An Observational Array for High-Resolution, Year-Round Measurements of Volume, Freshwater, and Ice Flux Variability in Davis Strait: Cruise Report for R/V *Knorr* 179-05, 22 September–4 October 2004

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NSF Grant OPP 02300381

Acknowledgments

We thank Captain A.D. Colburn and the crew of R/V *Knorr* for their enthusiastic and professional assistance throughout this project. This cruise could not have succeeded without their support. Elizabeth Caporelli provided coordinated clearances, logistics, and shore-side support, consistently finding ways to ease the difficulties involved in this remote field program. Jim Johnson, Eric Boget, Paul Aguilar, and Keith Magness (APL-UW) prepared mooring hardware for the Davis Strait deployments. Dr. Kumiko Azetsu-Scott (Bedford Institute of Oceanography) and Dr. Mark Warner (University of Washington) supported the marine chemistry program. This project is sponsored by the National Science Foundation Office of Polar Programs under grant OPP02300381.

Abstract

As part of the Freshwater Initiative sponsored by the National Science Foundation Office of Polar Programs, a team of scientists from the Applied Physics Laboratory of the University of Washington and the Bedford Institute of Oceanography are investigating freshwater exchange through Davis Strait. This 300-km-wide strait sits between Baffin Island and the west coast of Greenland and acts as the gateway for waters passing between the Canadian Arctic Archipelago and the subpolar North Atlantic. In autumn 2004 the R/V *Knorr* cruise 179-05 undertook the first of three one-year mooring deployments. Six subsurface moorings, one off-axis sound source, eight bottom landers, and two Seagldiers were deployed successfully slightly north of the Davis Strait sill. Four cross-strait hydrographic lines, complete with sampling for chemical tracers, characterized water mass variability from the southern end of Baffin Bay to the northern tip of the Labrador Sea. The moored array will be recovered, serviced, and redeployed annually for a period of at least three years.

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1. Introduction

As part of coordinated domestic and international efforts to quantify the variability of fluxes connecting the Arctic and Atlantic oceans and to understand the role played by the Arctic and sub-Arctic in steering decadal-scale climate variability, we are developing an integrated observing system that will provide year-round measurements of volume, liquid freshwater, and ice fluxes across Davis Strait. Fluxes through the strait represent the net integrated Canadian Archipelago throughflow, modified by terrestrial inputs and oceanic processes during its southward transit through Baffin Bay. By the time they reach Davis Strait, arctic waters already embody most of the transformations they undergo prior to exerting their influence on the deepwater formation sites in the Labrador Sea. This makes the strait an ideal site for monitoring temporal and spatial variability of the critical upstream boundary condition for Labrador Sea convection. Measurements at Davis Strait will be used to study how fluctuations in the arctic freshwater system modulate deep water formation to the south, thus influencing the associated meridional overturning circulation (MOC). The system employs complementary techniques, combining mature technologies with recent developments in autonomous gliders to address all aspects of flow through Davis Strait, including some measurements that have not previously been technologically feasible. The components of the system include:

- A sparse array of subsurface moorings, each instrumented with upward looking sonar, acoustic Doppler current profiler (ADCP) and conductivity-temperature (CT) sensor at 100 m, along with conventional current meters and CT sensors at 300 m and 500 m, will provide time series of upper ocean currents, ice velocity, and ice thickness. These measurements will be used to estimate the ice component of freshwater flux, provide an absolute velocity reference for geostrophic shears calculated from Seaglider hydrographic sections, and derive error estimates for our lower-frequency flux calculations.

- Trawl and iceberg resistant bottom landers, instrumented with ADCPs and CT sensors, will be deployed across the Baffin and Greenland shelves to quantify variability associated with strong, narrow coastal flows.

- Acoustically navigated Seagliders will provide year-round, repeated, high-resolution hydrographic sections across the strait. The resulting sections will be combined with the moored array data to produce sections of absolute geostrophic velocity and to estimate volume and freshwater fluxes.

By quantifying, with robust error estimates, the spatial and temporal variability of the Canadian Archipelago throughflow at a location critical for assessing its impact on deep water formation in the North Atlantic, the observing system will make a major contribution to SEARCH and ARCSS objectives. In addition to the immediate impacts of improved estimates of freshwater inputs to the Labrador Sea, the array will provide an initial data set with which to study the relationships between arctic freshwater variability and large-scale atmospheric fluctuations [e.g., the North Atlantic Oscillation (NAO)]. The combination of emerging and existing technologies implemented in the observing system may serve as a prototype for accurate long-term monitoring of freshwater and ice fluxes in high-latitude environments subject to seasonal or permanent ice cover. Finally, acoustically navigated autonomous gliders capable of extended missions in ice covered environments will provide a significant new observational tool, opening important regions of high-latitude oceans to intensive measurement programs.

The Davis Strait measurement program began with mooring deployments and hydrographic surveys working from R/V *Knorr* (Fig. 1). Despite the climatologically poor autumn weather, the cruise was scheduled for 22 September to 4 October 2004 in order to minimize the chances of encountering sea ice. Efforts focused on deploying a moored array instrumented to measure velocity, temperature, salinity, and ice draft. The array included six subsurface moorings and eight bottom landers (deployed over the shallow Greenland and Baffin shelves). In conjunction with the oceanographic efforts, we deployed two 780-Hz RAFOS sound sources and six receivers in a configuration designed to provide a year-long record of attenuation as a function of distance, stratification, and overhead ice cover. The resulting data will inform the design of the acoustic navigation system that will be installed to support glider operations under the ice. We also carried two Seagliders that were part of a project focused on the dynamics of the wintertime Labrador Sea (Drs. Charles Eriksen and Peter Rhines, University of Washington). By agreement with Eriksen and Rhines, we planned to deploy both gliders in Davis Strait. The two vehicles would then collect a cross-strait section prior to transiting southward to avoid the onset of wintertime ice, augmenting whatever hydrography we obtain from the *Knorr*. Cruise objectives were (in order of priority):

1. Deploy all elements of the moored array, including an off-axis sound source
2. Deploy two Seagliders in the vicinity of Davis Strait
3. Hydrographic section along the mooring line
4. Hydrographic sections well north and south of the strait
5. High-resolution survey grid in the retroflection region southeast of the strait

An extended period of unseasonably good weather allowed us to accomplish our primary goals within the first half of the cruise. Mooring operations went smoothly, and two Seagliders were launched in 700 m of water on the Greenland side of the array. Following these operations we occupied four high-resolution hydrographic sections (Figs. 1–8). We conducted mooring line hydrography in conjunction with the deployments, and then moved north to occupy a section extending from Broughton Island (Baffin) to Disko (Greenland). Motivated by unexpected variability in the mooring line section over the Baffin slope, we chose to occupy an additional section (the Ross mooring line) within the strait. A final section from Cape Mercy to Sukkertop Banke characterized water mass variability south of the strait. Hydrographic stations included sampling for total inorganic carbon, total alkalinity, δO^{18}, CFC, nutrients, trace metals and mercury along the main mooring line and limited nutrient, CFC, and trace metal measurements on the northern and south mooring (66° 15′N) lines. Chemical oceanographers from the Bedford Institute of Oceanography and the University of Washington volunteered time and resources to support this small, but valuable, supplementary chemistry program. Time constraints prevented us from conducting the high-resolution retroflection survey.

This report begins with a narrative describing the activities undertaken during R/V *Knorr* 179-05, followed by a discussion of preliminary results from the four-section hydrographic program. A short section documents results from RAFOS tests conducted prior to deploying sources and receivers and provides information about the moored under-ice propagation experiment. The report concludes with tabular listings summarizing mooring and CTD deployments and a set of schematics that characterize the mooring configurations 'as deployed.'

2. Cruise Narrative

22 September

Depart Nuuk at 07:00 into deteriorating weather. *Knorr* remains in sheltered waters for fire and boat drills and orientation, sailing from the fjord at approximately 09:00. Following seas allow us to maintain speeds of over 12 kt and provide a comfortable ride.

Instrument testing reveals that one of our EG&G releases has failed in shipping. The battery pack has obviously out gassed, and there was a small amount of fluid in the pressure case. This release failed to acknowledge interrogation when bench tested, but did respond to the release command by releasing. We also noted that all of these older EG&G releases acknowledge DISABLE, but not ENABLE, commands. This one goes home for repair and will see use on the turn-around next year.

Seas get rougher as the day progresses. We arrive on station at the off-axis sound source site at 21:30. An attempt to initialize the trace metal bottle fails when three out of four bottles fire, but none successfully close to capture water. After consultation with the bosun and captain, we decide that conditions have deteriorated enough to make the sound source deployment very risky. All agree that risk to personnel and gear is high, especially because this will be our first mooring operation of the cruise and we will be sorting out procedures and learning to work together. The ship is also heaving enough to significantly increase the risk of damaging gear as it goes overboard. We choose to postpone the tests (source and releases) and source mooring deployment, and begin steaming for site C3. Given the promise of a good weather window in ~48 hr, we plan to execute the bathymetric survey from the center to the Greenland side with hydrographic stations at the appropriate sites. This may take us into improving conditions that will allow mooring operations to begin.

23 September

Choose ADCP sampling scheme that spaces 68 water pings and 7 bottom track pings at 23-sec intervals with 30-min ensembles. This will encounter limited interference with ULS transmissions (00:25–12:00, 12:25–00:00 at 5-min intervals, 00:00–00:25 and 12:00–12:25 at 10-sec intervals, samples last 0.5 sec), though discussions with Dick Moritz and Rebecca Woodgate (Polar Science Center, APL-UW) indicate that the loss is acceptable from the ULS perspective, and that the corrupted pings will be rejected by the ADCP (so that they will not contaminate ensembles). To minimize sampling overlap, we also offset the ULS clocks by moving them forward 1 min.

Arrive on site at C3 mid-morning to find workable conditions. Execute CTD profile while preparing the deck for mooring operations. Mooring deployment goes smoothly—all instruments over the side without mishap. A few regular steel cotter pins (which had been included with the stainless hardware we purchased) were deployed before the mismatch was noticed. Stainless pins were used exclusively in subsequent deployments. The anchor trip plate fashioned while dockside in Nuuk performed well. IBCAO bathymetry and multi-beam map match well in this region, which was largely flat with only the gentlest of slopes. We were thus able to find a site very near the original with the target depth, avoiding the need for an adjustment shot. We anticipate that anchor depth is within 2–4 m of target depth.

Although the release (sn 15707) tested well prior to shipping and again on the bench after loading out in Nuuk, we experienced difficulties when trying to triangulate the mooring site. Attempts to communicate with the release from distances of 2 n mi and less failed. We positioned ourselves directly over the anchor release site (probably within 200 m of the actual anchor position) and tried again. Attempts made with the transducer lowered to moderate depths failed. Dropping the transducer and additional 20 m allowed one of the two deck boxes (ours) to communicate reliably with the release. The other (borrowed from Polar Science Center, APL-UW) was unsuccessful. Some of our problems may be due to an unusually strong surface duct. The early CTD casts revealed a layer of warm water at 200–600 m. The layer is partially T-S compensated and exhibits strong interleaving features. The resulting profile departs significantly from climatology.

Weather deteriorates as evening progresses. Station ML08 (CTD and TM) goes smoothly, but we begin to question the wisdom of attempting a mooring deployment (C4). We instead elect to execute a hydrocast (ML09) and release test. We lower the three remaining EG&G releases (as a group, shackled head to tail with a safety chain bypassing the drop shackles) to 300 m and leave them for a 45-min cool-down soak. All three releases communicate successfully at the end of this period. We test cold temperature performance by firing each release immediately upon its return to the deck (before they begin to warm). All releases fire successfully. Following the test we begin transit to ML10. CTD at ML10 and then onward to C5.

24 September 2004

Arrive at site C5 around breakfast time with the unanticipated bonus of good weather and reasonably flat seas. While the hydro crew takes rosette and trace metal casts (ML11) C5 mooring prep commences. Mooring C5 deployed at 13:31 UTC without incident. Motivated by relatively benign conditions, we deploy Seagliders 014 and 015. Glider deployments are done using the *Knorr* trawl crane, with vehicles suspended from slings rigged with grease sticks. Launches go smoothly and both vehicles are functioning properly when we left the site. Transit to C6 and deploy mooring (21:53 UTC). One 100-m shot of Kevlar exhibits a severe kink and is thus replaced with adjustment shots. To provide a break for the hydrography crew, we skip sampling and proceed directly to WG1. Deploy WG1 (very simple near-bottom mooring to support the LongRanger ADCP) at 23:57 UTC and then return to C6 for hydrographic sampling.

A few lessons from the first few days:

- Need to assemble a glider spares kit that will travel whenever we are conducting glider operations. This will include a full selection of fasteners (all types), a couple of spare communications cables, dummy plugs for the communications port, wands, etc. This is to be carried in addition to the normal load of gear. The spares Pelican is not intended for day-to-day use, only as a ready supply of critical components to recover from losses while in the field.

- Need to recheck mooring diagrams. We discovered several discrepancies between the diagrams and the actual designs.
- Inspect Kevlar for damage during deployment. May want to mark off the spare reel in sensible increments to make it easier to fabricate longer replacement shots. Would need the ability to replace a 500-m piece.
- Need a roller to protect Kevlar as it goes over the transom. Rough, rusted spots have the potential to damage the line, and the method of deployment we are using (block suspended from crane, bull line across deck to stop off) runs the cable directly over the transom.

25 September

Hydrographic sampling at ML 12 (C6), 13 (WG1), 14 and 15 (WG2) during the night. On station at WG2 in morning. First attempt to deploy lander with IceCAT (ice threatened conductivity and temperature) fails when the IceCat float works loose of the temporary slings binding it to the lander housing. This is tricky because the linkage must hold through the actual lander deployment but fail shortly afterward to free the IceCat float. We devise a more stable mounting scheme and redeploy, but increased stress on the dissolvable link that holds the float release together causes it to fail, again releasing the float prematurely. This time, the lander is fairly deep when the float releases. On the third attempt the weak link fails, detaching the IceCat float from the lander. We retrieve the float, but because the lander has been released, cannot reaffix it to the frame. Inspection reveals that the IceCat mooring wire slipped into the opening between the PVC cylinder and the bottom Viny float. We speculate that this created a loop that caught one of the release frame's legs. The resulting tug parted the link and prematurely released the float. One obvious fix is to tape the seam between the Vinys and the PVC tube. An alternative method of time-released float attachment is also needed.

During lander deployments at WG3 (ADCP frame) and WG4 (MicroCAT) we have trouble communicating with the Benthos releases. Because the *Knorr* was in dynamic positioning mode over the mooring sites, thruster noise may be an issue. Other sources of contamination (multi-beam, echo sounder) were shut down. The 75-kHz ADCP continued to operate during the interrogations, though it seems unlikely that this was the noise source. In one instance the ADCP frame was brought back to the surface because we were unable to ascertain whether it had been released. Trawl winch tension provides another potential indicator. The MicroCAT frames present a large, flat sail area and must thus be lowered slowly (5 m min^{-1}) to maintain tension on the wire. Even at these speeds, tensions are extremely small. A successful release produces a small, but permanent, shift (or offset) in the line tension, though this can be difficult to discern through the noise.

The hydrographic station nearest the Greenland coast was shifted offshore to comply with the 3 n mi sampling restriction specified by the Danish government in our clearance. There are wonderful views of the coastline from the nearshore station. After completing the ML18 we set course for S1, the southern acoustic source site we bypassed due to poor working conditions.

As we enter the shallow waters of the Greenland shelf, the multi-beam data become less reliable (Amy Simoneau, SSSG technician, says that the threshold is ~100 m) and the 8-m bins and corresponding blanking range of the shipboard ADCP provide only a small number of bins through the water column. We choose to continue multi-beam data collection, in the event that the measurements can be filtered in post-processing. As an experiment we switch to 4-m bins (75-kHz ADCP) for part of the Greenland shelf operations. When departing the shelf we switch back to 8-m bins when we reach the 100-m isobath.

During the day's CTD casts we noticed an offset between primary and secondary conductivity/salinity. The two cells are ~0.1 psu apart, indicating problems with one or both sensors. We brought three freshly calibrated SBE T-C pairs taken from our towed profiling gear, and will use one of these pairs to evaluate the performance of the *Knorr* sensors once we reach the sound source mooring site.

26 September

Arrived at south source site late into the night following an eight-hour transit. Operations begin with a RAFOS receiver test. We program one source to transmit frequently and lower it, along with a receiver, on the trawl wire. The pair remain at 250 m for approximately 45 min, such that the receiver listens through several broadcasts. Data obtained upon recovery indicate that both source and receiver are working as expected.

In ordered to determine which (if any) of the *Knorr* conductivity cells is returning good data, we perform a comparison test using one of our own freshly calibrated sensors. We first remove the *Knorr* secondary, replacing it with our (Integrative Observational Platforms, IOP) sensor. Comparisons between *Knorr* primary and IOP conductivity cells reveal little difference—typically a few thousands in the resulting salinity. Comparisons between the *Knorr* secondary and an IOP sensor reveal salinity differences of tenths. We will use *Knorr* primaries to derive salinity for all casts prior to those on 26 September, and will use the IOP sensor as a secondary for the remainder of the cruise.

After reprogramming the source we deploy the southern source mooring. One 50-m adjustment shot is used to obtain correct source depth. Following this, we make the seven-hour steam to site C4, which we also bypassed earlier in the cruise due to poor operating conditions. This time the mooring deployment goes without incident. We then transit to site C2, deploying our second mooring of the day.

The CTD fails while preparing for deployment following C2. We trace the initial fault to the ground wire separating at the attachment point to the sea cable termination. This is a simple crimp connector and thus easily fixed. The second problem was a failure of one of the serial connectors that plumb the acquisition computer to the deck box. This may have happened when we rotated the rack out to facilitate access to the SB11 back panel. This was easily remedied. This late night cast involved some time pressure, as we were trying to lower an acoustic receiver on the rosette frame in ordered to sample a transmission from the southern source. Although we managed to make the transmission schedule, the receiver (at 200 m) failed to acquire the source signal. However, a second attempt (receiver at 150 m) directed at hearing a later transmission from the C3 source was successful.

Hydrographic profiles collected in the western half of the strait as part of the main line section reveal a layer of warm, saline water beginning at approximately 200 m. This core has water mass characteristics similar to those of the Irminger waters that move northward below the surface along the Greenland slope.

27 September

We transit to site C1 to deploy the last subsurface mooring. Problems with our EG&G deck boxes prevent us from interrogating the release after deployment. To optimize time and ensure a large daylight window for working near the Baffin coast, we elect to depart without successfully communicating with the release, planning to return after deploying the Baffin shelf landers.

Because the Baffin shelf landers were configured to provide some measure of vertical (as well as lateral) resolution, site depth is important. We thus begin by conducting a multi-beam bathymetric survey extending to the 50-m isobath, extremely close to the Baffin coast. The bottom appears to vary smoothly, with few prominent features. However, we approach very close to shore before encountering the 50-m isobath. This, combined with swift currents and drifting ice, complicates station keeping and lander (BI1) deployment. The *Knorr* maneuverability and dynamic positioning system thus play important roles when operating over the Baffin shelf. Following this we deployed a lander (BI2, complete with IceCat) at the 75-m isobath. Considerable effort was invested in devising a new two-stage IceCat release scheme. During previous deployments the float released while the lander was being lowered to the seabed, probably because we were unable to secure it tightly enough to protect from wave action. Cinching the securing lines tightly placed too much strain on the dissolvable links that were (eventually) supposed to release the float. We abort the first deployment of BI2 due to communications problems with the deployment frame's Benthos release. The IceCat deployed prematurely, but unspooled properly and was streaming away from the lander, suggesting that it would have deployed successfully. For the second deployment, a long piece of polypropylene formed a yoke from the lander bottom leading to the deployment frame release. This load-bearing security harness holds the float tight against the lander body during deployment, but releases when the deployment frame separates from the lander. The float deploys approximately two days afterward when a dissolvable link releases a simple retention line. Acoustic communications problems are solved by switching to a more robust protocol. The second deployment is successful.

The third site (BI3) consists of an ADCP tripod deployed at the 100-m isobath. Midway through the initial deployment, the recovery float surfaced. The recovery float release is fitted with a jaw extension that holds the float retention line under tension. The jaw notch was too shallow, thus allowing the line to escape. Another contributing factor was likely the compression of the float retention line on the drum as the lander was lowered. After deepening the notch to provide a more positive catch and shimming the plate holding the float line on the drum (thus increasing the tension on the notch), the lander deployment proceeded normally.

We deployed a bottom lander (Microcat only) at the fourth site (BI4, 150 m) just prior to midnight (local), thus completing the moored array. A conventional mooring would probably have been acceptable for this site and would have offered easier deployment. Following this last deployment we finished the main line hydrographic casts (filling out sampling on the Baffin side) and revisited site C1 to interrogate the release with our recently resurrected deck set. These tasks proceeded rapidly, allowing us to turn north toward the Baffin shelf end of our second hydrographic section.

28 September

We arrive at the first site for another spectacular view of the Baffin coast. Hydrographic casts proceed rapidly, due both to the shallow depths and relatively small quantity of chemical sampling. Station lengths increase with increasing water depths. We conduct some nutrient and CFC sampling, primarily directed at the bottom waters, Greenland shelf, and major currents.

29 September

Continue northern line hydrographic stations, working through the southern end of Baffin Bay.

30 September

Finish northern line hydrographic section with a series of casts over the Greenland shelf leading into Disko Island. A close look at the main line data suggests that the anomalous warm, salty West Greenland water seen on the western side of Davis Strait may extend into southern Baffin Bay near the base of the Baffin Island slope.

1 October

We occupy the southern main line hydrographic survey, situated over the old Ross mooring/hydrography line. A subsurface ridge divides the strait at this latitude, complicating flow patterns. We choose to sample here because we suspect that the inflowing Irminger water may branch when it encounters the mid-strait ridge, with one leg flowing northward along the Greenland slope and another producing the warm, saline core observed farther north along the western side of the strait. Ultimately, this section reveals a weak, thinner subsurface maximum in temperature and salinity that extends across the strait from the region of northward flowing Irminger water over the Greenland slope.

Pilot whales pass close to *Knorr* and loiter through a cast, providing a great viewing opportunity. The pod includes several adults and at least one juvenile.

2 October

As we approach the Baffin coast on the south main line, CTD primary–secondary salinity differences take a sharp jump within the upper 60 m. Both sensors perform well in vertically uniform regions, but the secondary exhibits severe spiking where conditions change rapidly with depth. This appears to be either a pump or plumbing problem. The evening shift replaces the secondary conductivity cell. They find that the Woods Hole Oceanographic Institution (WHOI) spare may be off calibration, and fails to resolve the spiking problem. Later (at SML 02) we exchange the secondary pump for one of our own and replace the Y-tube and purge assembly. Spiking vanishes and secondary performance at SML 02 is as good or better than that of casts earlier in the cruise, suggesting that the problems lie either with the pump or the connecting plumbing. The SSSG technician notes that she was unable to pass a cleaning needle through the purge hole (though the needle may have been too large), suggesting that clogged plumbing drove the problems. In any event, the IOP pump will remain on the CTD for the rest of the cruise.

We complete the southern mooring line (Ross line) and steam to the start of the southern line.

3 October

Continue occupation of southern line. Concerns about deteriorating weather and strong southerly winds may slow the return transit to Nuuk, reducing the time available to complete the section. The western half of the section reveals a broad, thick subsurface temperature and salinity maximum that we associate with Irminger waters that have turned westward and southward at the southern entrance to Davis Strait. The mid-morning time estimate indicates that we are well ahead of schedule, so we decide to make an excursion to the north (from SL 11), taking a gamble in an effort to sketch the northern extent of the flow. Unfortunately, we run out of time before we come to the end of the feature, and must return to the southern line to resume sampling. We finish the southern line around 23:00 and immediately set course for Nuuk. The poor weather has not materialized and we make good time.

4 October

The *Knorr* ties up dockside in Nuuk at 09:00, concluding the cruise.

3. Hydrography Results

Mooring (Main Line) Section, Davis Strait

Near isothermal-isohaline conditions dominate the West Greenland shelf with temperatures from 4.3 to 4.7ºC and salinities from 32.6 to 32.8 (Figs. 9 and 10). The hydrographic survey found warmer than normal (T > 4ºC), West Greenland Current waters over the slope, and near bottom waters (T between 1 and 2ºC) on the eastern side of the strait. At ML04 (C1/C2) CTD station (CTD15, base of the Baffin Island slope) there was a deep warm layer about 200 m thick with maximum temperature of about 5.35ºC, the highest seen on the section, salinity 34.9 at 400 m. Temperature was above 3ºC at 335–500 m. Compared to the long-term mean distribution, this was above normal and quite possibly has not been observed to date. It is also characterized by a flattening of the generally west to isopycnal shoaling. The deeper T–S characteristics at this station are the same as West Greenland Current water characterized, for example, by the hydrographic properties at ML11 (C5) and ML12 (C6) (Fig. 10). This could represent a return flow of West Greenland Current water that has split off from the main flow on the eastern side of the strait or a northward-flowing, ephemeral branch of the West Greenland Current.

The cold intermediate layer of "arctic water" (T < 0ºC, S < 33.7) extended from just below surface to about 300 m, stretching from the Baffin coast two-thirds the distance across the strait. The 600–1000-m deep water was between 1 and 2ºC, about 1ºC warmer than usual.

Sea surface temperatures and salinities increased from west to east across the strait by 3.5ºC and 1.8. Most of this change occurred over the West Greenland slope.

Shallow water on both sides of the strait exhibited saturated dissolved oxygen concentrations, with higher subsurface saturations on the West Greenland slope relative to those over Baffin slope. Not surprisingly, the deep waters had the lowest saturations. The dissolved oxygen sensor (Seabird Electronics SBE43) responds slowly with a strong temperature dependence, and can thus experience problems in regions having large temperature gradients (such as Davis Strait). Moreover, we noticed that the surface saturations were typically 5–20% below the expected 100–115% values. However, overall we expect that the relative concentrations are qualitatively correct.

Northern Line, Broughton Island to Disko Island

On the western side of southern Baffin Bay, a 30-m layer of about 1ºC, 31 overlay a subsurface layer of arctic water that reached 300 m in thickness on the western side of the bay (Fig. 11).

Hydrographic profiles from the southern end of Baffin Bay revealed classic structures over the deepest region of the section (e.g., NL08, 10 and 11; Fig. 12): a 250-m thick upper layer of arctic water overlying a 750-m layer of West Greenland intermediate water (T ~ 1ºC, S ~ 34.4). Baffin Bay deep water (T 0–1ºC, S 34.4–34.5) formed the bottom layer (1000–1700 m). A warm (2–3ºC), salty (to 34.5) layer was observed between 300–500 m just west of the central axis of southern Baffin Bay (NL09-11, Figs.

11 and 12). This may be associated with the exceptionally warm, salty core found on the western side of the mooring line section. The T–S characteristics of these warm, salty patches are essentially identical (Fig. 10 and 12).

Arctic water projected onto the West Greenland Shelf as a near-surface, 50-m thick layer. It overlay relatively warm, salty West Greenland Current water that extended from about 500 m depth along the upper slope onto the shelf. The warmest surface temperatures were observed on the West Greenland shelf, reaching 4.4ºC over the inner half. Near-surface salinities of 33.3 were also the highest found along the section.

Sea surface temperatures (salinities) increased by 3ºC (2) from west to east across the strait, with most of the change occurring over the West Greenland slope.

The outstanding dissolved oxygen feature was the low saturation (50–60%) associated with the West Greenland intermediate water and the additional decrease (30–50%) in the Baffin Bay deep water. Dissolved oxygen decreased nearly linearly with depth, with the slopes varying between the two water masses.

South Main Line, 66º 15’ N, along Ross mooring line 1987–1990

South of the mooring line, arctic water extended 200 km eastward from the Baffin coast to the base of the West Greenland slope in a 220-m thick near surface layer (Fig. 13 and 14). The layer is nearly pinched off about halfway across its extent. Below this, a tongue of West Greenland Current water extended westward from the West Greenland slope, nearly reaching the Baffin coast. Warm (>5ºC), saline (to 34.8) shelf water penetrates to the base of the slope. A ridge that runs southward from the section’s center complicates local hydrography and circulation. Sea surface temperatures were above 4ºC over the West Greenland shelf and slope, separated from waters to the west by a sharp sea surface temperature front (2ºC) situated over the slope.

Isopycnal slopes undergo multiple changes across the section, implying reversals in cross-section shear. Beginning on the western side of the line, isopycnals slope upward to the east for about 50 km, implying southward flow; the slopes reverse over the next 50 km indicating northward flow. Assuming geostrophic flow that vanishes at the bottom, we roughly estimate sea surface slopes of 0.08 m over 50 km, implying a surface current of about 0.12 m s^{-1}. However, these assumptions also imply a southward-flowing (or at best very weak) West Greenland Current, inconsistent with both long-held and contemporary thinking about the nature of this flow. Long-term averages of archived potential density sections show broad, upward sloping (west to east) isopycnals across the strait with a sharp downward turn over the upper West Greenland slope and shelf, consistent with expectations of a northward flowing West Greenland Current. Although the mooring line section (Fig. 9) exhibits this slope reversal, the section immediately to the south (Fig. 13) does not.

Dissolved oxygen saturations ranged from about 60–100% with lower values characteristic of the deeper, colder waters along the section’s western side.

Southern Line, Cape Mercy to Sukkertop Banke along 65º 2’ N

The 200-m thick wedge of arctic water observed in the northern sections extends 200 km from the Baffin coast in our southernmost line (Fig. 15). West Greenland Current waters appear as far west as SL05 (at 200 m), only 100 km from Baffin Island. Temperature and salinity increase eastward within this layer. The West Greenland Current dominates water mass variability along this section (Figs. 15 and 16). Isopycnal slopes imply broad southward flow between the Baffin coast and SL13. Slopes reverse east of SL013, implying northward shears consistent with a north-flowing West Greenland Current. Dissolved oxygen saturations of ~80% characterized the entire section.

Sea surface temperature (salinity) increased by 4ºC (1.5) from the Baffin coast to 58.5º W. Surface temperature then remained roughly constant to the Greenland coast, while salinity decreased by ~0.6.

Hydrographic and Chemical Sampling Notes

Saturday, 25 September, primary and secondary CTD salinity sensors typically disagree by about 0.09 (P-S=0.09), with secondary cells exhibiting clearly erroneous values. Replaced WHOI secondary with a sensor provided by the APL-UW group. WHOI primary calibrated January 2004, secondary November 2003.

Later in cruise, a faulty pump on the secondary T–C pair provided sluggish flow rates, which produced large spikes in secondary salinities (see Table 8, CTD 58–60 comments). Ship supplies did not include a spare pump, so an APL-UW pump was substituted. A stock of CTD sensors and pumps brought aboard by APL-UW enabled both sensors to remain operational.

Problems encountered during hydrographic sampling suggest the collection of salinity samples for post-cruise comparison in future years. However, only one salinity sample was collected (station 13) on this cruise.

Operation of CTD is somewhat cumbersome relative to that on some Canadian high-latitude vessels. Recovery requires hooking of CTD frame and use of tuggers to bring CTD package aboard. Deployment is more straightforward. It required three from the science party to stand a CTD watch.

Altimeter performance was variable throughout the cruise, generally better in the last half than the first. Bottom proximity alarm failed to sound when the starting depth was within the range of the altimeter and the altimeter detected the bottom from the surface.

Availability of technical support was very helpful.

Ship’s SST and SSS loggers helped to define surface fronts between stations. SST and CTD shallow temperatures agreed very well, SSS was consistently about 0.7 low compared to CTD readings.

Recommendations for drawing water samples:

CFCs

- N_2 flow control needs improvement; regulator was difficult to adjust for low flows required during sealing
- More robust storage container for drawn samples, both for storage and shipping
- Splash guard should be tapered to seal off stainless tube when samples are drawn; this would aid sampling greatly
- Gas cylinders should have inside storage during transit; they arrived in Nuuk with caps seized requiring a day of treatment with CFC-free lubricating oil

Nutrients

- More level trays (rust-free) for taking and storing samples during freezing stage
- More gloves

TIC/TALKS

- Improved pre-cleaning of the ground glass stoppers

Trace metals, Hg

- Better designed laminar flow hood; to handle noxious materials, a sealed, gloved Br dispensing hood inside the fume hood is necessary at sea
- More gloves

General

- Salinity bottles cleaned on the outside as well as the inside inspires user confidence
- The stainless steel weight to provide tension for the clean wire cast was clearly too light in all but the calmest of conditions. Our normal cast was to 200 m; in the moderate seas at the beginning of the cruise, wire angles approached 45º. A weight (about 2–3 times heavier) provided by the ship was wrapped in a heavy plastic bag and suspended 20 m below the deepest bottle.
- If possible, ensure sampling area is smoke-free
- An ambitious chemical program and poor weather created a demanding workload for the hydrography team and especially for the sole chemist; two experienced chemical technicians should be assigned to support this level of sampling in future cruises

4. RAFOS Test Results

On the morning of 26 September 2004 we lowered SS31 (a 780-Hz RAFOS source) and RAFOS receiver 1–250 m at the off-axis sound source site. The source was programmed to transmit every 10 min. Before deployment the clock was faked to a time prior to midnight so that the 'window' would open shortly after lowering (at 00:00 faked) with the transmission schedule beginning thereafter (00:10 faked). The receiver came on at 395 sec past each 10-min mark. As in normal operation, pairs of starts alternated between raw mode and correlation mode, beginning with two raw listens. In raw mode, the receiver wakes at the specified time and spends 180 sec determining an appropriate gain setting. It then acquires 65344 samples at 346.6667 Hz (4/9*780) or ~188.5 sec of data. Samples are 8-bit signed integers. In correlation mode the receiver turns on and gathers correlations for 420 sec. At the end of this period the receiver module is queried and reports back the three highest correlations and the indexes at which they occurred. Correlations are gathered at 5.417 Hz (4/9*780/64) and reported as an unsigned 8-bit quantity.

Lowering commenced at approximately 06:05 (UTC) and was complete by 06:20. Maximum correlations were:

UT	correlation	index	t (day hour)
0606	116	1295	6.16697
0636	197	1298	6.66696
0646	131	1299	6.83665
0716	132	1298	7.33365
0726	150	1298	7.50029

Raw results show a gain setting near 128 (midpoint, approximately 20 dB from variable gain stage). The raw data from the 06:26:35 reception actually begins at approximately 06:29:40 (3 min for gain fixing plus a 5-sec start-up time). The test transmission from SS31 saturates the 40-sec period between 06:30:00 and 06:30:40. The 0630 transmission from SS32 should arrive at site C3 approximately 100 sec past 06:30, or approximately 120 sec into the raw record. Following this test SS31 was deployed on the off-axis source mooring.

At 03:00 27 September 2004 (UTC), RAFOS receiver 1 was re-programmed for correlation mode listening, attached to the CTD rosette frame, and lowered to 250 m at the C-2 mooring site. The receiver was situated at 250 m for the SS31 03:30 transmission (a source located roughly 180 km away). Maximum correlation was 42 at 3.51875, a value that is seldom, if ever, significant. The receiver was lowered to 150 m at 06:30 to listen for a transmission from SS32, located on the C-3 mooring 48 km away. Maximum correlation was 95 at 6.51013 hours, indicating a 53-km range. Correlations of 95 are on the low side of typical significant correlations.

Following this test RAFOS receiver 1 was re-programmed to a 3-hr interval (10800 sec) with starts 1635 sec past the 3-hr marks. SS32 broadcasts at 00:30, 06:30, 12:30, 18:30 (UTC) from C-3. SS31 broadcasts at 03:30, 09:30, 15:30, 21:30 (UTC) from the off-axis site. Both sources are set at 250 m depth to minimize the chance of iceberg encounter. Receivers were deployed on moorings to provide a range of separations and depths. RAFOS 1 was deployed on the mooring C-1 at 150 m. C-2 carries RAFOS 2 and 6 at 150 m and 300 m. C-3 carries RAFOS 3 at 150 m. C-5 has RAFOS 4 and 5 at 150 m and 300 m. Source–receiver ranges are:

source	receiver	range (km)
SS32 on C-3	1 on C-1	78
	2 on C-2	48
	6 on C-2	48
	3 on C-3	0
	4 on C-5	85
	5 on C-5	85
SS31 on OA	1 on C-1	210
	2 on C-2	185
	6 on C-2	185
	3 on C-3	153
	4 on C-5	120
	5 on C-5	120

5. Moorings and Hydrographic Stations

Table 1. *Davis Strait Mooring and Hydrographic Sites (West to East)*

Mooring	Mooring Deployment Time (UTC)	Hydro Station	Latitude (N)	Longitude (W)	Depth (m)	Notes
S1	-	-	65 58.007	56 19.958	535	RAFOS source.
BI1	27/09/04 15:52	-	66 39.8839	61 16.1437	55	Lander
BI2	27/09/04 21:43	ML01	66 39.4211	61 12.3997	81	Lander w/ IceCat, CTD
BI3	28/09/04 00:27	-	66 39.4648	61 12.2250	99	Lander w/ ADCP
BI4	28/09/04 01:35	-	66 39.6062	61 10.1156	150	Lander
-	-	ML02	66 40.50	60 58.42	-	CTD, TM
C1	27/09/04 12:16	ML03	66 41.5263	60 46.8288	450	Mooring, CTD
-	-	ML04	66 43.92	60 28.51	-	CTD
C2	27/09/04 02:10	ML05	66 45.6648	60 04.4616	659.4	Mooring, CTD, TM
-	-	ML06	66 49.59	59 37.07	-	CTD
C3	23/09/04 15:17	ML07	66 51.4129	59 03.6852	1038.7	Mooring, CTD, TM
-	-	ML08	66 56.18	58 22.74	-	CTD
C4	26/09/04 15:43	ML09	66 58.8868	57 41.1202	870.25	Mooring, CTD, TM
-	-	ML10	67 01.13	57 21.95	-	CTD
C5	24/09/04 13:31	ML11	67 02.1618	57 02.2977	700.1	Mooring, CTD, TM, TM Launch Seagliders 014 and 015
C6	24/09/04 21:53	ML12	67 04.1647	56 40.8859	393.4	Mooring, CTD, TM
WG1	24/09/04 23:57	ML13	67 06.242	56 19.340	151.4	75 KHz ADCP, CTD
-	-	ML14	67 09.680	55 49.320	-	CTD
WG2	25/09/04 13:20	ML15	67 11.5743	55 18.6631	74.9	Lander w/ IceCat, CTD, TM
WG3	25/09/04 15:45	ML16	67 13.800	54 51.590	57	Lander w/ADCP, CTD
WG4	25/09/04 18:00	ML17	67 15.801	54 28.788	56	Lander, CTD
-	-	ML18	67 18.500	54 01.000	-	CTD

Table 2. *Mooring Line Hydrographic Stations (ML)*

Site	Time (UCT)	Target Latitude (N)	Target Longitude (W)	Latitude (N)	Longitude (W)	Depth (m)	Notes
ML01	27/09/04 22:07	66 39.17	61 15.48	66 39.42	61 12.66	73	
ML02	28/09/04 02:42	66 40.50	60 58.42	66 40.39	60 58.90	60	
ML03	28/09/04 13:42	66 41.61	60 48.58	66 41.41	60 48.38	442	
ML04	27/09/04 08:58	66 43.92	60 28.51	66 43.40	60 29.95	539	
ML05	27/09/04 04:51	66 45.64	60 04.27	66 45.33	60 08.59	598	
ML06	26/09/04 22:48	66 49.59	59 37.07	66 49.61	59 37.42	923	
ML07	23/09/04 10:35	66 51.14	59 03.62	66 50.69	59 05.06	1064	
ML08	23/09/04 21:52 22:35	66 56.18	58 22.74	66 56.27 66 56.37	58 22.61 58 22.61	1013	
ML09	24/09/04 04:20	66 58.69	57 40.48	66 58.46	57 39.99	849	
ML10	24/09/04 07:37	67 01.13	57 21.95	67 00.95	57 22.31	803	
ML11	24/09/04 09:20 14:30	67 02.16	57 02.33	67 02.36 67 02.12	57 01.97 57 02.29	686	
ML12	25/09/04 01:38 03:04	67 04.13	56 40.61	67 04.45 67 05.40	56 41.65 56 42.20	389 384	
ML13	25/09/04 05:32	67 06.30	56 18.60	67 06.40	56 18.14	166	
ML14	25/09/04 07:30	67 09.68	55 49.32	67 09.72	55 49.37	121	
ML15	25/09/04 09:16 10:38	67 11.55	55 18.93	67 11.62 67 11.76	55 18.60 55 18.62	73 71	
ML16	25/09/04 15:07	67 13.80	54 51.60	67 13.80	54 51.58	60	
ML17	25/09/04 18:18	67 15.80	54 28.80	67 15.80	54 28.79	56	
ML18	25/09/04 19:46	67 18.98	53 57.06	67 18.67	54 00.60	29	
SSRC	26/09/04 05:20	65 58.00	56 20.00	65 57.03	56 20.41	539	

Table 3. *Northern Line Hydrographic Stations (NL)*

Site	Time (UCT)	Target Latitude (N)	Target Longitude (W)	Latitude (N)	Longitude (W)	Depth (m)	Notes
NL01	28/09/04 16:26	67 28.18	63 09.43	67 28.09	63 09.28	58	
NL02	28/09/04 17:40	67 32.84	62 57.77	67 32.90	62 57.55	98	
NL03	28/09/04 18:40	67 37.50	62 46.11	67 37.52	62 45.97	132	
NL04	28/09/04 19:35	67 40.63	62 36.57	67 40.62	62 36.35	666	
NL05	28/09/04 21:05	67 43.37	62 29.23	67 43.28	62 29.19	931	
NL06	28/09/04 22:16	67 46.10	62 21.89	67 46.12	62 21.72	1006	
NL07	29/09/04 00:26	67 50.76	62 13.51	67 50.79	62 14.13	1113	
NL08	28/09/04 02:14	67 55.08	62 03.36	67 55.05	62 03.14	1420	
NL09	29/09/04 04:46	68 02.89	61 46.24	69 02.91	61 46.44	1663	
NL10	29/09/04 07:17	68 10.69	61 29.12	68 10.64	61 29.44	1706	
NL11	29/09/04 11:12	68 18.50	61 12.00	68 18.49	61 12.29	1700	
NL12	29/09/04 14:10	68 23.73	60 29.94	68 23.66	60 29.57	1605	
NL13	29/09/04 16:15	68 26.32	60 09.12	68 26.27	60 08.84	1451	
NL14	29/09/04 17:54	68 28.04	59 55.25	68 28.09	59 55.55	1260	
NL15	29/09/04 19:30	68 29.77	59 41.37	68 29.61	59 41.16	861	
NL16	29/09/04 21:06	68 31.50	59 27.49	68 31.47	59 27.46	591	
NL17	29/09/04 22:01	68 32.36	59 20.55	68 32.24	59 20.73	519	
NL18	29/09/04 23:20	68 34.19	59 05.83	68 34.19	59 06.03	305	
NL19	30/09/04 01:30	68 39.43	58 23.78	68 39.50	58 23.95	312	
NL20	30/09/04 04:09	68 44.66	57 41.72	68 44.68	57 42.88	274	
NL21	30/09/04 06:26	68 49.89	56 59.67	68 50.09	56 58.85	278	

Site	Time (UCT)	Target Latitude (N)	Target Longitude (W)	Latitude (N)	Longitude (W)	Depth (m)	Notes
NL22	30/09/04 08:19	68 55.12	56 17.61	68 55.19	56 17.13	173	
NL23	30/09/04 10:16	69 00.35	55 35.55	69 00.37	55 35.26	136	
NL24	30/09/04 12:06	69 05.58	54 53.50	69 05.59	54 53.39	180	
NL25	30/09/04 14:01	69 10.00	54 18.00	69 10.06	54 18.13	115	

Table 4. *South Mooring Line (SML, Ross Line)*

Site	Time (UCT)	Target Latitude (N)	Target Longitude (W)	Latitude (N)	Longitude (W)	Depth (m)	Notes
SML01	02/10/04 06 :51	66 15.00	61 11.71	66 14.97	61 11.96	183	
SML02	02/10/04 05:10	66 15.00	60 45.14	66 14.94	60 45.30	403	
SML03	02/10/04 03:28	66 15.00	60 18.58	66 14.98	60 18.66	445	
SML04	02/10/04 01:49	66 15.00	59 52.01	66 15.02	59 52.44	603	
SML05	02/10/04 00:07	66 15.00	59 25.44	66 15.00	59 25.70	691	
SML06	01/10/04 22:28	66 15.00	58 58.88	66 14.90	58 58.85	656	
SML07	01/10/04 21:05	66 15.00	58 38.95	66 14.95	58 38.97	559	
SML08	01/10/04 19:35	66 15.00	58 19.03	66 15.02	58 18.95	640	
SML09	01/10/04 18:00	66 15.00	57 59.10	66 14.99	57 59.29	583	
SML10	01/10/04 16:37	66 15.00	57 39.18	66 14.83	57 39.25	540	
SML11	01/10/04 14:58	66 15.00	57 19.25	66 14.90	57 19.58	639	
SML12	01/10/04 13:24	66 15.00	56 59.33	66 14.96	56 59.67	653	
SML13	01/10/04 11:30	66 15.00	56 39.40	66 14.94	56 39.65	583	
SML14	01/10/04 10:18	66 15.00	56 19.48	66 14.97	56 19.51	173	
SML15	01/10/04 09:04	66 15.00	55 59.55	66 14.39	55 59.45	151	
SML16	01/10/04 06:56	66 15.00	55 19.70	66 14.93	55 19.95	197	
SML17	01/10/04 04:05	66 15.00	54 39.85	66 14.92	54 40.00	75	

Table 5. *South Line (SL)*

Site	Time (UCT)	Target Latitude (N)	Target Longitude (W)	Latitude (N)	Longitude (W)	Depth (m)	Notes
SL01	03/10/04 15:04	65 02.00	62 40.90	65 02.16	62 40.97	180	
SL02	03/10/04 16:50	65 02.00	62 02.70	65 01.97	62 02.20	275	
SL03	03/10/04 18:42	65 02.00	61 24.50	65 02.04	61 24.26	269	
SL04	03/10/04 20:28	65 02.00	60 46.29	65 01.98	60 46.14	288	
SL05	03/10/04 22:19	65 02.00	60 08.09	65 01.91	60 07.66	335	
SL06	03/10/04 00:16	65 02.00	59 29.89	65 02.01	59 29.22	435	
SL07	03/10/04 02:18	65 02.00	58 51.69	65 02.00	58 51.32	468	
SL08	03/10/04 03:30	65 02.00	58 32.59	65 02.07	58 32.85	511	
SL09	03/10/04 04:52	65 02.00	58 13.49	65 02.09	58 13.43	618	
SL10	03/10/04 06:16	65 02.00	57 54.39	65 02.14	57 54.59	677	
SL11	03/10/04 07:5	65 02.00	57 28.92	65 02.02	57 29.07	718	
SL11a	03/10/04 09:57	NA	NA	65 14.20	57 28.90	656	Off-axis to north.
SL12	03/10/04 11:48	65 02.00	57 03.45	65 02.12	57 03.49	715	
SL13	03/10/04 13:34	65 02.00	56 37.99	65 02.14	56 37.92	653	
SL14	03/10/04 15:07	65 02.00	56 12.52	65 02.08	56 12.53	781	
SL15	03/10/04 16:45	65 02.00	55 47.05	65 02.01	55 46.86	827	
SL16	03/10/04 18:21	65 02.00	55 21.58	65 01.98	55 21.32	756	
SL17	03/10/04 19:40	65 02.00	55 02.48	65 01.93	55 02.26	644	
SL18	03/10/04 20:56	65 02.00	54 43.38	65 01.98	54 43.24	353	
SL19	03/10/04 22:00	65 02.00	54 24.28	65 02.01	54 24.11	154	
SL20	03/10/04 23:17	65 02.00	53 58.81	65 02.07	53 58.30	91	
SL21	03/10/04 00:31	65 02.00	53 33.34	65 02.09	53 33.07	83	

Table 6. *Chemical Sampling Summary*

CTD No.	Site	TIC / TALK	dO18	Trace Metals	Hg	Nutrients[1]	Salinity	CFC	Bottom Depth (m)
Nuuk			2						
1	ML07	13	8			15		10	1064
2	ML08	-		4		4	4		1013
3	ML09	11	7			13			849
4	ML10								803
5	ML11	10	8	8	8	12+8	9	11	686
6	ML12	7	8	4		9+4	4	8	384
7	ML13	5	7			7			166
8	ML14	4	6			6			121
9	ML15	3	6	4		6+4	4	2	73
11	ML17	3	5			5			56
12	ML18					2			29
16	ML05	9	7	4	4	11+4	4	9	598
18	ML03	8	7			10			442
20	ML02	7	7	4	2	8+4	4	7	374
24	NL04					10		7	666
26	NL06					15		8	1006
30	NL10			4		11+4	3	11	1706
35	NL15					9			861
37	NL17					7			519
38	NL18					6			305
40	NL20					6			296
42	NL22					5			173
44	NL24					5			180
45	NL25					4			115
50	SML13							6	583
51	SML12							9	653
TOTAL		**80**	**76**	**32**	**14**	**213**	**32**	**88**	

[1]Only unique nutrient sampling depths are recorded. Duplicate samples were taken at most depths. Thus, the actual number of samples is about twice the 213 indicated.

Table 7. *Sequential Station Positions*

Site	Latitude (N)		Longitude (W)		Date (UTC)	Depth (m)	CTD No.	Trace Metal	Hg	Mooring	Ship Intake	
	Deg	Min	Deg	Min							SST	SSS
Nuuk	64	10.54	51	45.13	19/09/04 15:30	20						
off axis	65	58.37	56	20.42		539						
ML07	66	50.69	59	5.06	23/09/04 10:35	1064	1			y	1.65	30.45
ML08	66	56.27	58	22.61	23/09/04 21:52	1013	2				2.13	30.64
ML08	66	56.37	58	21.75		1011		TM				
ML09	66	58.46	57	39.99	24/09/04 4:20	849	3				3.37	31.71
ML10	67	0.95	57	22.31	24/09/04 7:37	803	4				4.32	32.16
ML11	67	2.36	57	1.97	24/09/04 9:20	686	5			y	4.47	32.15
ML11	67	2.12	57	2.29	24/09/04 14:30	699		TM	Hg		4.46	32.17
ML12	67	4.45	56	41.65	25/09/04 1:38	389		TM			4.33	32.13
ML12	67	5.4	56	42.2	25/09/04 3:04	384	6			y	4.37	32.13
ML13	67	6.4	56	18.14	25/09/04 5:32	166	7			y	4.66	
ML14	67	9.72	55	49.37	25/09/04 7:30	121	8			y	4.63	32.07
ML15	67	11.62	55	18.6	25/09/04 9:16	73	9			y	4.69	32.09
ML15	67	11.76	55	18.62	25/09/04 10:38	71		TM			4.67	32.11
ML16	67	13.8	54	51.58	25/09/04 15:07	60	10			y		
ML17	67	15.8	54	28.79	25/09/04 18:18	56	11			y	4.33	
ML18	67	18.67	54	0.6	25/09/04 19:46	29	12				4.62	
off axis source	65	57.93	56	20.41	26/09/04 5:20	539	13,14				4.74	31.75
ML09	66	58.46	57	39.99	26/09/04 18:00	849				y	3.27	31.74
ML06	66	49.61	59	37.42	26/09/05 22:48	923	15				1.31	30.12
ML05	66	45.33	60	8.59	27/09/04 4:51	598	16	TM		y	1.18	30.21
ML04	66	43.4	60	29.95	27/09/04 8:58	539	17				1.2	30.25
ML03	66	41.41	60	48.38	27/09/04 13:42	442	18			y	1.08	30.31
BI1	66	38.88	61	16.14	27/09/04 15:52	55.3				y		
ML01	66	39.42	61	12.66	27/09/04 22:07	73	19			y	0.57	30.57
BI3	66	39.46	61	12.22	27/09/04 0:27	98.8				y		

Site	Latitude (N)		Longitude (W)		Date (UTC)	Depth (m)	CTD No.	Trace Metal	Hg	Mooring	Ship Intake	
	Deg	Min	Deg	Min							SST	SSS
BI4	66	39.61	61	10.12	28/09/04 1:35	151.3				y		
ML02	66	40.39	60	58.9	28/09/04 2:42	374	20	TM			0.78	30.47
C1	66	41.41	60	48.38	28/09/04 7:30	442				release test		
NL1	67	28.09	63	9.28	28/09/04 16:26	58	21				0.7	30.36
NL2	67	32.9	62	57.55	28/09/04 17:40	98	22				0.8	30.51
NL3	67	37.52	62	45.97	28/09/04 18:40	132	23				0.76	30.44
NL4	67	40.62	62	36.35	28/09/04 19:35	666	24				1.09	30.38
NL5	67	43.28	62	29.19	28/09/04 21:05	931	25				1.03	30.39
NL6	67	46.12	62	21.72	28/09/04 22:16	1006	26				1.06	30.31
NL7	67	50.79	62	14.13	29/09/04 0:26	1113	27				1.14	29.99
NL8	67	55.05	62	3.14	28/09/04 2:14	1420	28				1.19	29.87
NL9	68	2.91	61	46.44	29/09/04 4:46	1663	29				1.39	30.24
NL10	68	10.64	61	29.44	29/09/04 7:17	1706	30				1.2	29.87
NL11	68	18.49	61	12.29	29/09/04 11:12	1700	31				1.1	29.74
NL12	68	23.66	60	29.57	29/09/04 14:10	1605	32				1.16	29.45
NL13	68	26.27	60	8.84	29/09/04 16:15	1451	33				1.19	29.49
NL14	68	28.09	59	55.55	29/09/04 17:54	1260	34				1.89	31.48
NL15	68	29.61	59	41.16	29/09/04 19:30	861	35	nuts			2.01	31.72
NL16	68	31.47	59	27.46	29/09/04 21:06	591	36				2.12	31.75
NL17	68	32.24	59	20.73	29/09/04 22:01	519	37	nuts			2.13	31.73
NL18	68	34.19	59	6.03	29/09/04 23:20	305	38	nuts			2.2	31.63
NL19	68	39.5	58	23.95	30/09/04 1:30	312	39				2.01	32.24
NL20	68	44.68	57	42.88	30/09/04 4:09	274	40	nuts			3.96	32.71
NL21	68	50.09	56	58.85	30/09/04 6:26	278	41				3.88	32.75
NL22	68	55.19	56	17.13	30/09/04 8:19	173	42	nuts			4.1	32.63
NL23	69	0.37	55	35.26	30/09/04 10:16	136	43				4.14	32.86
NL24	69	5.59	54	53.39	30/09/04 12:06	180	44	nuts			4.35	32.77

Site	Latitude (N)		Longitude (W)		Date (UTC)	Depth (m)	CTD No.	Trace Metal	Hg	Mooring	Ship Intake	
	Deg	Min	Deg	Min							SST	SSS
NL25	69	10.06	54	18.13	30/09/04 14:01	115	45	nuts			4.38	32.81
SML17	66	14.92	54	40	01/10/04 4:05	75	46				4.1	31.85
SML16	66	14.93	55	19.95	01/10/04 6:56	197	47				4.34	32.16
SML15	66	14.39	55	59.45	01/10/04 9:04	151	48				4.27	32.06
SML14	66	14.97	56	19.51	01/10/04 10:18	173	49				4.27	32.12
SML13	66	14.94	56	39.65	01/10/04 11:30	583	50	cfc			4.35	32.08
SML12	66	14.96	56	59.67	01/10/04 13:24	653	51	cfc			4.26	32.06
SML11	66	14.9	57	19.58	01/10/04 14:58	639	52				3.1	32.08
SML10	66	14.83	57	39.25	01/10/04 16:37	540	53				2.1	31.64
SML9	66	14.99	57	59.29	01/10/04 18:00	583	54				1.56	31.37
SML8	66	15.02	58	18.95	01/10/04 19:35	640	55				1.65	31.43
SML7	66	14.95	58	38.97	01/10/04 21:05	559	56				1.72	31.31
SML6	66	14.9	58	58.85	01/10/04 22:28	656	57				2.18	31.37
SML5	66	15	59	25.7	02/10/04 0:07	691	58				2.51	31.56
SML4	66	15.02	59	52.44	02/10/04 1:49	603	59				2.02	31.24
SML3	66	14.98	60	18.66	02/10/04 3:28	445	60				1.31	30.49
SML2	66	14.94	60	45.3	02/10/04 5:10	403	61				1.1	30.33
SML1	66	14.97	61	11.96	02/10/04 6:51	183	62				0.45	30.49
SL1	65	2.16	62	40.97	02/10/04 15:04	180	63				0.03	31.08
SL2	65	1.97	62	2.2	02/10/04 16:50	275	64				1.76	30.76
SL3	65	2.04	61	24.16	02/10/04 18:42	269	65				1.77	30.98
SL4	65	1.98	60	46.14	02/10/04 20:28	288	66				1.18	30.55
SL5	65	1.91	60	7.66	02/10/04 22:19	335	67				2.08	31.32
SL6	65	2.01	59	29.22	03/10/04 0:16	435	68				2.7	31.83
SL7	65	2	58	51.32	03/10/04 2:18	468	69				2.37	31.51
SL8	65	2.07	58	32.85	03/10/04 3:30	511	70				4.02	32.17
SL9	65	2.09	58	13.43	03/10/04 4:52	618	71				4.33	32.08

Site	Latitude (N)		Longitude (W)		Date (UTC)	Depth (m)	CTD No.	Trace Metal	Hg	Mooring	Ship Intake	
	Deg	Min	Deg	Min							SST	SSS
SL10	65	2.14	57	54.59	03/10/04 6:16	677	72				3.96	32.01
SL11	65	2.02	57	29.07	03/10/04 7:55	718	73				4.17	31.85
SL11a	65	14.2	57	28.9	03/10/04 9:57	656	74				3.88	31.17
SL12	65	2.12	57	3.49	03/10/04 11:48	715	75				4.03	31.79
SL13	65	2.14	56	37.92	03/10/04 13:34	653	76				3.94	31.6
SL14	65	2.08	56	12.53	03/10/04 15:07	781	77				3.87	31.46
SL15	65	2.01	55	46.86	03/10/04 16:45	827	78				3.84	31.70
SL16	65	1.98	55	21.32	03/10/04 18:21	756	79				3.91	31.58
SL17	65	1.93	55	2.26	03/10/04 19:40	644	80				3.77	31.38
SL18	65	1.98	54	43.24	03/10/04 20:56	353	81				3.77	31.30
SL19	65	2.01	54	24.11	03/10/04 22:00	154	82				3.83	31.34
SL20	65	2.07	53	58.30	03/10/04 23:17	91	83				4.07	31.54
SL21	65	2.09	53	33.07	04/10/04 00:31	83	84				4.04	31.53

Table 8. *CTD Event Log*

CTD No.	Comments
1	Trouble with winch readout, different depth than CTD pressure sensor; altimeter not registering; stopped 100 m off bottom; 1 m sample cracked when closing ampoule with torch; nitrogen flow regulator has poor control. Collected water for clean bottle soak; tried earlier but bottles did not close because we were cocking the bottles improperly on 2nd cocking operation. Consequently trace metal cast moved to next CTD station. Stainless steel weight too light in these seas and for 200 m depth cast.
2	The trace metal cast used ship's weight wrapped in plastic bag and 20 m below first bottle.
3	No water in 20 m rosette bottle. Bottom end cap caught on bottle rim.
5	Two trace metal and Hg casts. Length of clean wire limited bottom bottle to 550 m for safety. Captured core of WGC water very well. CFC 271641 at 497 m may have a pinhole in glass.
9	Trace metal cast as well as CTD-rosette. Because the depth was shallow and conditions were fairly calm, we used the stainless anchor attached 5m below the deepest bottle.
12	Surface bottle did not sit properly. Bottle drained in CTD hanger. Depth was jumping by ±5 m; discrepancies among wire out, sounder and altimeter. Final indication place deepest bottle about 4 m off bottom.
NOTE	Saturday, August 25, primary and secondary CTD salinity sensors typical disagree by about 0.09 (P-S=0.09). Secondary cell has some wild values. Swapped APL cell for secondary. WHOI primary calibrated Jan. 2004, secondary Nov. 2003. Changing secondary cell for one of APL's freshly calibrated.
13	WHOI primary, APL cell agree Acoustic site
14	WHOI secondary, APL cell disagree; offset about 0.091, WHOI secondary too high. Acoustic site. CTD now equipped with WHOI primary, APL sensor configured as secondary.
16	Electrical faults with CTD. Deck unit cannot communicate with carousel. Ground wire broken. Repairs made to system.
20	Had been storing CFC samples in chemical lab off main lab. Moved CFC samples to refrigerator. All subsequent samples stored in fridge.
28	Before cast, lanyard holding internal, Teflon-coated spring gave way on bottle 14. Decide to leave it as is and bypass bottle 14, if necessary.
45	Two shallowest depth nutrients had only one sample drawn because of lack of bottles. Used remaining dO^{18} bottles.
50, 51	Last cfc stations in WGC
58	The difference between the salinities measured by the 2 sensors has been growing. CTD 58 featured large, near-surface (0–60 m) spikes from the APL secondary cell. Will check pump connections at next station. CTD 57 also had spiking. Cells were in near agreement in the bottom mixed layer.
59	Again large spikes in the APL data. Decided to change to WHOI backup for next cast.
60	Spiking persists in cell connected to secondary sensor. WHOI backup also has an offset of about 0.4. Decided to replace the pump and trap (Y tube flow conduit). It is possible that spiking caused by deteriorating pump performance occurred as early as CTD 46. Reconnected APL cell as secondary.
61	Problem appears solved.

6. Mooring Diagrams (as deployed)

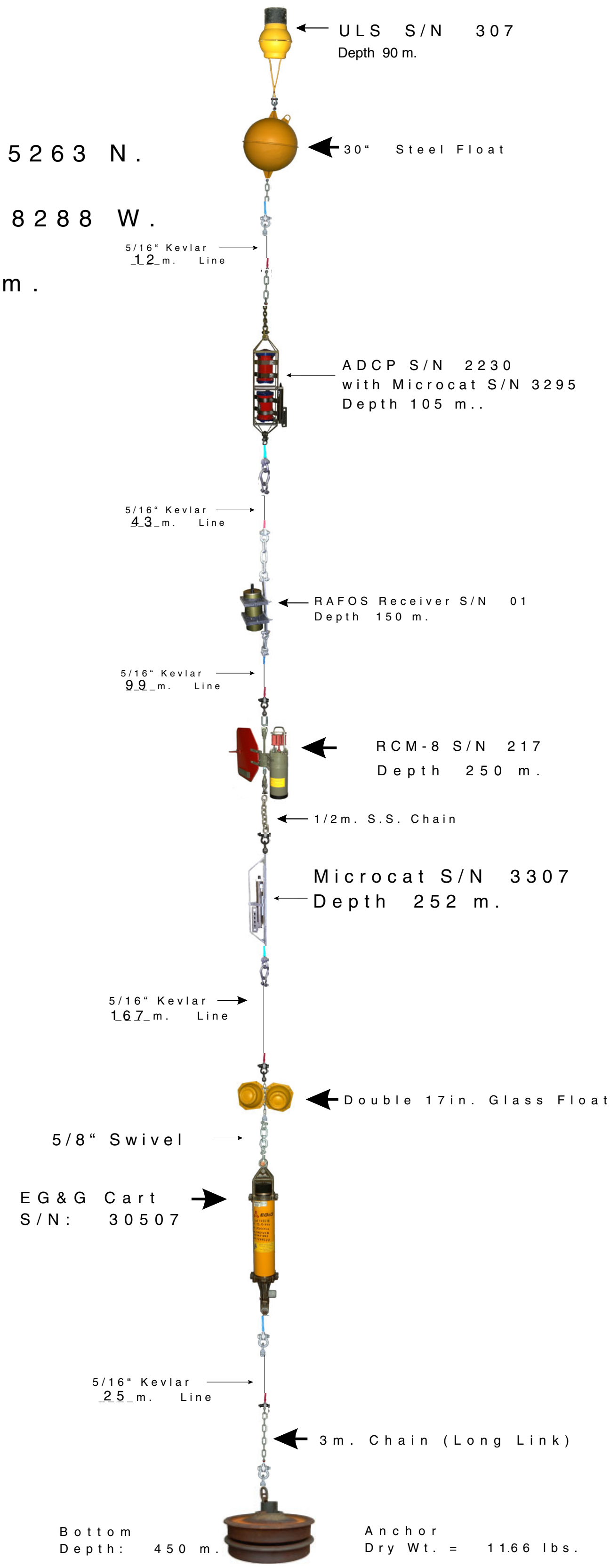
MOORING ID: Central 1

Latitude: 66 41 . 5263 N.

Longitude: 60 46 . 8288 W.

Corrected Depth: 450 m.

Davis Strait 04



Deploy Date: 27 Sept. 04

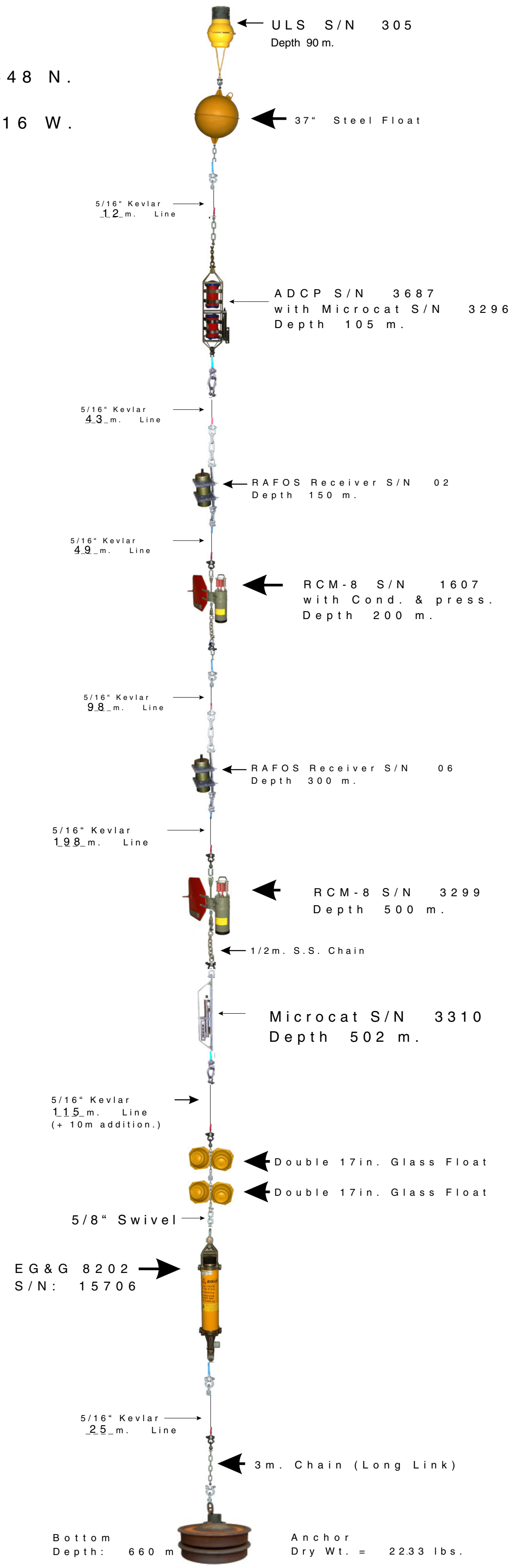
Anchor Deploy Time: 1216

MOORING ID: Central 2

Latitude: 66 45 . 6648 N.

Longitude: 60 04 . 4616 W.

Corrected Depth: 660 m.



Deploy Date: 27 Sept. 04

Anchor Deploy Time: 0210

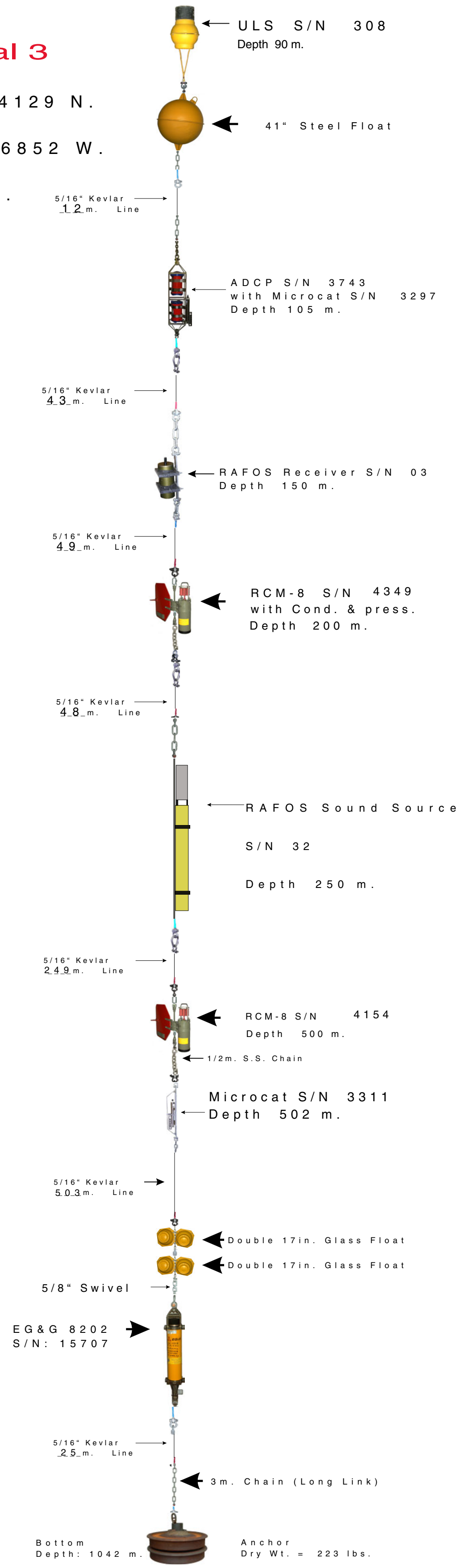
MOORING ID: Central 3

Latitude: 66 51 . 4129 N.

Longitude: 59 03 . 6852 W.

Corrected Depth: 1042 m.

Davis Strait 04



Deploy Date: 23 Sept. 04

Anchor Deploy Time: 1517

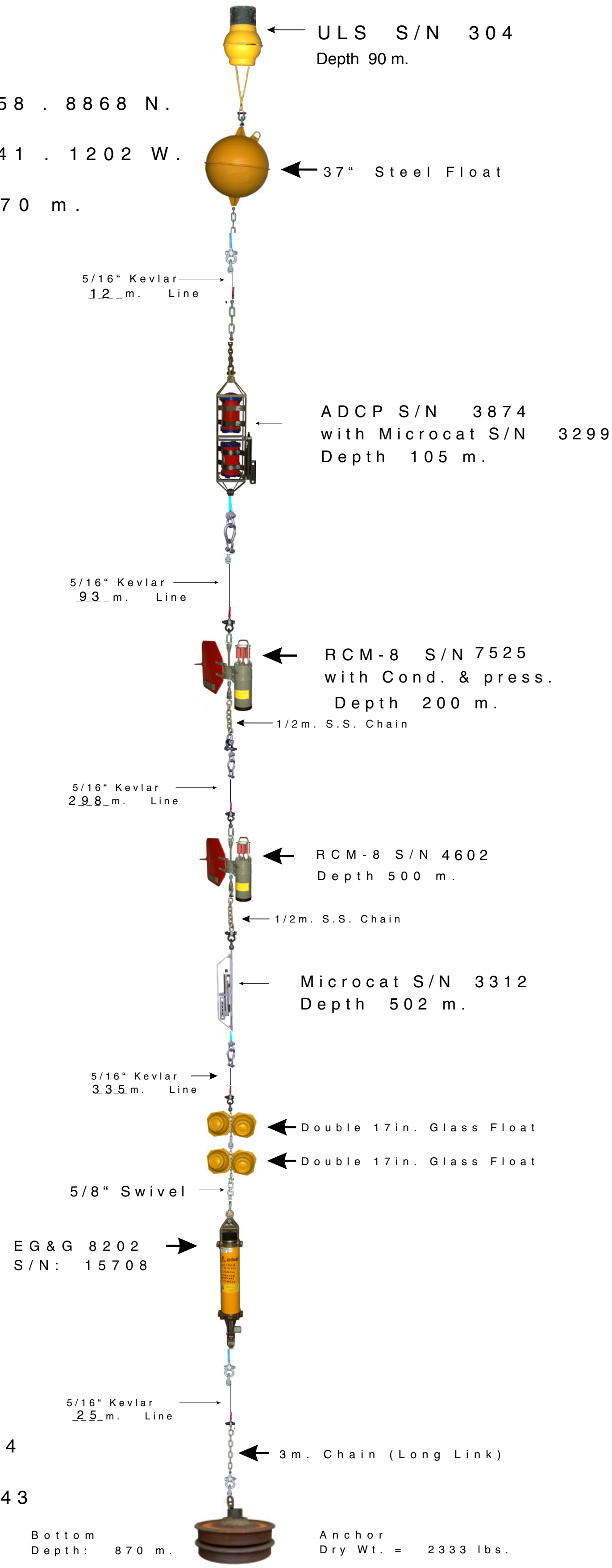
MOORING ID: Central 4

Latitude: 66 58 . 8868 N.

Longitude: 57 41 . 1202 W.

Corrected Depth: 870 m.

Davis
Strait
04



Deploy Date: 26 Sept. 04

Anchor Deploy Time: 1543

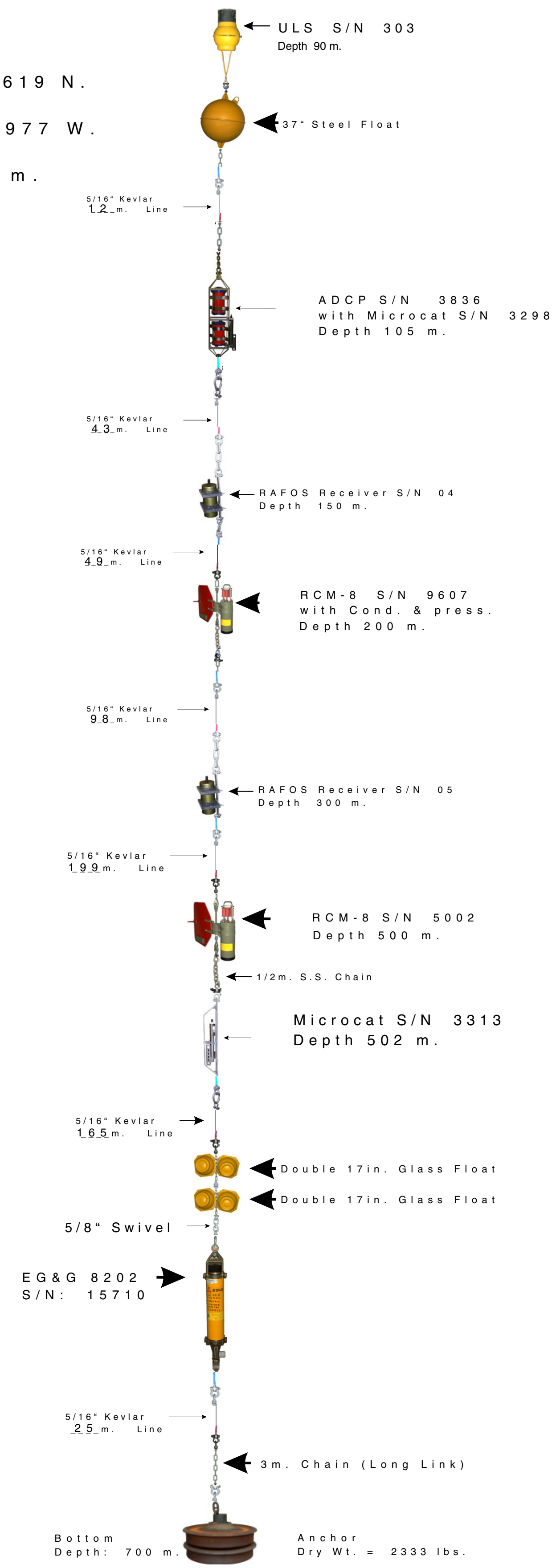
MOORING ID: Central 5

Latitude: 67 02. 1619 N.

Longitude: 57 02. 2977 W.

Corrected Depth: 700 m.

Davis Strait 04



Deploy Date: 24 Sept. 04

Anchor Deploy Time: 1331

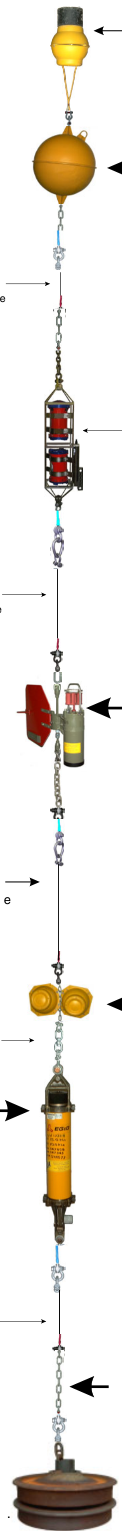
MOORING ID: Central 6

Latitude: 67 04 . 1649 N.

Longitude: 56 40 . 8856 W.

Corrected Depth: 393 m.

Davis Strait 04



Deploy Date: 24 Sept. 04

Anchor Deploy Time: 2153

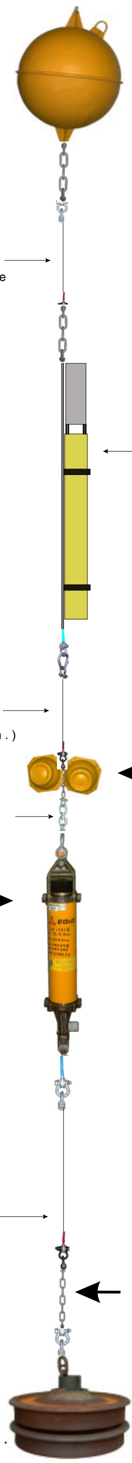
MOORING ID: Off-Axis

Latitude: 65 58 . 007 N.

Longitude: 56 19 . 958 W.

Corrected Depth: 535 m.

Davis Strait 04



Deploy Date: 25 Sept. 04

Anchor Deploy Time: 0930

7. Cruise Participants List

Science Party

Craig Lee	Chief Scientist	Univ. of Washington, Applied Physics Laboratory
Jason Gobat	Scientist	Univ. of Washington, Applied Physics Laboratory
Keith Van Thiel	Scientist	Univ. of Washington, Applied Physics Laboratory
Brian Petrie	Scientist	Bedford Institute of Oceanography
James Abriel	Scientist	Bedford Institute of Oceanography
Victor Soukhovtsev	Scientist	Bedford Institute of Oceanography
Murray Scotney	Scientist	Bedford Institute of Oceanography
Amy Simoneau	SSSG Tech	Woods Hole Oceanographic Institution
Christina Van Hilst	SSSG Tech	Woods Hole Oceanographic Institution

From left to right: Craig Lee, Victor Soukhovtsev, James Abriel, Murray Scotney, Jason Gobat, Keith Van Thiel, and Brian Petrie

R/V *Knorr* Crew

A.D Colburn	Master	Woods Hole Oceanographic Institution
Paul Carty	Chief Mate	Woods Hole Oceanographic Institution
Deidre Emrich	2nd Mate	Woods Hole Oceanographic Institution
Derek Bergeron	3rd Mate	Woods Hole Oceanographic Institution

Peter Liarikos	Bosun	Woods Hole Oceanographic Institution
Edward Gaham	AB	Woods Hole Oceanographic Institution
Michael Mulkern	AB	Woods Hole Oceanographic Institution
Kevin Butler	AB	Woods Hole Oceanographic Institution
Lorna Allison	OS	Woods Hole Oceanographic Institution
Bankole Salami	OS	Woods Hole Oceanographic Institution
Stephen Walsh	Chief Engineer	Woods Hole Oceanographic Institution
John McGrath	1st Assistant Engineer	Woods Hole Oceanographic Institution
Wayne Sylvia	2nd Assistant Engineer	Woods Hole Oceanographic Institution
Peter Marczak	3rd Assistant Engineer	Woods Hole Oceanographic Institution
Thidiane Kanoute	Electrician	Woods Hole Oceanographic Institution
Alan Farrington	Oiler	Woods Hole Oceanographic Institution
Carrie Bettencourt	Oiler	Woods Hole Oceanographic Institution
Tom Keller	Oiler	Woods Hole Oceanographic Institution
Brian O'Nuallain	Steward	Woods Hole Oceanographic Institution
Karen Johnson	Cook	Woods Hole Oceanographic Institution
James Brennan	Mess Attendant	Woods Hole Oceanographic Institution

9. Figures

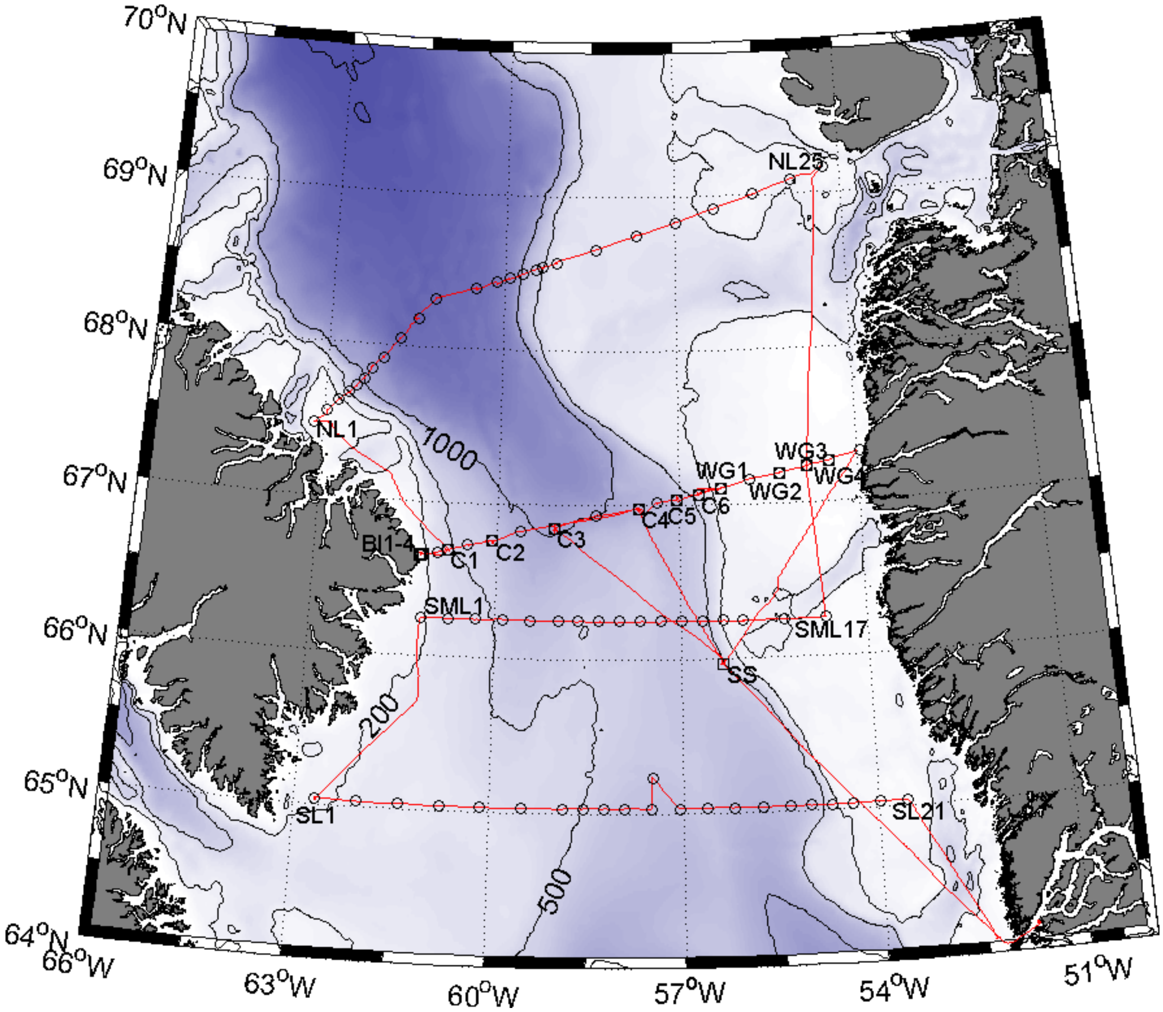


Figure 1. *The Davis Strait region. Red lines mark the cruise track, with circles indicating hydrographic stations and labeled squares marking mooring sites.*

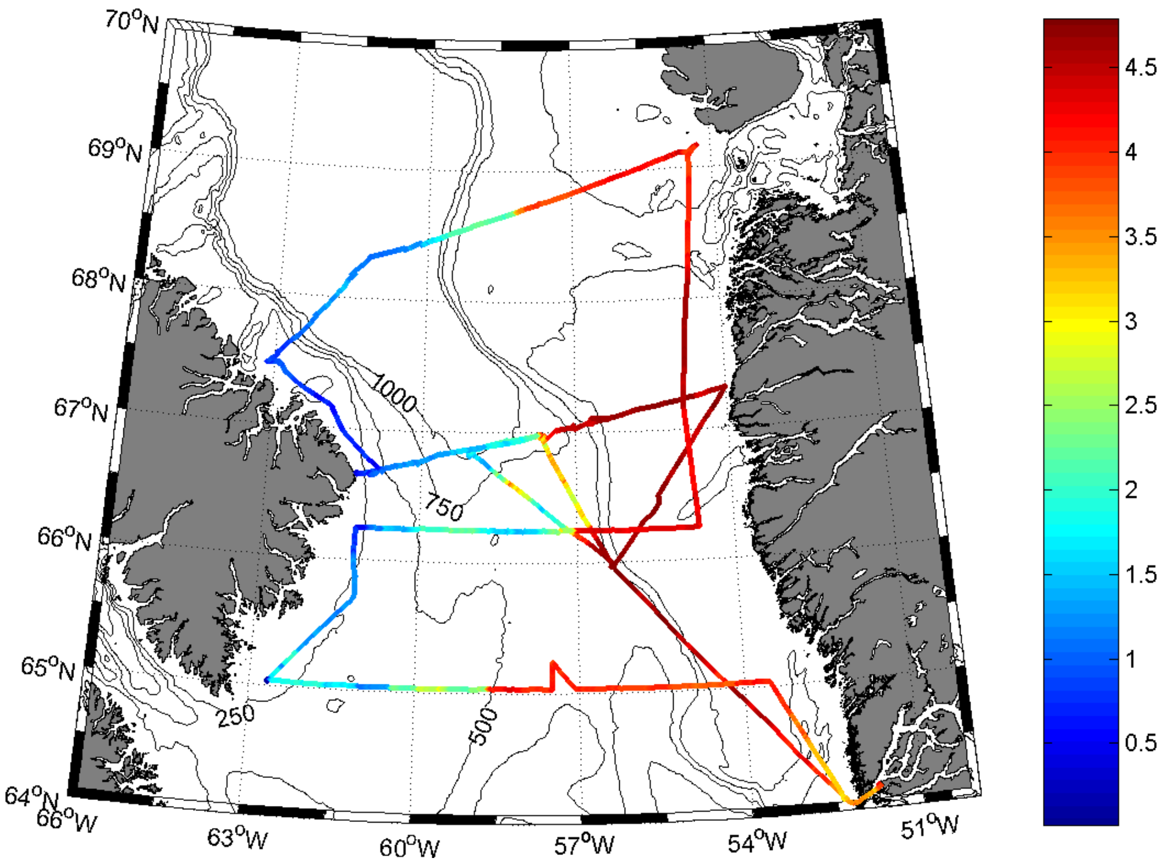


Figure 2. *Sea surface temperature measured by the R/V* Knorr *intake sensors. The color scale indicates temperature in ºC. Note the strong front just west of the Greenland slope.*

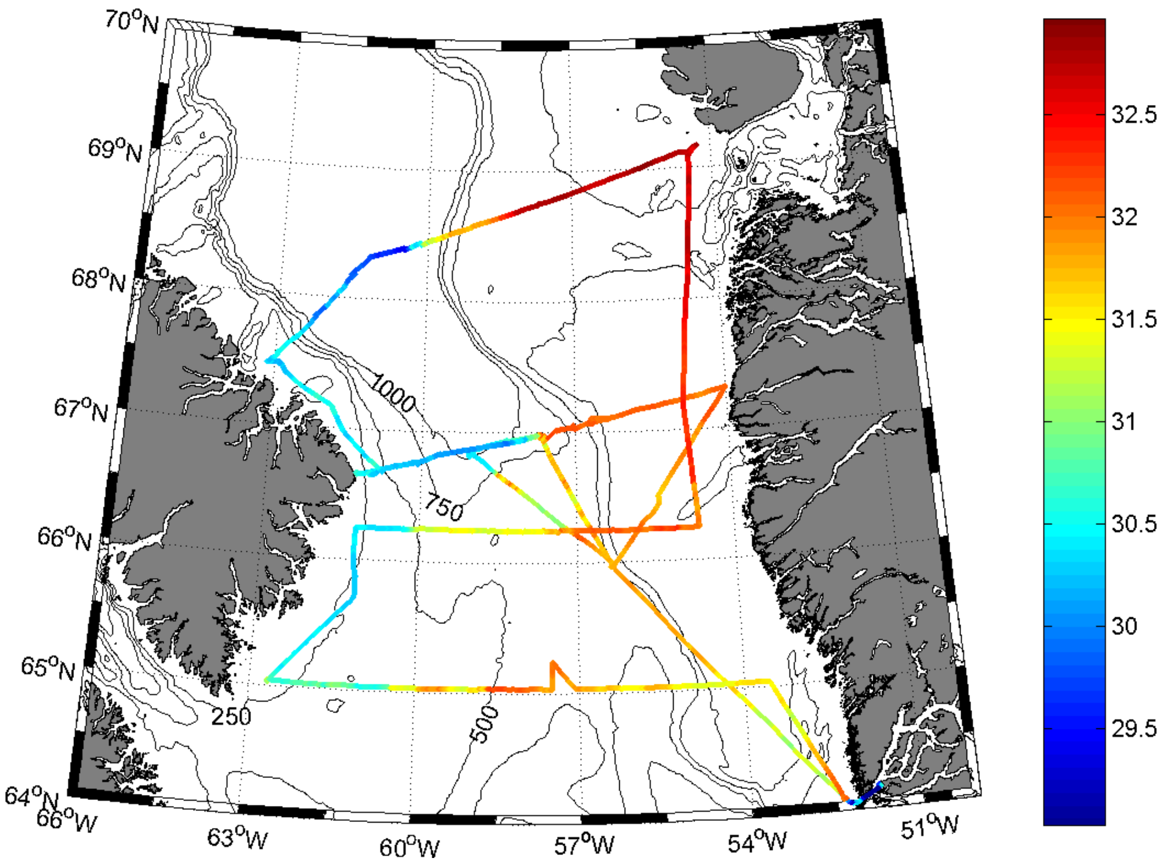


Figure 3. *Sea surface salinity measured by R/V* Knorr *intake sensors. Note the strong front just west of the Greenland slope and the fresh surface layer associated with south-flowing arctic waters over the Baffin slope.*

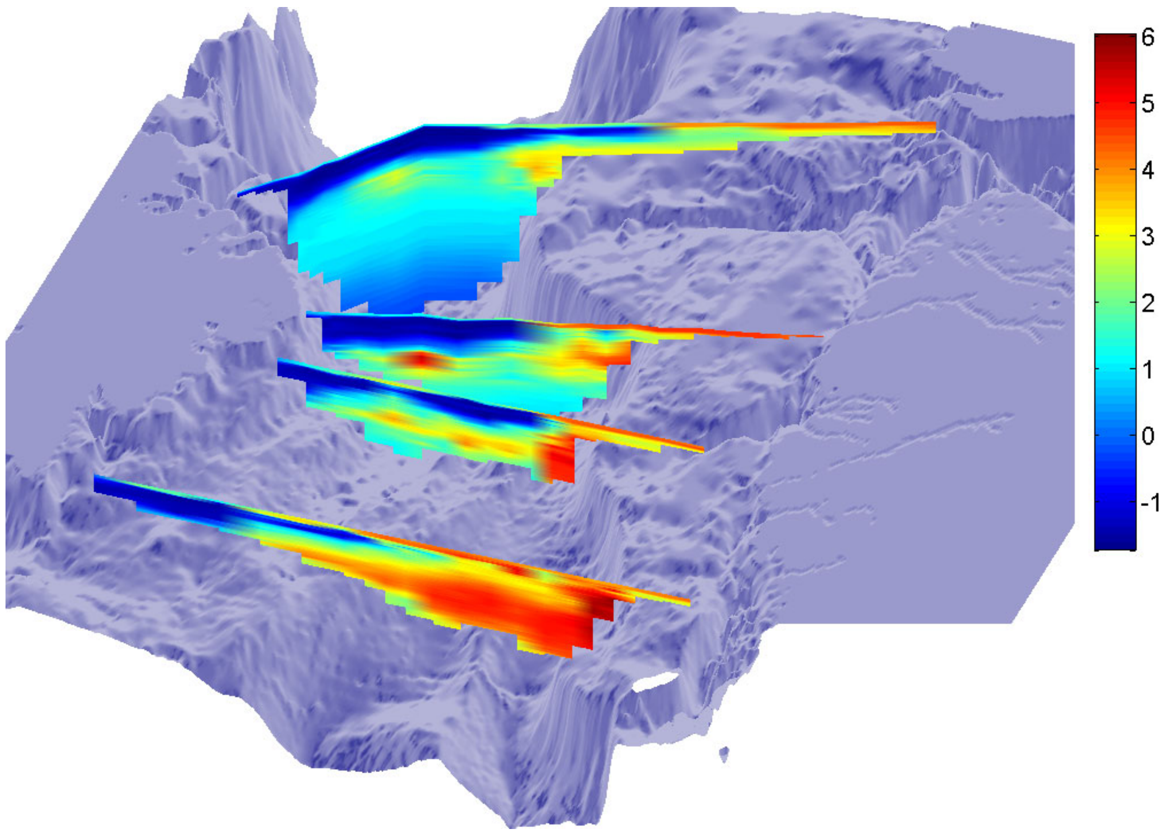


Figure 4. *Temperature across the four hydrographic sections, looking northward over Davis Strait. The color scale to the right indicates temperature in ºC. A layer of cold arctic water extends from the Baffin coast in a ~200-m thick surface layer. Warm Irminger water forms a subsurface layer over the Greenland slope and, in the northern sections, a narrow core over the Baffin slope.*

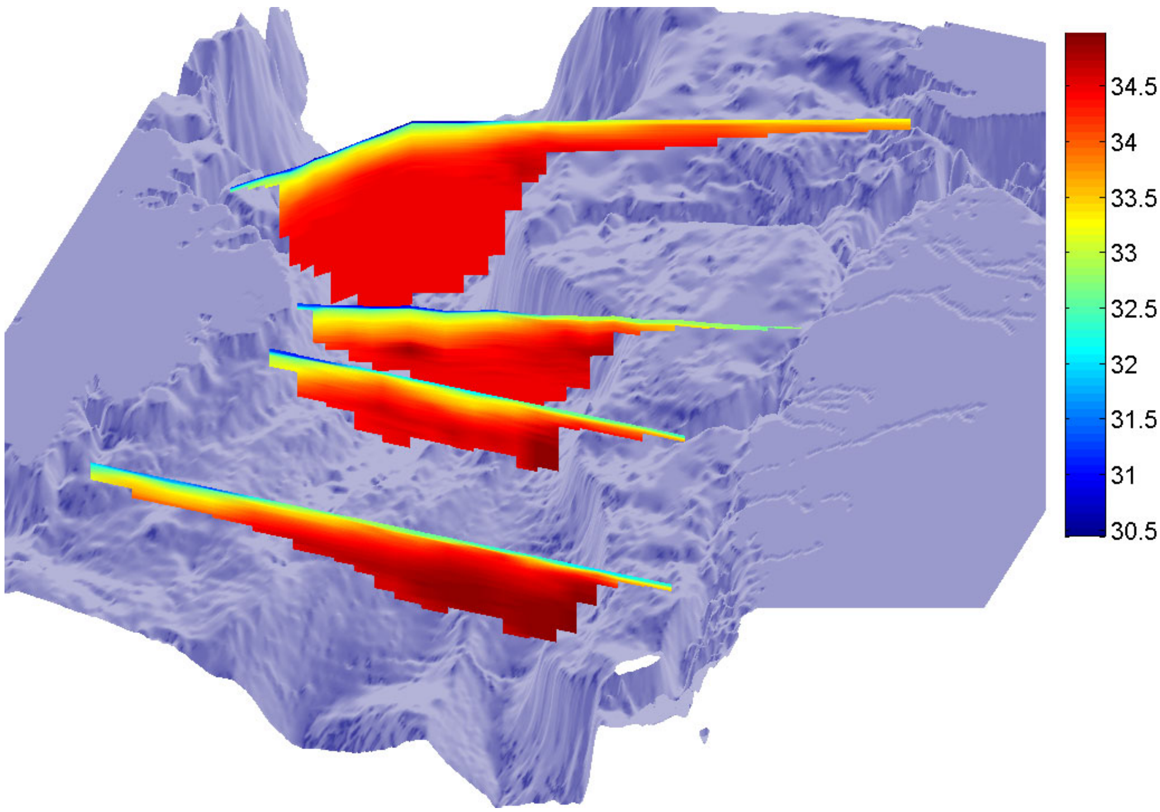


Figure 5. *Salinity across the four hydrographic sections, looking northward over Davis Strait. The surface layer exhibits the lowest salinities across the strait, with the freshest values associated with the surface-trapped arctic waters on the western side of the strait. Irminger waters found over the Greenland slope and in a small core over the Baffin slope exhibit elevated salinities.*

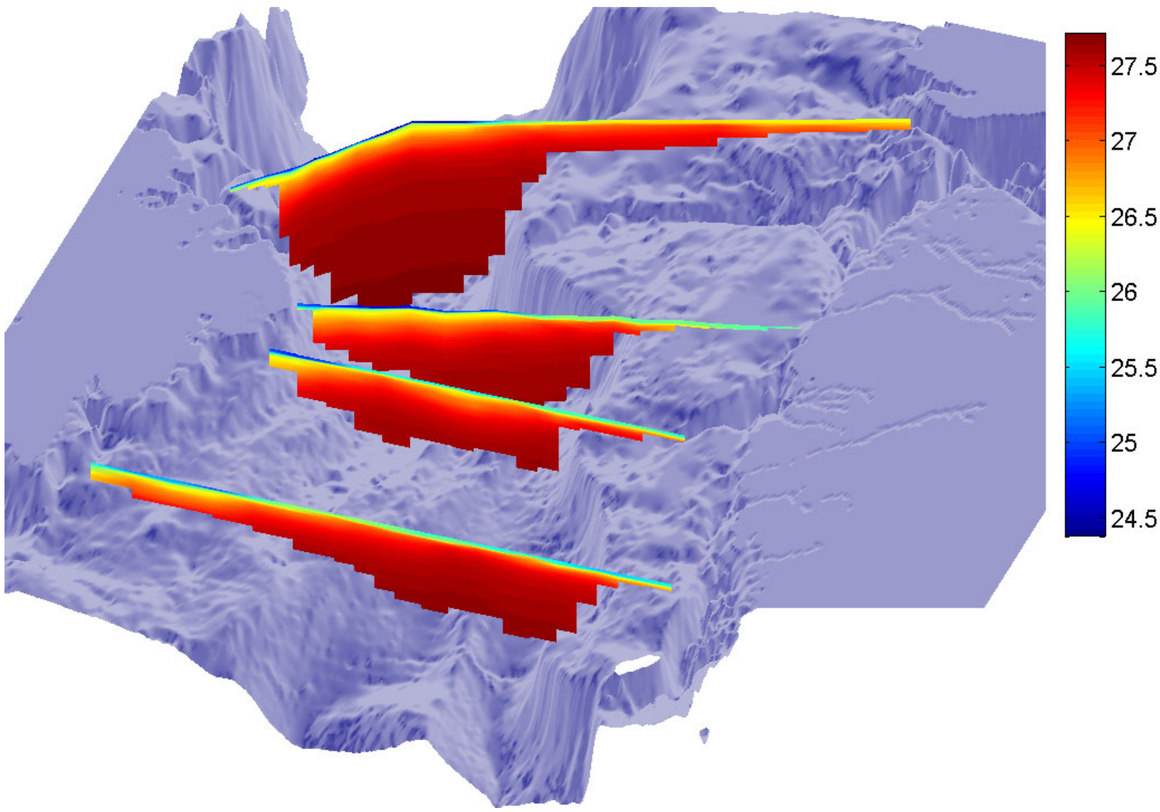


Figure 6. *Potential density across the four hydrographic sections, looking northward over Davis Strait. The color scale indicates* σ_θ *in kg* m^{-3}.

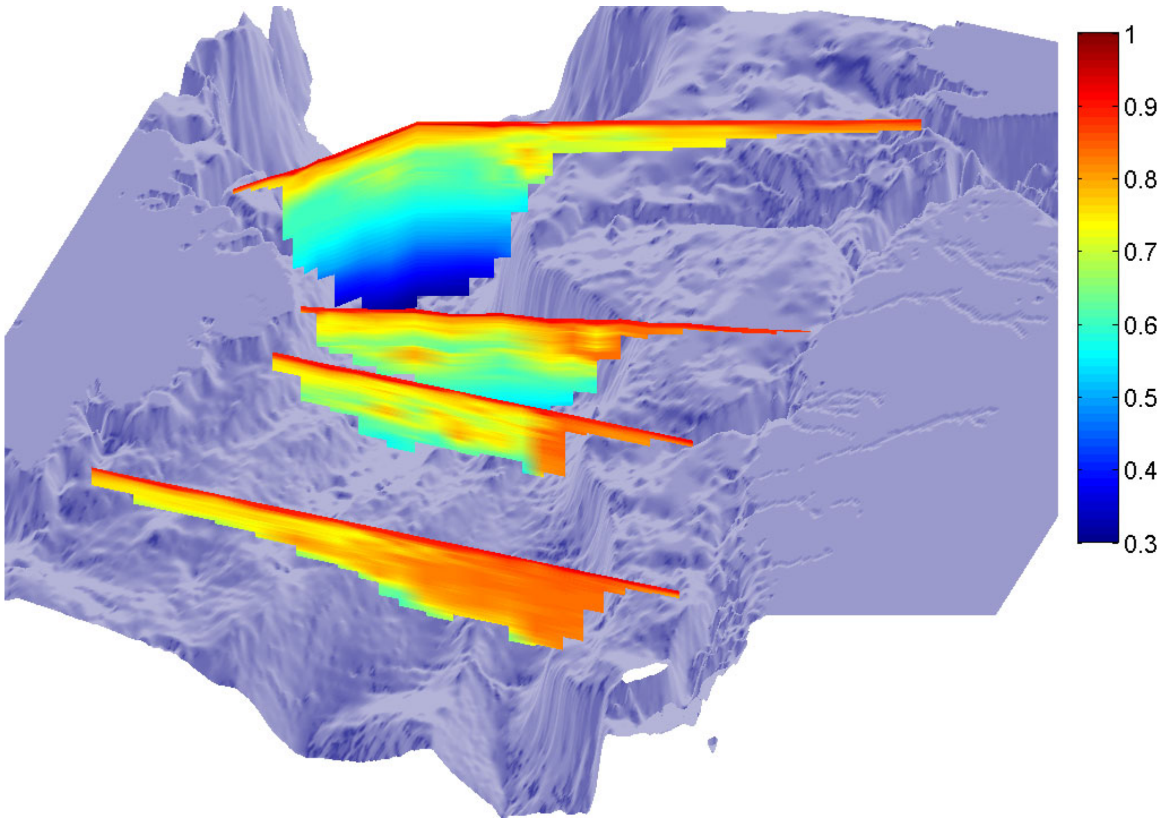


Figure 7. *Dissolved oxygen percent saturation across the four hydrographic sections, looking northward over Davis Strait. Irminger waters over the Greenland and Baffin slopes show high dissolved oxygen saturation. Deep waters at the southern end of Baffin Bay exhibit the lowest values.*

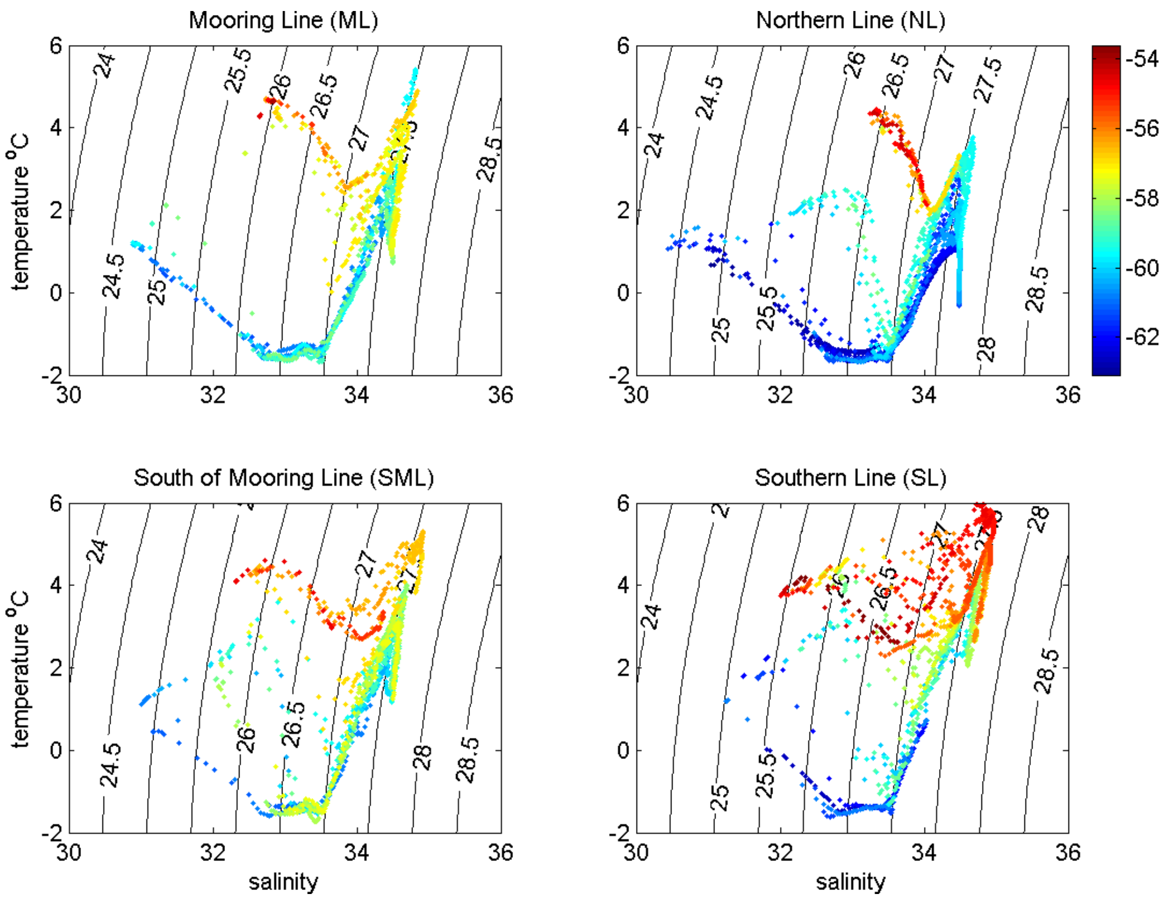


Figure 8*. Potential temperature–salinity diagrams for the four hydrographic sections. Contours mark potential density and marker color indicates longitude (an indicator of cross-strait position).*

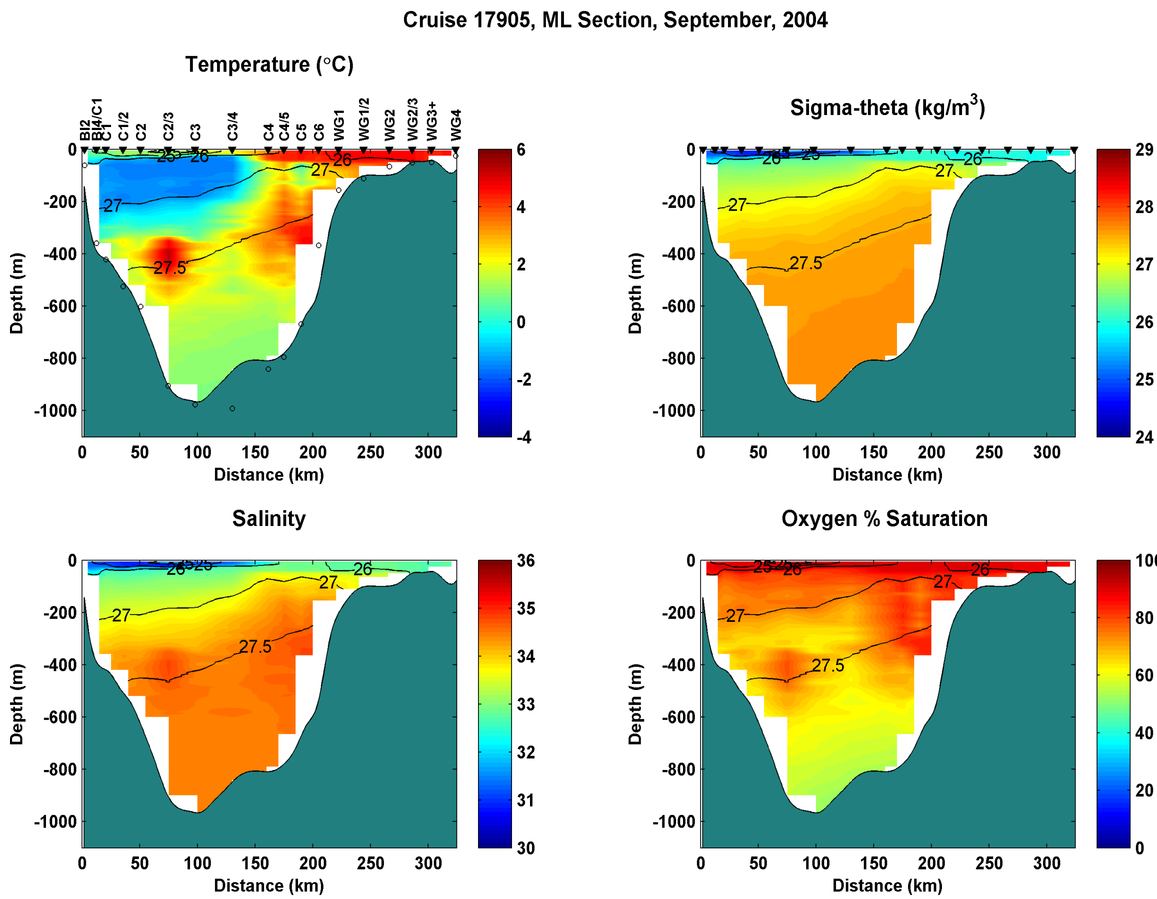


***Figure 9**. Potential temperature, salinity, potential density, and dissolved oxygen along the mooring (main line) section. Contours mark potential density surfaces.*

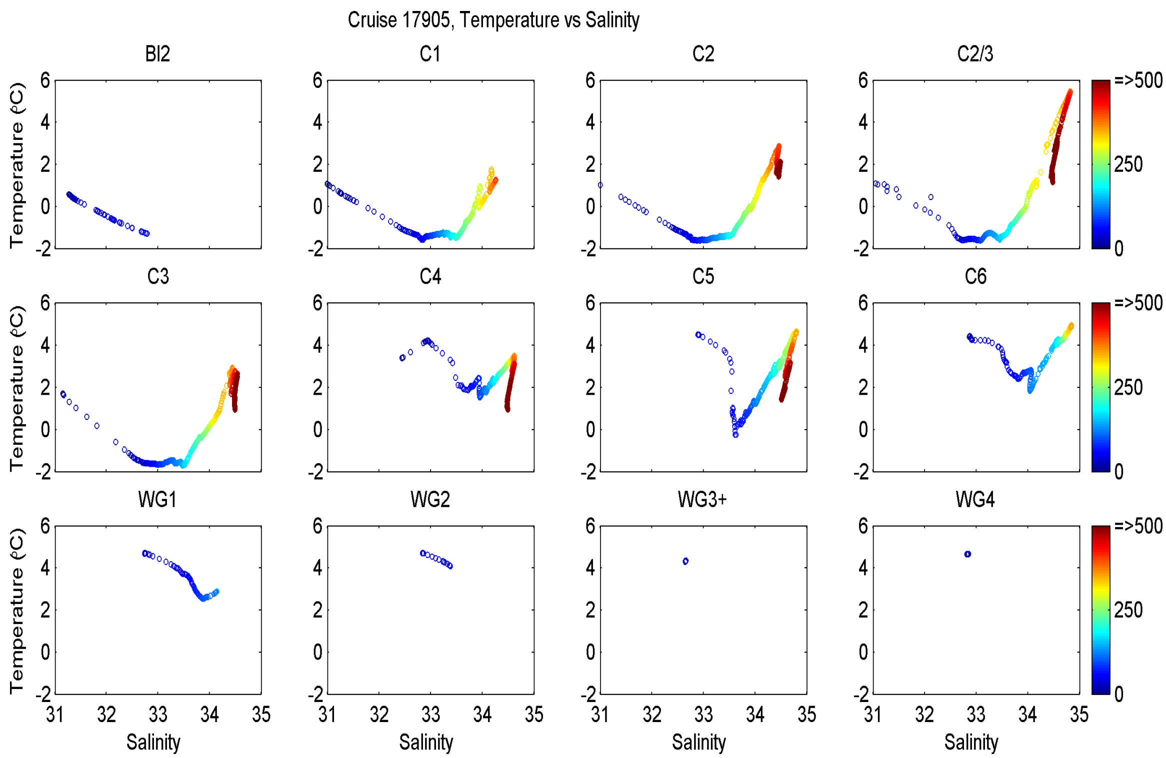


Figure 10. *Potential temperature–salinity diagrams from hydrographic stations at the mooring sites and ML06 (C2/C3). Marker color indicates measurement depth (color scale to left in meters).*

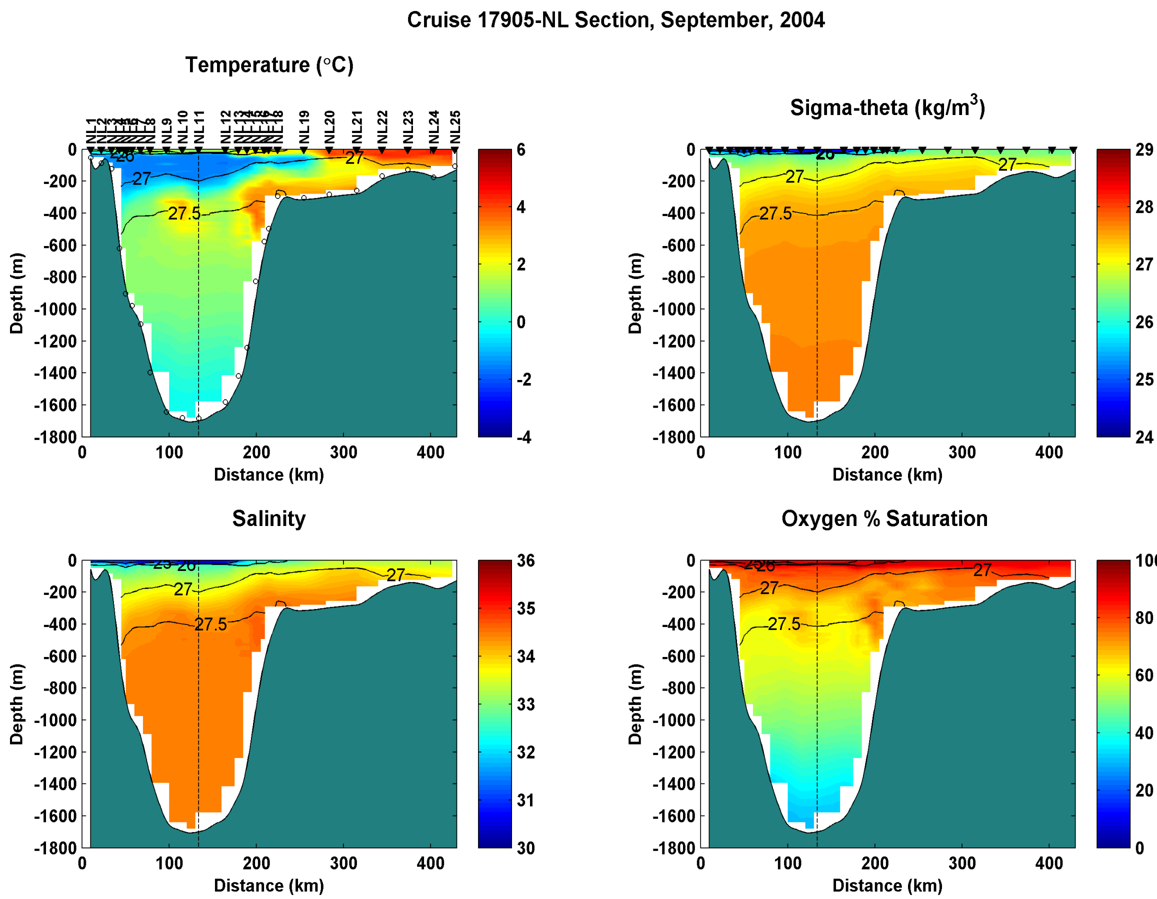


***Figure 11**. Potential temperature, salinity, potential density, and dissolved oxygen across southern Baffin Bay, from Broughton Island to Disko (northern line). Contours mark potential density surfaces.*

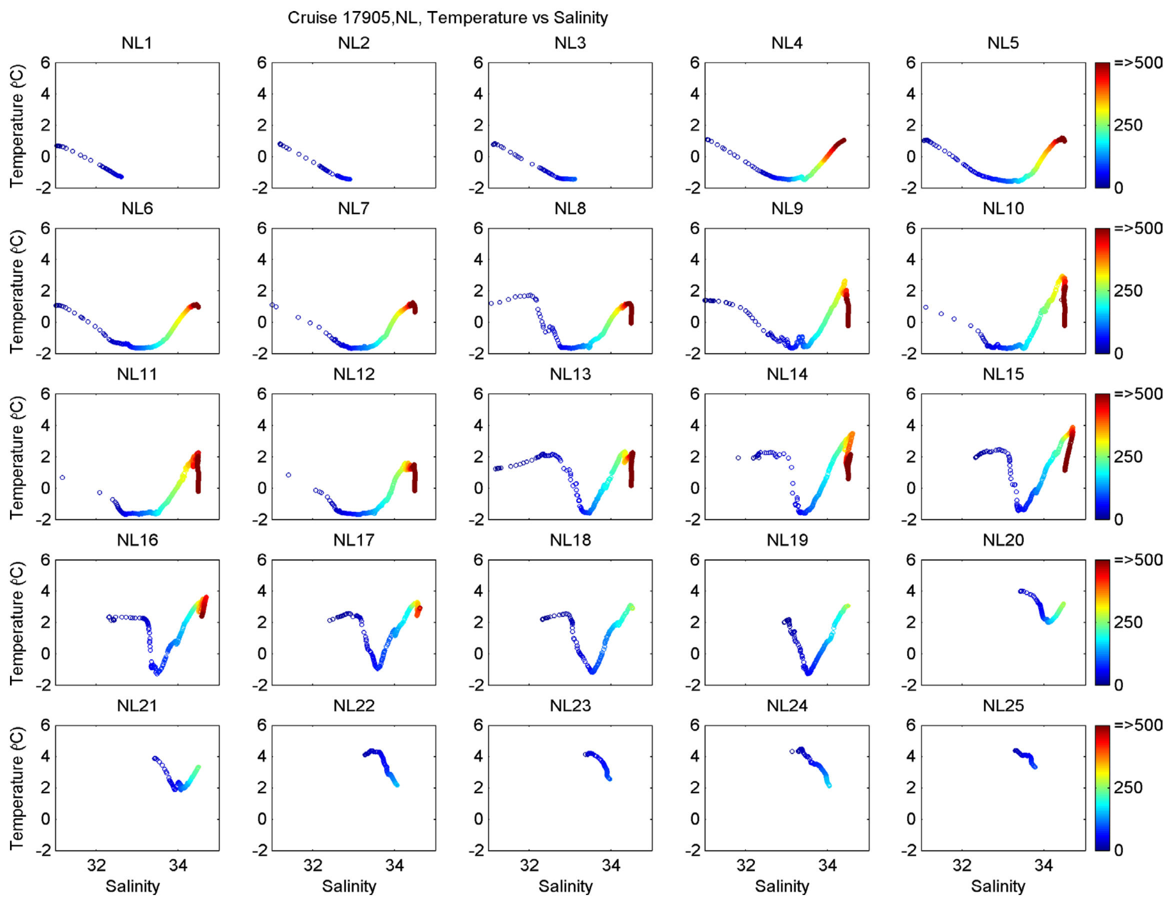


Figure 12. *Potential temperature–salinity diagrams from hydrographic stations across southern Baffin Bay, from Broughton Island to Disko (northern line). Marker color indicates measurement depth (color scale to left in meters).*

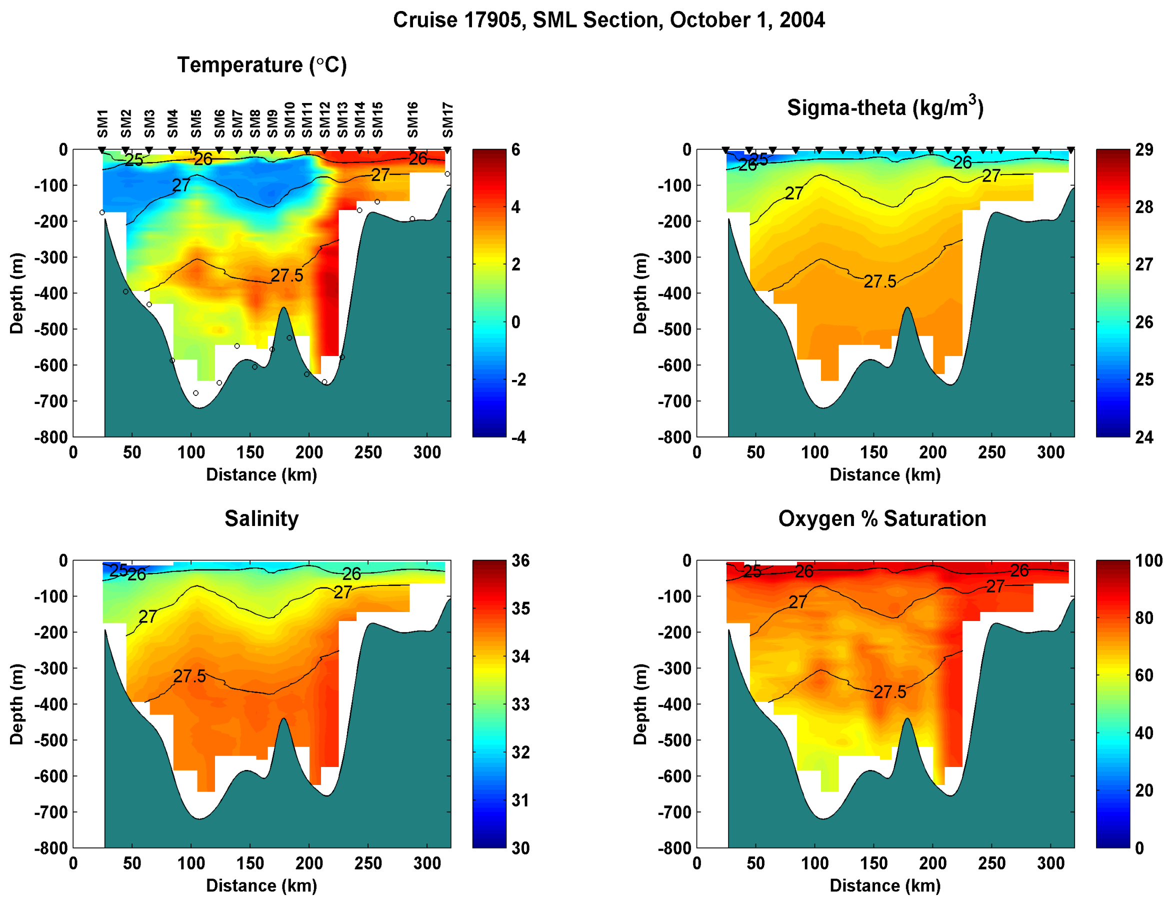


Figure 13. *Potential temperature, salinity, potential density, and dissolved oxygen across 66º 15' N (previously occupied by the Ross array, south main line). Contours mark potential density surfaces.*

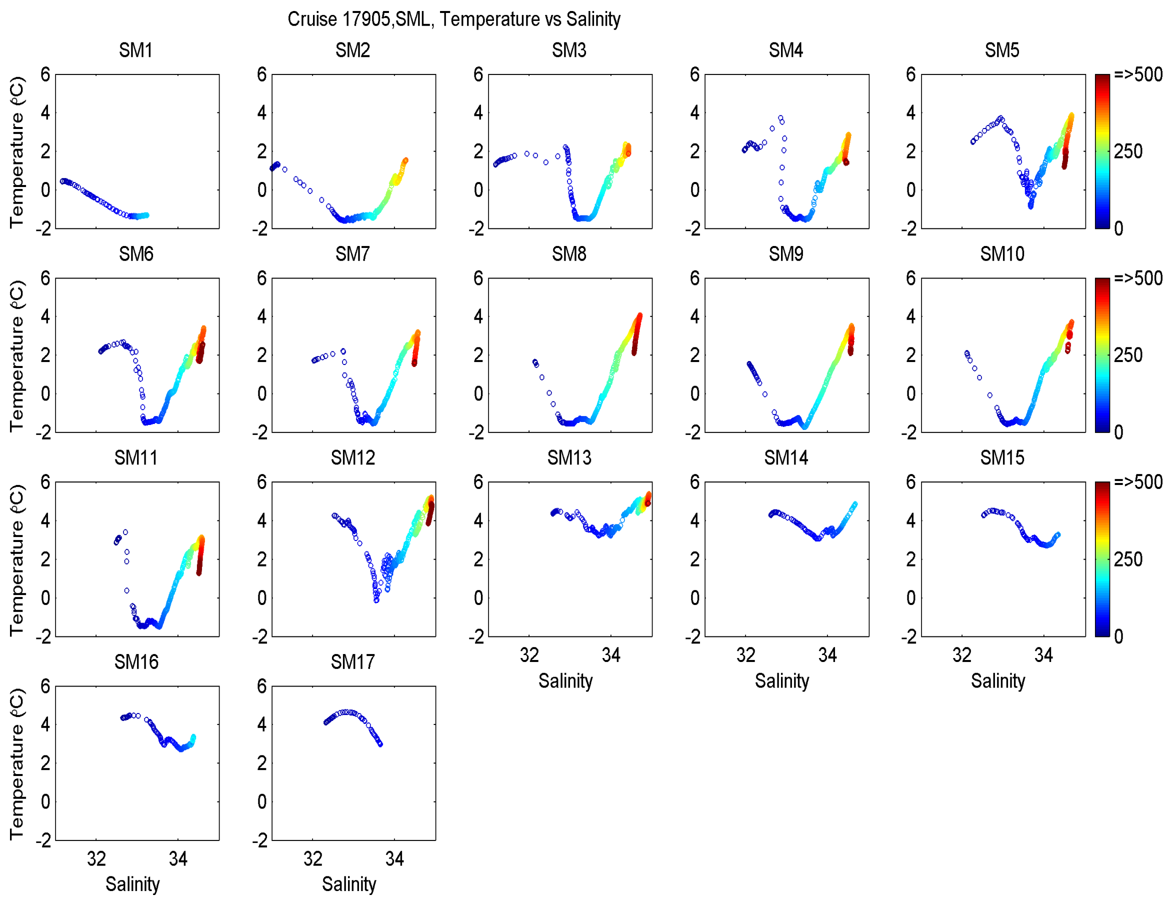


Figure 14. *Potential temperature–salinity diagrams from hydrographic stations across 66º 15' N (previously occupied by the Ross array, south main line). Marker color indicates measurement depth (color scale to left in meters).*

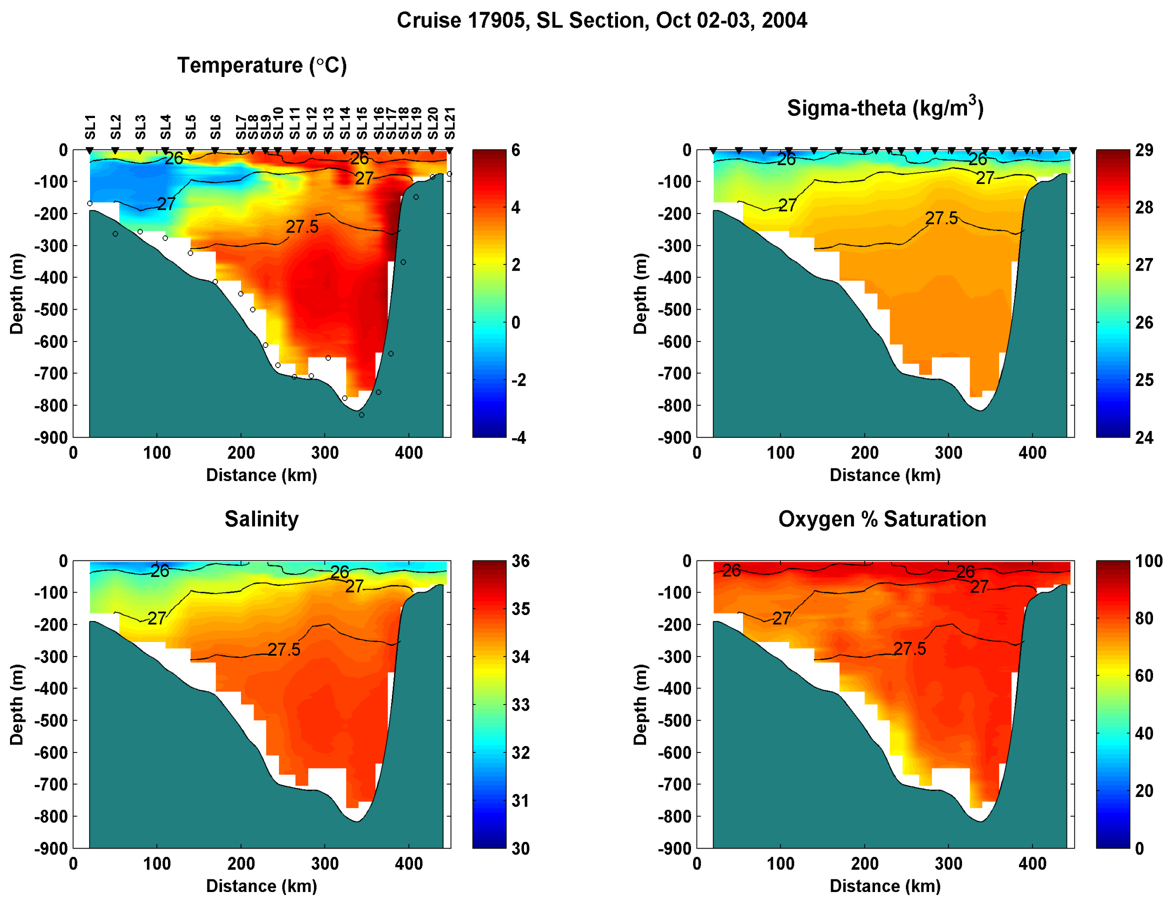


Figure 15. *Potential temperature, salinity, potential density, and dissolved oxygen across 65° 02' N (southern line). Contours mark potential density surfaces.*

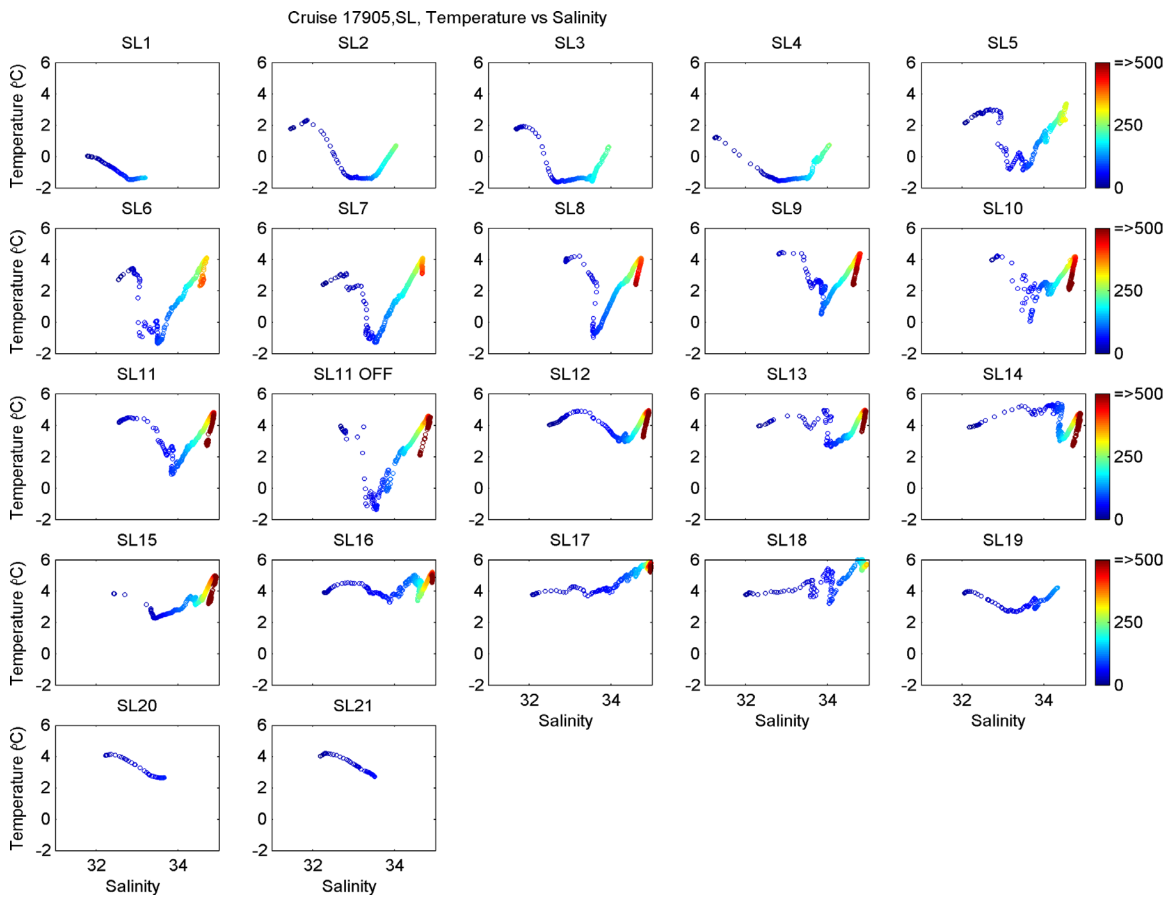


Figure 16. *Potential temperature–salinity diagrams from hydrographic stations across 65º 02' N (southern line). Marker color indicates measurement depth (color scale to left in meters).*

REPORT DOCUMENTATION PAGE			Form Approved OPM No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
November 2004

3. REPORT TYPE AND DATES COVERED
Technical Report

4. TITLE AND SUBTITLE
An Observational Array for High-Resolution, Year-Round Measurements of Volume, Freshwater, and Ice Flux Variability in Davis Strait: Cruise Report for R/V *Knorr* 179-05, 22 September–4 October 2004

5. FUNDING NUMBERS
NSF OPP02300381

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER
TR 0408

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Neil Swanberg
Office of Polar Programs
National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

As part of the Freshwater Initiative sponsored by theNational Science Foundation Office of Polar Programs, a team of scientists from the Applied Physics Laboratory of the University of Washington and the Bedford Institute of Oceanography are investigating freshwater exchange through Davis Strait. This 300-km-wide strait sits between Baffin Island and the west coast of Greenland and acts as the gateway for waters passing between the Canadian Arctic Archipelago and the subpolar North Atlantic. In autumn 2004 R/V *Knorr* cruise 179-05 undertook the first of three one-year mooring deployments. Six subsurface moorings, one off-axis sound source, eight bottom landers, and two Seagldiers were deployed successfully slightly north of the Davis Strait sill. Four cross-strait hydrographic lines, complete with sampling for chemical tracers, characterized water mass variability from the southern end of Baffin Bay to the northern tip of the Labrador Sea. The moored array will be recovered, serviced, and redeployed annually for a period of at least three years.

14. SUBJECT TERMS
Davis Strait, freshwater flux, under-ice moorings, autonomous underwater vehicles, gliders, Seaglider

15. NUMBER OF PAGES
57

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR