTD locations (inverted cyan triangles) occupied by R/V Oceanus 395 in July-August, 2003. The two moored profilers that were turned around are denoted by the blue squares. The isobaths are 200m, 500m, 1000m, 2000m, and 3000m.

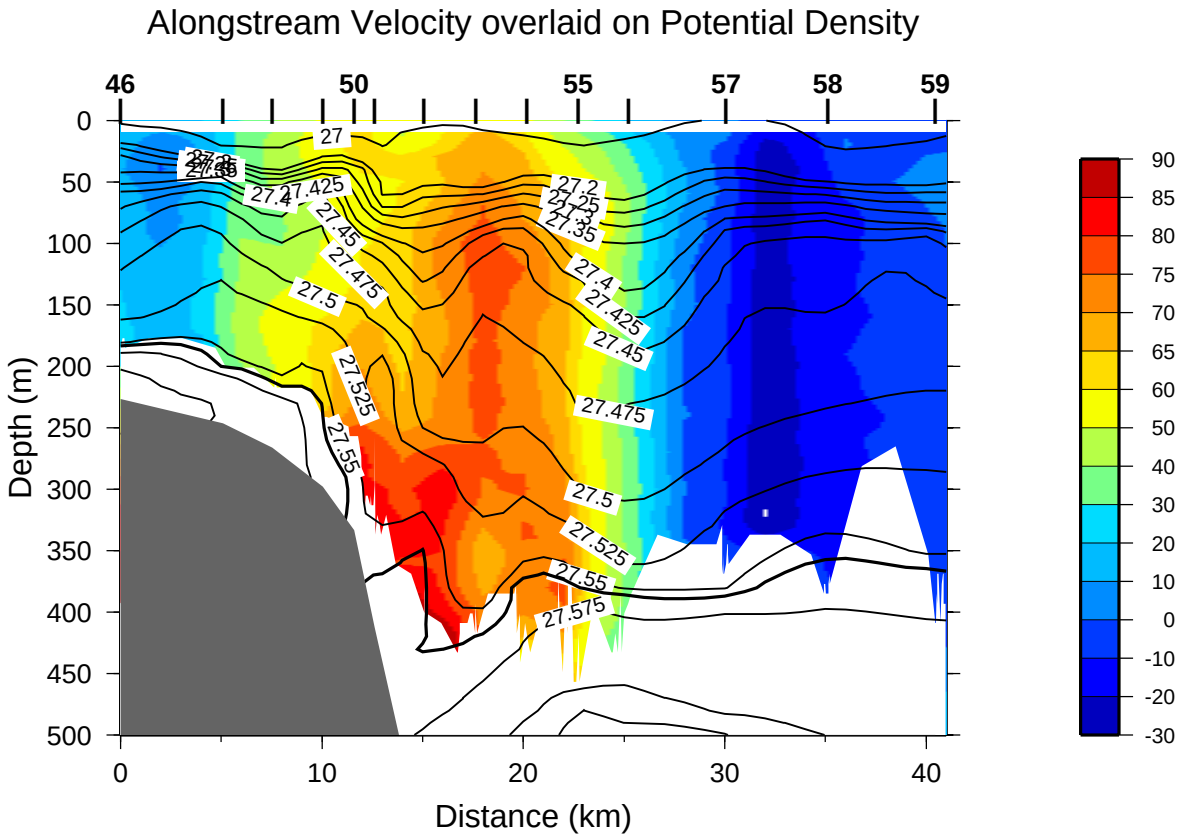

Figure 2: Alongstream velocity from the vessel mounted ADCP (color; positive is equatorward) overlaid on potential density (contours). Note that the ADCP returns no data near the bottom or deeper than approximately 400m. The 27.558 density contour is highlighted (thicker black).