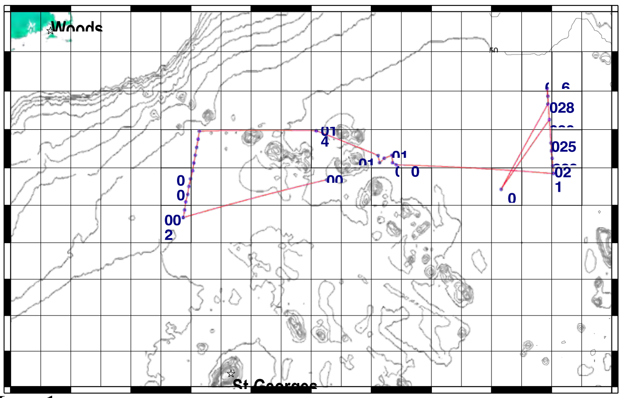
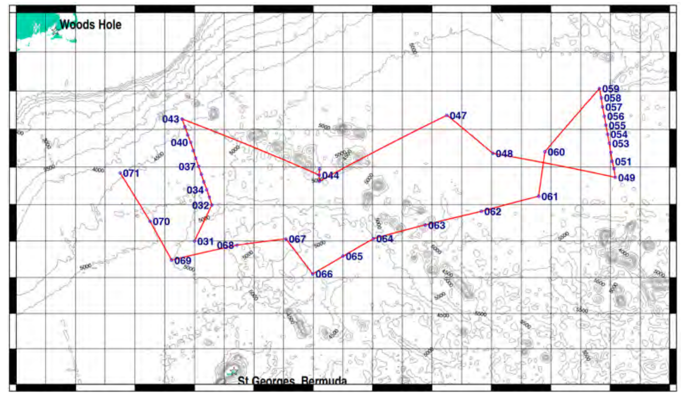
CRUISE REPORT: CLIMODE 4

(Updated FEB 2022)



Leg 1



Leg 2

Highlights

Cruise Summary Information

Section Designation	**CLIMODE 4** (aka: KN188-1)
Expedition designation (ExpoCodes)	**316N20070207**
Chief Scientists	**Terrence M. Joyce / WHOI**
Dates	2007-02-07/2007-03-22
Ship	RV *Knorr*
Ports of call	Woods Hole, Massachusetts - St. Georges, Bermuda - Woods Hole, Massachusetts
Geographic Boundaries	40° 4.22" N 68° 30.17' W 51° 49.76' W 35° 5.81' N
Stations	72
Floats and drifters deployed	33 Argos-tracked surface drifting buoys deployed leg 1 6 Bobbers deployed leg 1 27 Global Drifter Program surface drifters deployed leg 2 8 Bobbers deployed leg 2
Moorings deployed or recovered	0

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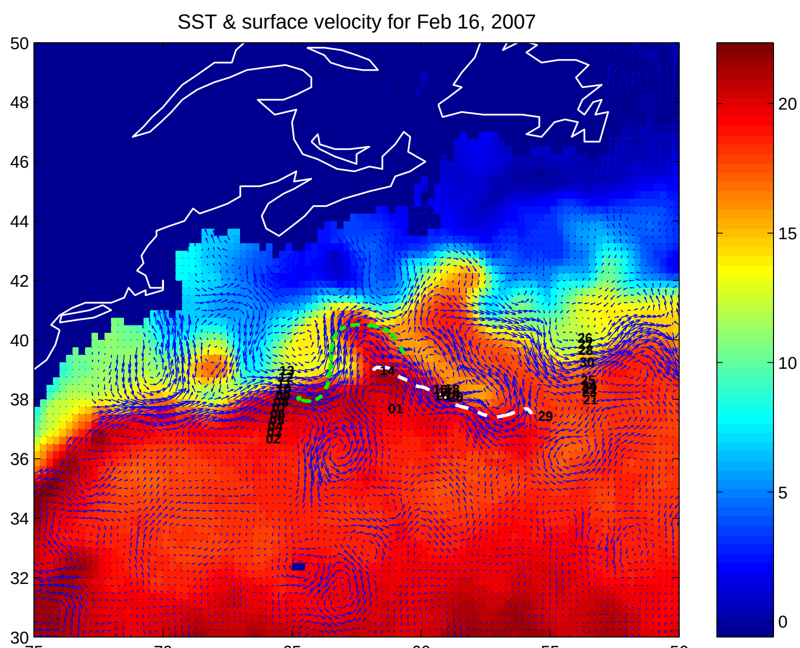
Final report assembly by Jerry Kappa, SIO/UCSD

Cruise Report, CLIMODE 4, Leg 1:
7 – 27 February 2007, R/V Knorr



This research is supported by the US CLIVAR program within the National Science Foundation

Summary

This cruise on the Research Vessel Knorr is the first of two legs of wintertime observations in the CLIvar Mode water Dynamics Experiment (CLIMODE, www.climode.org). The goal of these winter cruises is to obtain data during and following wintertime cooling over the CLIMODE region, to observe the formation of a major water mass of the N. Atlantic Ocean, Eighteen Degree Water (EDW), and to deploy instrumentation (floats and drifters) that will report back the evolution of the EDW. This is the 1st of two legs of the 4th CLIMODE cruise, hence we name it CLIMODE 4-1. It is also leg 1 of cruise 188 on the Knorr, hence it is also named KN188-1: two different name conventions just to contribute to possible confusion.

In this report, we will discuss a variety of different measurements made on the cruise & who the participants were. Here we summarize: the 27 members of the scientific collected 30 CTD casts, all but 4 were to 1000m depth, those 4 were to 2000m, 28 microstructure profiles, deployed 50 radiosondes, 33 surface drifters, and 10 floats. In addition, we recoverd a 3m diameter surface discus buoy that had broken loose from a mooring deployed for CLIMODE last November, and deployed and recovered the ASIS/FILIS compound spar. Weather stopped operations for approximately 36 hours, during two periods with sustained winds in excess of 40 kts. Two different varieties of microstructure profilers were used, and three different types of floats were released. Details will be found below.

Fig. 1. During recovery of surface mooring on 9 Feb., this water spout picture was captured by A. Plueddemann.

Thanks go out to Captain Sheasley, Bo'sun Liarikos, Steward Da Lomba and all of the crew of the R/V Knorr for helping make this a successful cruise. Thanks also go to Kathie Kelley & her APL/UW team, and Roger Samelson & the OSU group, for providing the satellite and high resolution weather forecasting data we used continuously for planning and interpreting our shipboard

measurements. SeaNet was essential in this communication linkage. The 27 members of the scientific party & their duties on the vessel are listed in Table 1. A cruise/event summary table is found in Table 2. The ODF group from Scripps, has prepared a CTD/hydro report, which is contained in an Appendix.

Cruise Narrative by T. Joyce

The Knorr departed the WHOI dock at 1415Z on 7 February and headed east to intercept a CLIMODE surface buoy previously moored in the Gulf Stream that had broken loose on 1 February. This mooring drifted in the Gulf Stream following a constant surface

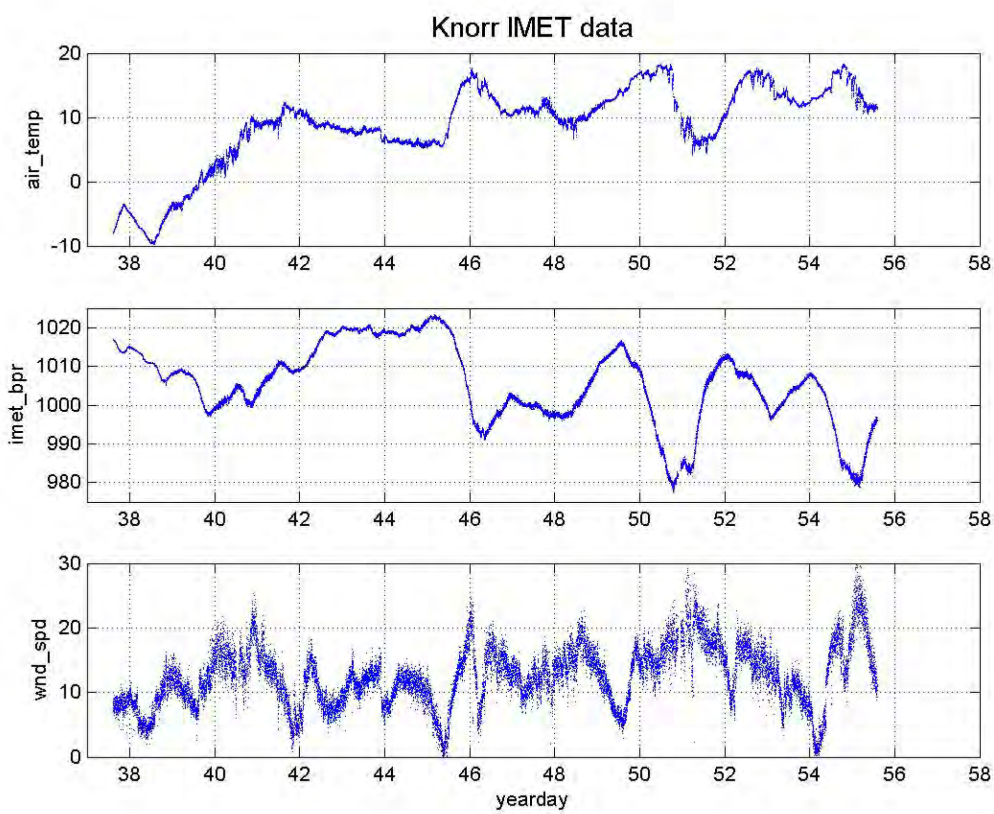


Figure 2. Cruise record of air temperature, pressure and wind speed from the IMET bow mast.

temperature contour of ca. 18C until it was recovered at 1630Z on 9 February. An Argos radio transmitter provided location information that allowed us to track and recover the mooring. All scientific instrumentation below the buoy to a depth of 930m was recovered. Since no releases responded to an interrogation, we inferred they were not on the end of the mooring. We elected to cut the remaining line and resume our original cruise plan instead of investing 4-5 more hours on line recovery. During the mooring recovery, it snowed and hailed occasionally, and a waterspout was seen and photographed by one of the scientific party (Fig. 1). With a first CTD station near the buoy recovery site, we steamed back west and began our first CTD/AMP section on 11 February. The section was completed 40 hours later on 13 February. We then steamed east to a site in a northward meander of the Gulf Stream and deployed the ASIS/FILIS compound spar and an EM-Apex float on 13 February. Thereafter, we began Seasoar operations which continued until the SeaSoar snared a line from a long liner; it was recovered on 16 February before it could complete the second 'ladder' survey.

We then returned to the ASIS and began a one inertial period (19 hrs) time series of CTD/AMP casts, after which we steamed to the east and began CTD section 2. This was interrupted after 5 stations due to weather on 19 February , during which we made way towards the northern end of the planned line. Work resumed a day later and three stations were completed. The section was broken off again so that we could complete the downstream SeaSoar survey, after which we steamed westward to recover the ASIS/FILIS taking advantage of a good weather window. The ASIS/FILIS were recovered without incident and we returned to complete the CTD section. However, a low pressure system intensified and caught up with us before we could complete the section (Fig. 2, yearday 55). Knowing the winds would be 40-60 kts for a substantial period of time, we elected to slowly head back towards Bermuda. En route, we stopped at three points to deploy floats and surface drifters. The ship arrived in St. George's, Bermuda on the morning of 27 February.

SeaSoar & Shipboard ADCP – Frank Bahr

For this cruise, SeaSoar was equipped with a SeaBird 911+ CTD carrying an internal pressure sensor, dual temperature and conductivity sensors, an oxygen sensor, and a fluorometer. The vehicle was deployed twice, from 2/14 2:37 to 2/16 22:20 and from 2/21 7:52 to 2/22 13:17.

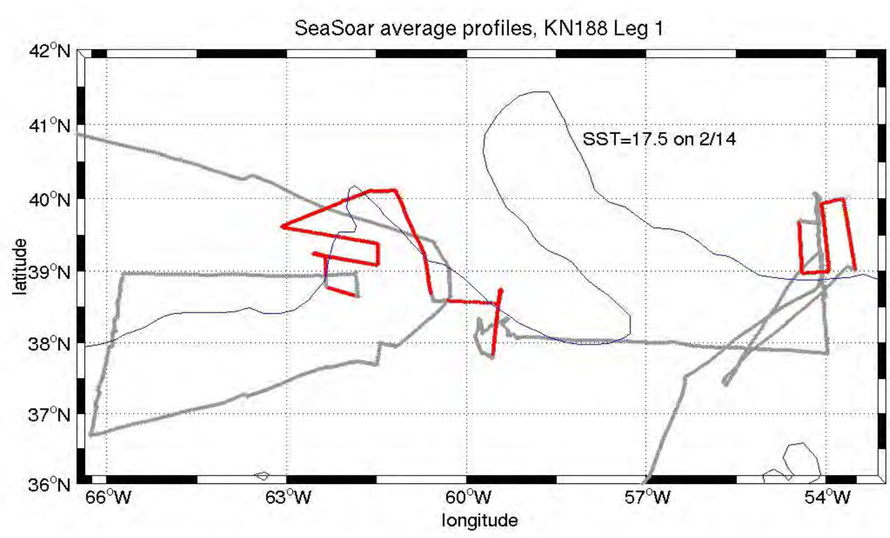


Figure 3. SeaSoar track locations (red).for CLIMODE 4-1.

Following the initial deployment on 2/16, SeaSoar flew well, covering a depth range between about 30 and 450m. After a few hours, however, problems developed, causing the vehicle to abort dives prematurely and abruptly head for the surface. Part of the problem was eventually determined to be a sharp cable bend near a connector, which allowed small portions of water to enter and shorten the impeller count measurement.

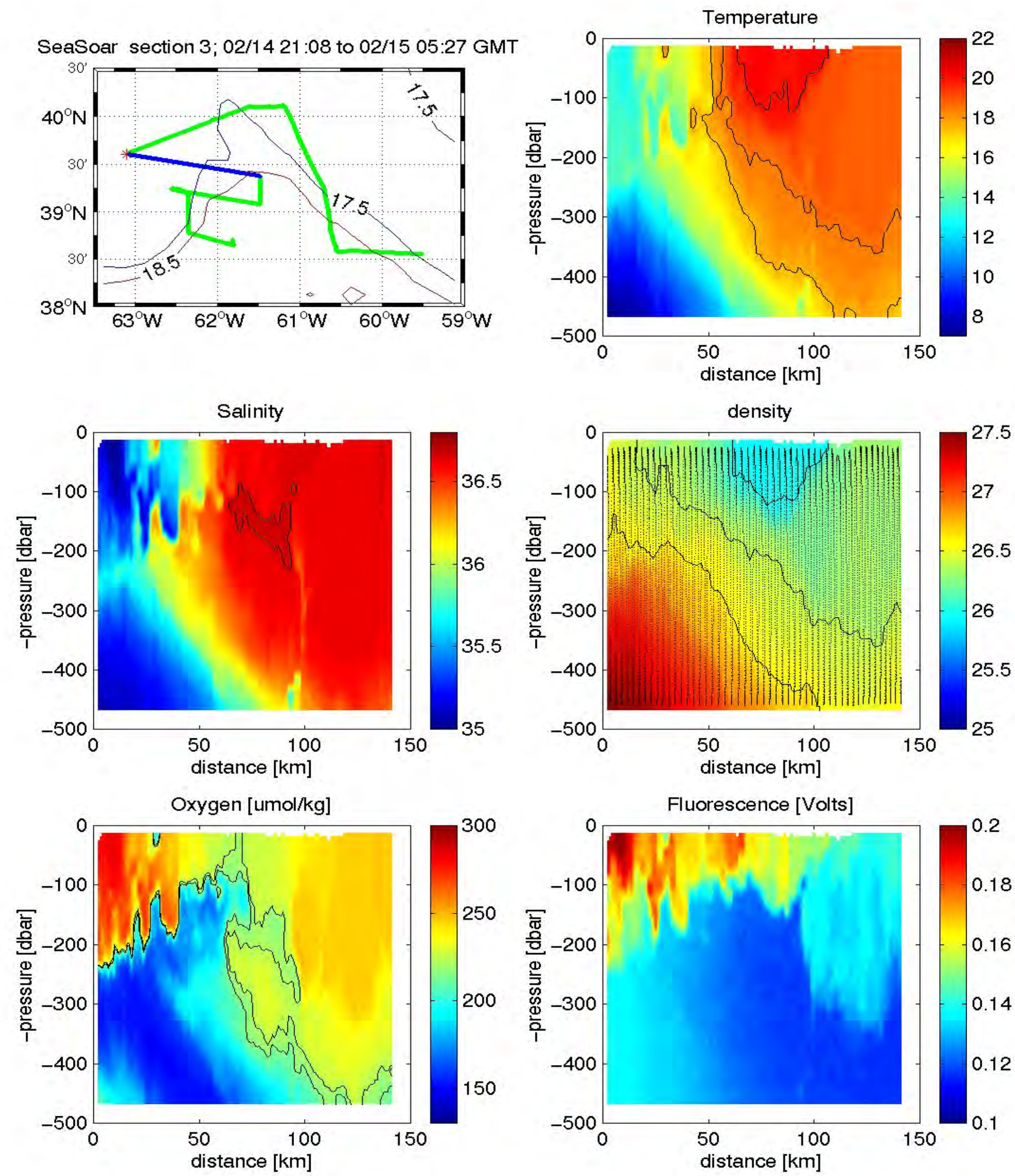


Fig. 4, SeaSoar sections for leg 3, first deployment.

Paul Fucile identified an alternate path to send control commands to the vehicle, and we developed a rudimentary flight program that carried us through the rest of the deployment. Late on the 16th, however, the vehicle suddenly stopped flying altogether, going through a series of 360 degree rolls. We recovered, and found a 1/2 inch thick long line wrapped around the vehicle.

Between deployments, we repaired the small damage to the vehicle from the line encounter (the strain relief was split, and a small amount of fairing had been stripped off the cable). Early into the second deployment, we were plagued again by a small electronic glitch having to do with the now dummied-up impeller counter. Fortunately, our deck unit allowed us to simply eliminate the counter from the data stream. SeaSoar worked fine for the remaineder of the second deployment.

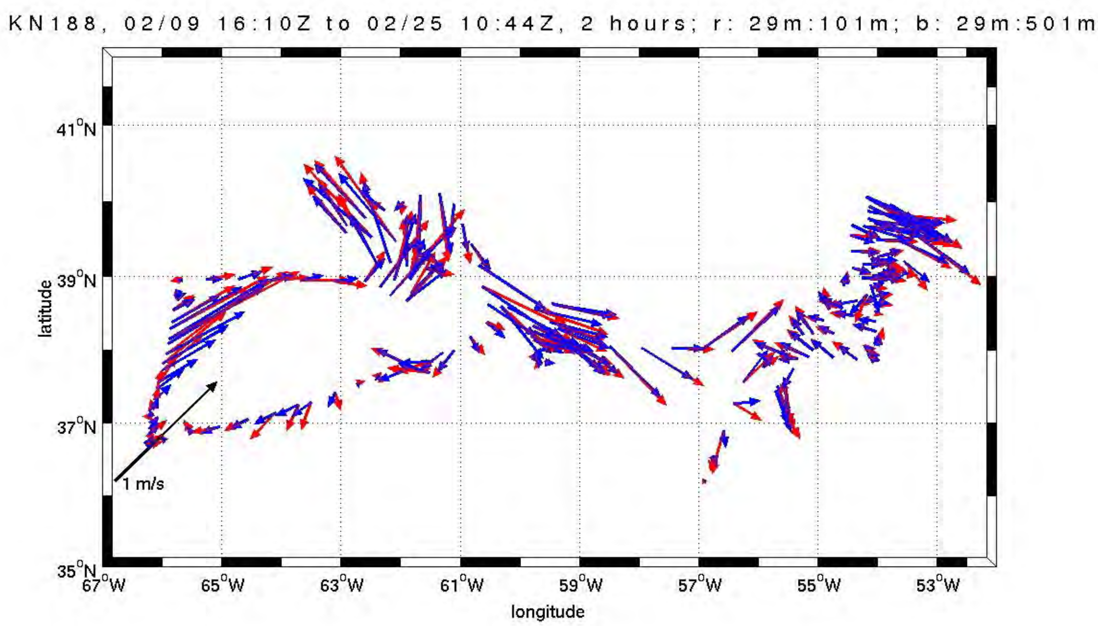


Fig. 5, ADCP overall velocities for two different depth integrations.

Shipboard acoustic Doppler current profiles from the Knorr's 75KHz "Ocean Surveyor" (RDI) were collected during the whole cruise. Initially, the instrument was configured to collect 8m bins. Within a day of our departure, we crossed the shelf and reached deep water. For the first 20 hours, the instrument performed reasonably well, profiling down to about 500m. Starting around 22:00Z on the 8th, however, as weather conditions worsened, we encountered significant time periods of near total data loss. On Feb 9, 16:04Z, we changed the instrument configuration to the more robust default of 16m bins. Performance improved somewhat, with many good periods of profiling depths beyond 800m. However, a significant number of bad profiles remained: even with reduced quality thresholds, 1053 out of 4504 profiles between 2/9 16:04Z and 2/25 10:44 did not contain good velocity bins (note: a large portion of those were intermittent drop-outs; an eye-ball estimate suggests sustained gaps occurred over about 20%).

Early in the cruise, the PosMV GPS-based heading correction dropped out. Ship's tech Robbie was able to restart the data feed by re-initializing the instrument, and it provided better than 90% coverage for the remainder of the cruise.

CTD/Hydrogrpahy – T. Joyce

The contrast between the upstream and downstream sections is enormous. None of our Lagrangian probes managed to transition from one to the other during the course of the cruise. Both the ASIS and the EMAPEX detrained from the Gulf Stream flow before they got to the longitude of the eastern section (54W). We will try to illustrate this by showing the pair of temperature/oxygen sections next to one another.

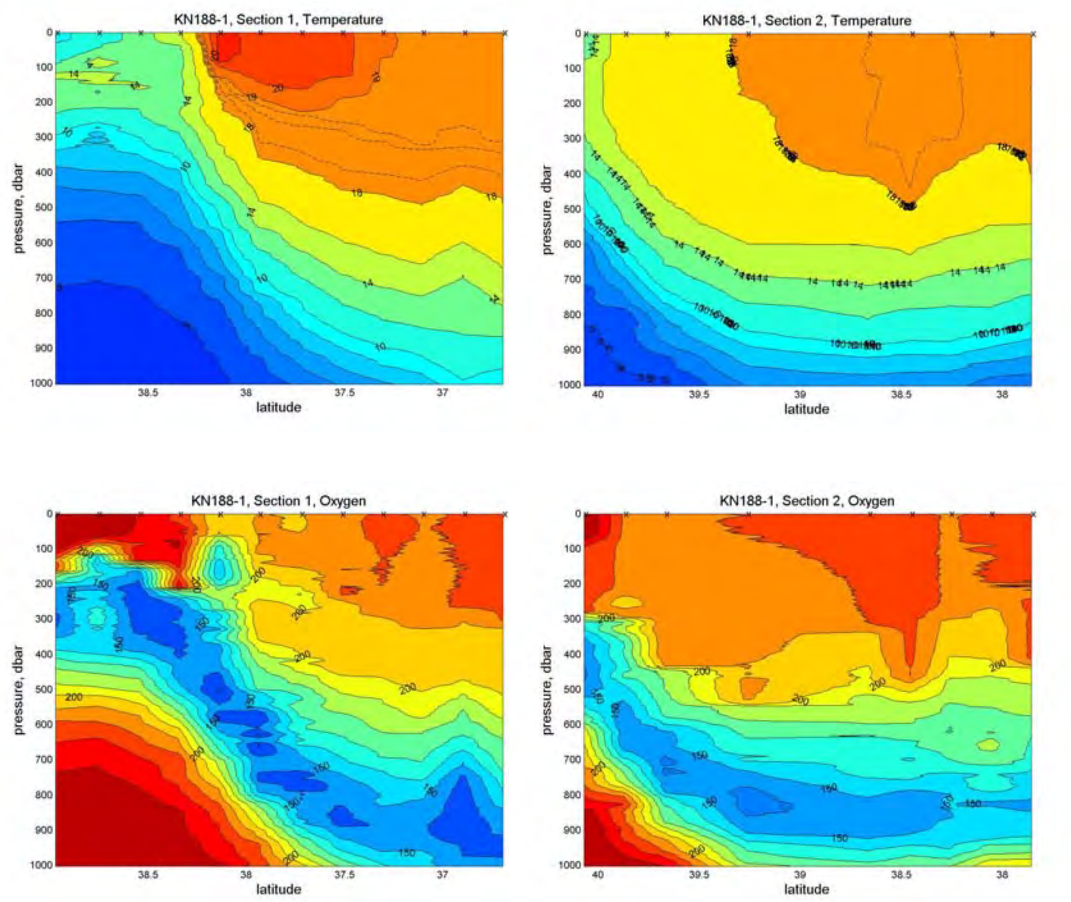


Fig. 6, Temperature and dissolved Oxygen sections across the Gulf Stream from 66W (left) to 54W (right). These stations are shown on the front page.

The surface temperature maximum in the warm core of the Gulf Stream disappeared between the two sections. The mixed layer south of the Gulf Stream in the EDW region deepened from 350m, 18.75C to 400m, 18-18.25C. Further east, the 17C outcropped within the north wall of the Gulf Stream near 40N. The eastern section did not go all the way across the Stream, which was somewhat more diffuse than to the west. Between the two sections, the subsurface salinity maximum under the warm core disappeared (not shown) and the oxygen became nearly saturated throughout the EDW layer. The deepest mixed layer on the eastern section was not the furthest south, and south of 38.5N, the upper layer flow was westward as tracked by the surface drifters and the ADCP.

The two sections were located in different regions based on the SST maps. The upstream section showed outcropping of the 17.5-18.5 isotherms within the Gulf Stream, while these open up east of 55W, where the eastern section was located. In leg 2 we need to explore the connection between the two regions where the water mass characteristics of the eastward flow change to produce the above contrasts.

CO_2 – N. Bates (contributed by M. Jeffries)

The Marine Biogeochemistry Lab at the Bermuda Institute of Ocean Sciences (formerly Bermuda Biological Station for Research) run by Dr. Nick Bates is primarily interested in understanding the movement of carbon between the atmosphere and the world's oceans. By measuring the dissolved inorganic carbon and the alkalinity of a sea water sample, the carbon budget for that particular water mass can be determined. CLIMODE aims to determine the magnitude of formation and dissipation of Eighteen Degree Water in the North Atlantic near the Gulf Stream. Our goal in the Marine Biogeochemistry Lab is to quantify the importance of this formation in relation to the global carbon budget.

Sea water has absorbed nearly 2/3 of the anthropogenic CO2 from the atmosphere. This buffering affect has helped to control the global rise in atmospheric CO2 concentration which is directly related to global warming. Given a better understanding of mode water formation and the amount of carbon sequestration in it, we can better predict the future uptake of CO2 by the ocean. With this aim during CLIMODE-4, 507 water samples (493 niskin, 14 underway) were collected from 30 stations using the JGOFS methodology for collection of DIC samples. In addition to water sampling, an underway pCO2 system (SAMI) measured the partial pressure of CO2 in the surface ocean along our cruise track for the duration of the 21 day cruise. Surface water samples drawn from the shipboard pumped underway system were taken along the cruise track and will be used to validate the SAMI pCO2 measurements. Preliminary results are not yet available.

Nutrient Measurements - K. Cashman

Earlier work suggests that the pattern of primary productivity for the North Atlantic subtropical gyre is set by the strength of its subsurface nutrient reservoir. The spatial and temporal variability of this reservoir is thought to be caused by the variation in the production and advection of EDW). As EDW is formed, the nutrients contained are depleted due to biological utilization. Subsequently, as the EDW is exported into the gyre a low-nutrient wedge is formed beneath the euphotic zone. When this water is vertically mixed, the low nutrient signature is expressed in the surface waters.

As in past CLIMODE cruises, the primary goal of the CLIMODE 4 cruise was to determine the cross-stream nutrient structure in the winter as well as to determine the level of nutrient depletion in newly-formed mode waters. Additionally, since CLIMODE 4 has sampled farther east than past CLIMODE cruises, understanding the downstream fate of the nutrients carried by the stream has become a priority as well.

During the first leg of the CLIMODE 4 cruise nutrient samples (nitrite, nitrate, phosphate and silicate) were gathered at 30 CTD stations which included two cross-stream transects. The samples were stored in pre-sterilized polypropylene sample tubes which were frozen immediately after collection. Upon return to Wood's Hole in late March, the samples will be shipped in dry-ice filled coolers to Scripps Institute of Oceanography for analysis by Susan Becker.

Microstructure Profiling – M. Gregg

Personnel: Mike Gregg, Jack Miller, Dave Winkel, Steve Bayer, Andrew Cookson, Ryu Inoue, all from the Applied Physics Lab., University of Washington.

Instruments: Two microstructure profilers (AMP4 and AMP5) plus a 150~kHz broadband ADCP installed in one of the ship's transducer wells. The ADCP was on CLIMODE cruise 4, legs 1 and 2, but data were recorded only during leg1. AMP4 took casts to 250-280 m, and AMP7 was used to 1000 m, although most profiles ended at 500-600 m. Both instruments carried two airfoils, two FastTip thermistors and a Neil Brown 3-cm conductivity cell.

Profiling: With one or two exceptions for sea state, one AMP profile was taken with every CTD cast. When in the Gulf Stream, Knorr was headed into the current moving at 1-1.5 knots into it which in most cases meant that the ship was moving slowly downstream relative to the bottom.

Analysis: Temperature and electrical conductivity will be compared to the CTD casts and adjusted to fit them when necessary, owing to their greater accuracy. Turbulent dissipation rates and diapycnal diffusivities have been computed from airfoil data, and rms scales of density overturns will be estimated from potential density. The dissipation rates and diffusivities will be interpreted using stratification and shear in the water column and surface fluxes. We also plan to compare them with standard mixing parameterizations, e.g. KPP. Ryu Inoue will be the primary analyst, for his postdoctoral research.

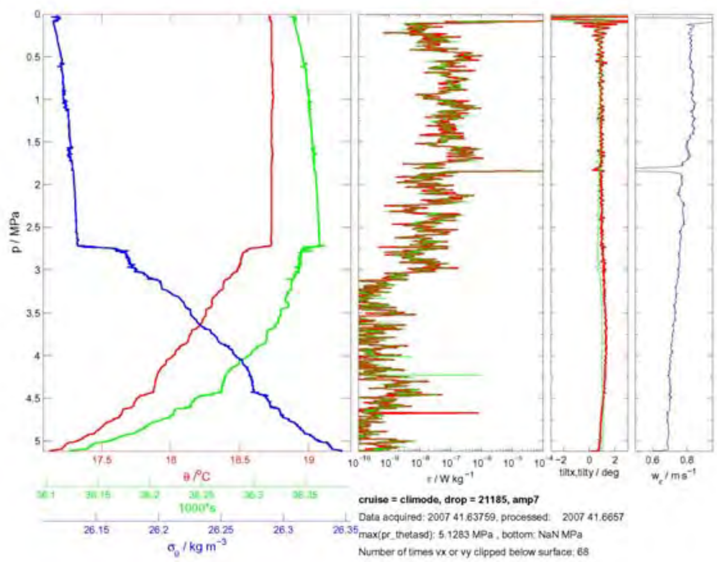


Fig. 7, Sample profile, computed and plotted while the profiler was being hauled in. Taken during a period of strong forcing, turbulence is continuous to almost 50 m below the bottom of the surface mixed layer. Owing the the homogenity of potential temperature, the salinity gradient in the mixed layer is suspect and will be checked, and possible corrected, against the CTD at this station.

FILIS/EM-Apex - J. Toole

This subprogram of CLIMODE is focused on acquiring quasi-Lagrangian observations of finescale temperature, salinity and velocity variability in the upper ocean. The original vehicle envisioned to acquire these data was FILIS, the Finescale Lagrangian Instrument System. FILIS consists of a Moored Profiler (equipped with a CTD and an Acoustic Current Meter - ACM) mounted on a 500-m drifting vertical tether. For CLIMODE, the FILIS was attached to the ASIS buoy and the whole system was allowed to drift with the upper ocean currents (plus the effects of wind and wave on the ASIS). The Profiler we used was a WHOI-built Coastal Moored Profiler (CMP) that had a Nobska MAVS ACM integrated into the system. (Prior to CLIMODE, CMPs were only fitted with CTD sensors.) The FILIS was employed during the winter 2006 cruise with mixed results. While demonstrating the viability of the approach, the foam floatation that was added to the CMP to compensate for the water weight of the MAVS ACM partially crushed under pressure (this despite the foam being rated to survive well below the maximum 500 m deployment depth). The negative buoyancy that resulted ended up too great for the CMP to climb up the tether. For 2007, high-density syntactic foam floatation was utilized instead. This floatation appeared to performed well. Also new for 2007, the CMP control software was enhanced to support full, two-way communications with the MAVS ACM. Operationally, the CMP controller initiates data acquisition by the CTD and ACM prior to each one-way traverse of the supporting tether. At the end of each profile, the CMP controller downloads data from the external sensors and archives those data to flash memory card. The CMP was programmed to profile continuously in time, pausing only long enough at the top and bottom of its tether to offload and archive data.

Given the mixed results from the 2006 cruise, a source for additional finescale data was sought. Drs. Tom Sanford and James Girton (UW/APL) kindly agreed to loan us two profiling floats equipped with Sanford's electromagnetic velocity sensor. These so-called EM-Apex floats are variations of the standard Webb Argo float. For CLIMODE, the two EM-Apex floats were programmed to profile continuously between the surface and 500 or 550 m depth. Each time upon surfacing, the CTD and EM data are relayed via Iridium to a server at UW/APL along with GPS position information. We arranged to have the position data automatically emailed to the ship upon receipt and for the derived temperature, salinity and velocity profiles to be made available for ftp access over the Knorr's Highseasnet internet link.

Deployment and recovery of the FILIS in conjunction with ASIS during Knorr cruise 188-1 are detailed elsewhere. With the able assistance of John Lund and John Kemp, EM-APEX float no. 1636 was released from the ship immediately after the ASIS/FILIS was deployed. Initially, the float was programmed to descend to 500 db, but after consultation with Girton ashore, this was increased to 550 db to fully span the depth interval of the 18^{o}C water layer. Initially, the ASIS/FILIS and EM-Apex drifted together, but after about 12 hours, the spar buoy system moved north of the float and then accelerated to the east. For the next 6 days, the float followed behind the spar buoy system on nearly the same track, albeit somewhat more slowly. On February 18, the EM-Apex float began to shift south of the ASIS/FILIS track as both instruments slowed. Then, while ASIS turned to continue east past 57^{o}W along ~37.5^{o}N, the EM-Apex slowed still further and turned south. When ASIS was recovered, the EMA 1636 was 67 nmi to the west. In light of the time of day (night) and weather forecast, recovery of EMA-1636 was not deemed feasible on the 24th. Moreover, merit was seen in allowing the float to continue sampling through the time period between Knorr cruise legs. Thus the float was left to continue working. As of the noontime of February 26 when this report was submitted, EMA-1636 had returned 198 temperature, salinity and velocity profiles.

In view of the rough conditions at sea, it was decided to delay opening the glass instrument housing of the CMP to extract the flash memory card until R/V Knorr was secure in port. Upon reaching the calm waters of St.George's harbor, the glass electronics housing of the CMP was opened and the flash memory card extracted. A preliminary assessment of the data show that the vehicle successfully profiled between its programmed sampling depths of 10 and 475 m depth a total of 137 times during the deployment. During two, ~half-day intervals of particularly rough weather on February 15 and 20, the CMP failed to move up from near it's bottom stop. But once the sea state relaxed, the vehicle resumed full-depth profiling. The acquired CTD data appear of good quality, though the vertical motion of the CMP frequently reversed during profiles due to wave action on the tether. The ACM data appear noisy. At this point it is not known if this noise is a data unpacking problem or a reflection of the instrument performance on a highly dynamic tether.

EM-Apex data overview

Data from the EM-Apex float are available in near-real time and so an initial assessment of these observations is possible. Depth-time contour plots of the float data were constructed based on the data acquired through noontime on February 26. The float was deployed on the Sargasso Sea side of the Gulf Stream Warm Core where the surface mixed layer was approximately 100 m deep. While some variation of local mixed layer depth was observed, at no time did surface convection penetrate much below 150 m. In fact, the long-term trend in mixed layer depth observed by the float was a shoaling. The relative velocity profile data were combined with instrument drift velocity estimates from the position fixes to derive absolute velocity. The absolute velocity profile data were rotated into a local along- and across-drift coordinate system using the low-pass-filtered drift velocity. Notable in the depth-time contour plots of velocity is the period of fast drift between February 16 and 22 and strong near-inertial-period oscillations around and after the time of a major wind stress event. A subsequent major wind stress event around February 25 seems not to have generated as strong an inertial response. Curiously, the surface mixed layer shoaled during this latter wind event to less than 50 m depth. An ensemble average of the along- and across-drift absolute velocity profile suggests that the EM-Apex float moved on average with water parcels near 175 m depth with net surface flow to the right of the drift track and subsurface flow to the left. The mean along-stream velocity profile exhibits little vertical shear, as we expected based on the deployment position. MIT/WHOI Joint Program student Katie Silverthorne will be analyzing these observations in conjunction with various mixed layer models to understand the evolution of the upper ocean during the winter 2007 CLIMODE cruises.

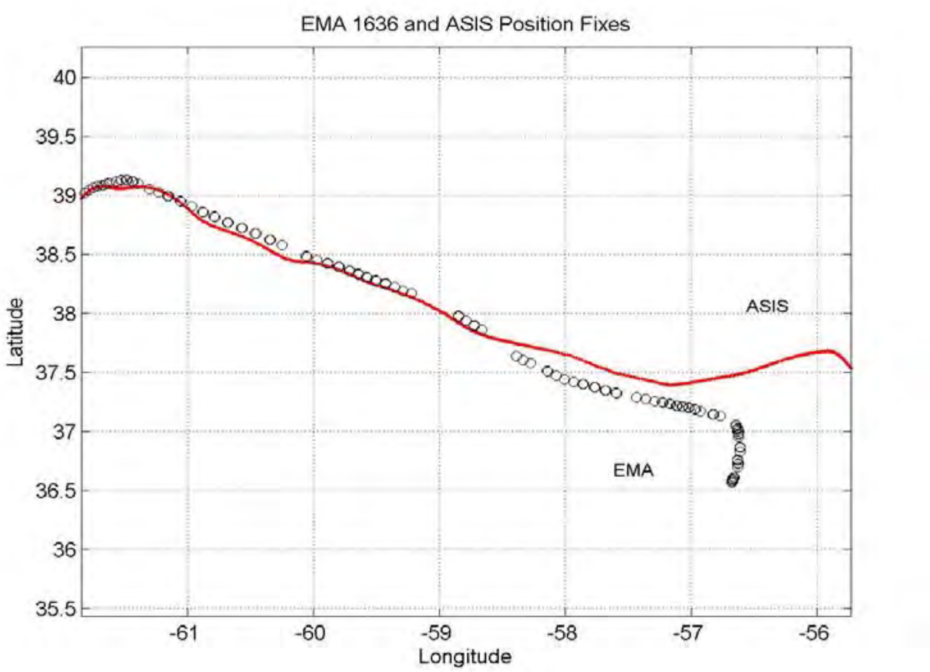


Figure 8 Position fixes of EM-Apex float 1636 (black circles) and the ASIS buoy (red dots).

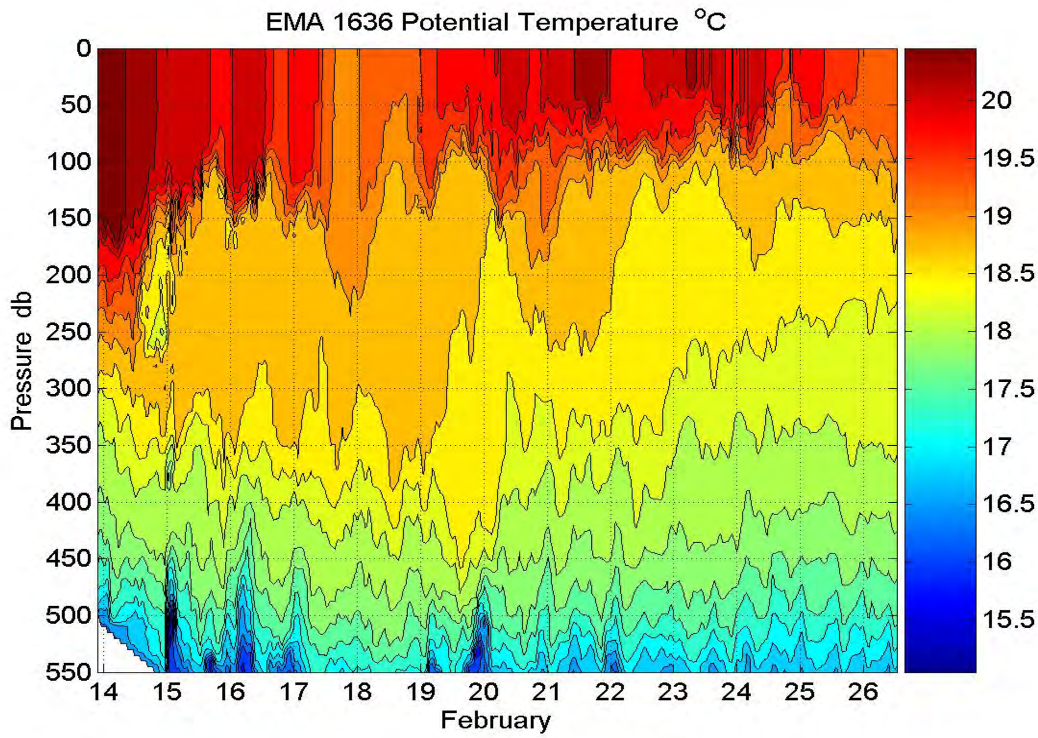


Figure 9. Depth-time contour plot of potential temperature derived from EM-Apex float 1636 through mid-day on February 26.

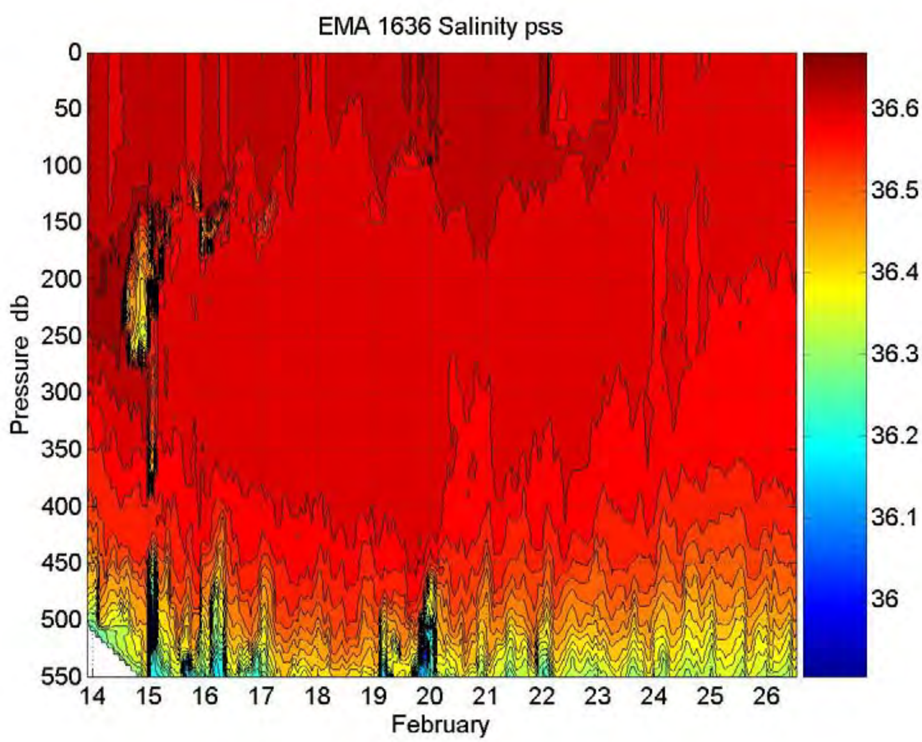


Figure 10. Depth-time contour plot of salinity derived from EM-Apex float 1636 through mid-day on February 26.

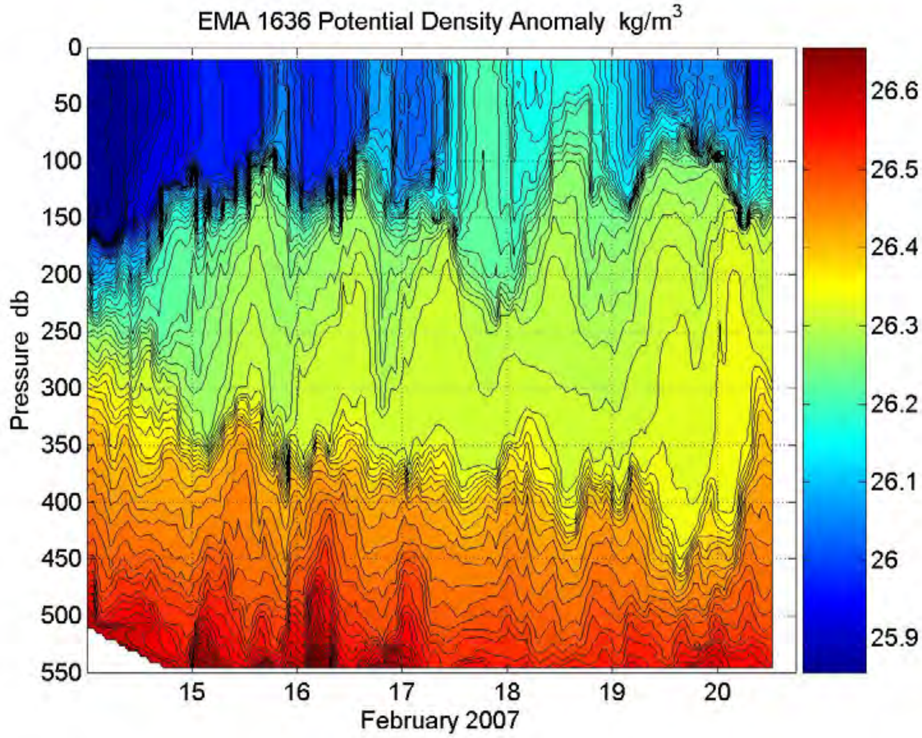


Figure 11. Depth-time contour plot of potential density derived from EM-Apex float 1636 through mid-day on February 26.

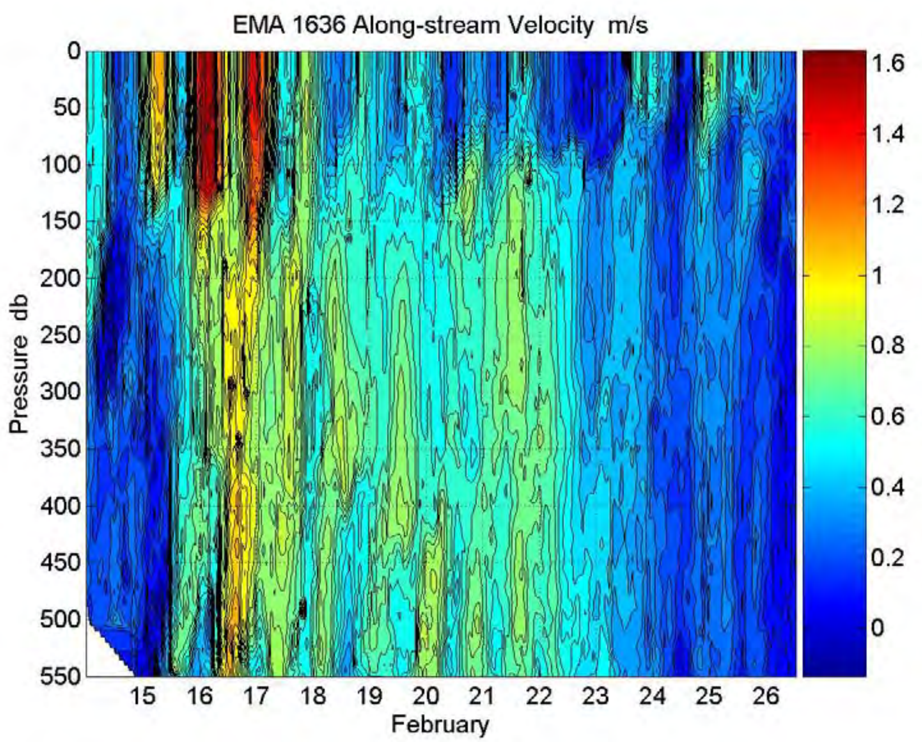


Figure 12. Depth-time contour plot of along-stream velocity derived from EM-Apex float 1636 through mid-day on February 26.

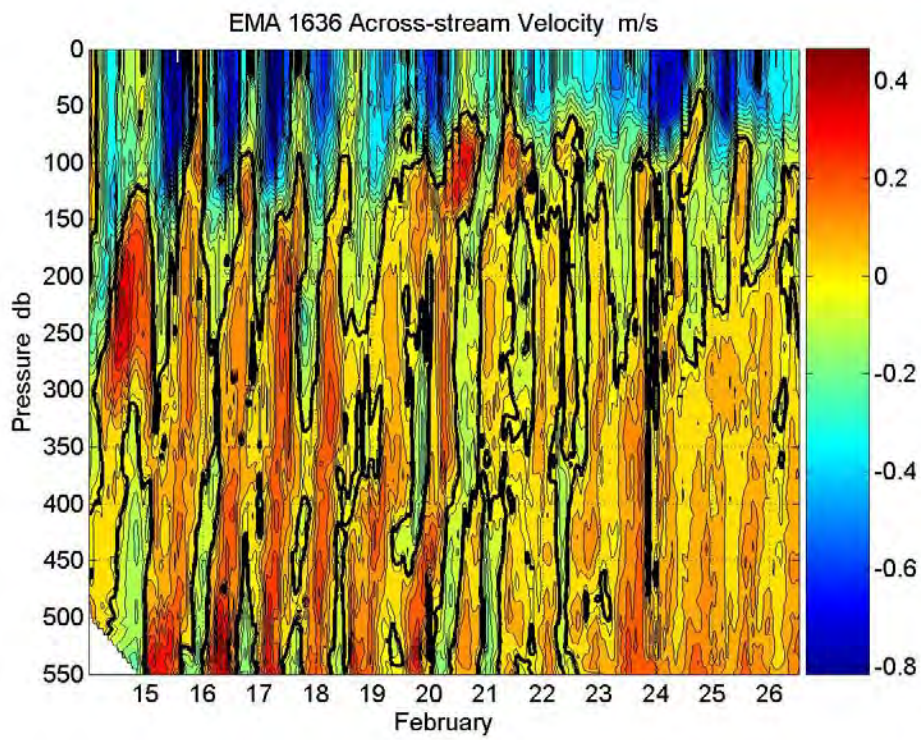


Figure 13. Depth-time contour plot of across-stream velocity derived from EM-Apex float 1636 through mid-day on February 26.

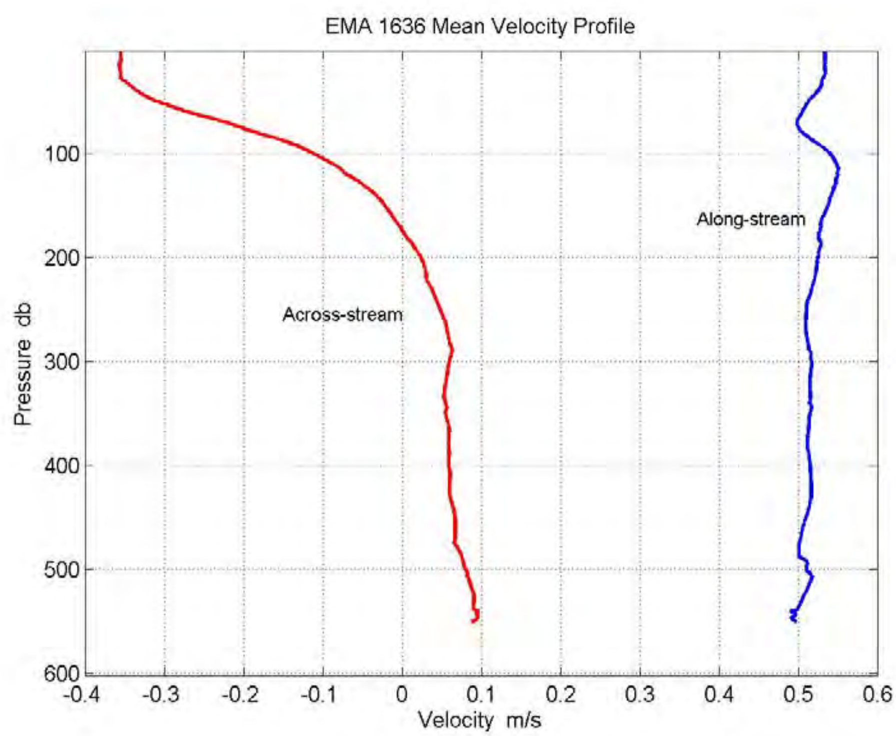


Figure 14. Time-mean velocity profile from EM-Apex float 1636 in along- and across-stream coordinates.

Atmospheric Profiling (NCAR) – G. Granger, L. Verstraete

NCAR successfully launched more than 50 balloon-borne radiosonde soundings from the Knorr during the first leg of cruise KN-188. Of those, all but one made it above the boundary layer, and just one other had no GPS signal and thus no winds. (Feb 21, 14:30 UTC.) Several more soundings were attempted but failed. The predominant reason for failures was strong winds blowing the balloon or the sonde into the ship or into the ocean. Beyond that, a few more launch times were not even attempted due to unsafe and unfavorable weather. Overall, the success rate was good given the tricky conditions.

Briefly, the sounding launch plan laid out by Jim Edson called for soundings at the CTD transect stations and 3-hourly soundings during SeaSoar legs. We achieved this for the most part, except where the weather proved too uncooperative. As an example, Figure 15 shows the soundings for the western CTD transect, Figure 16 shows the easternmost transect and Sea Soar legs.

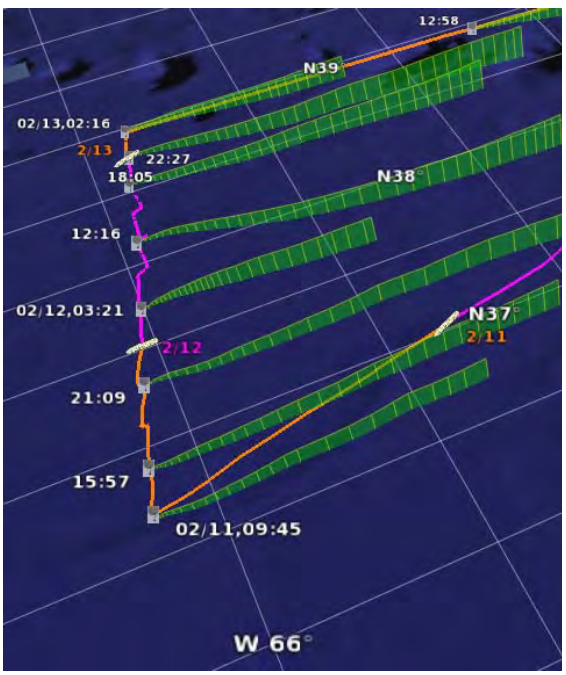


Figure 15. West transect of KN-188-1, showing ship track in orange and violet, sonde tracks in yellow (horizontal position) and green (height above ground).

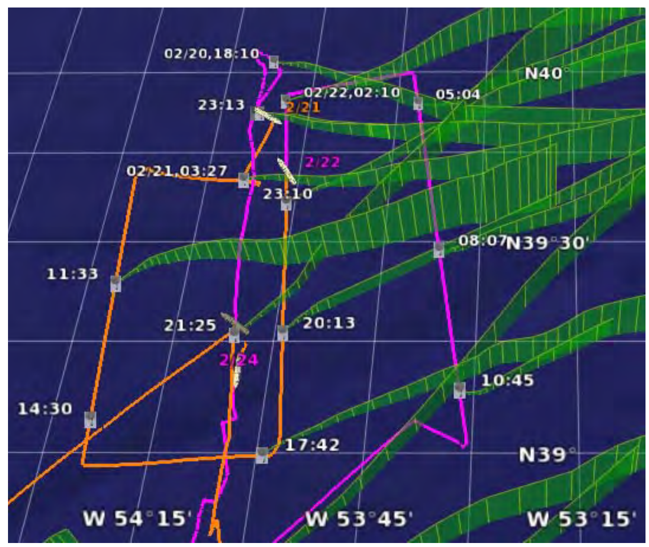


Figure 16. East transect and Sea Soar legs with sounding balloon tracks.

The wind profiler radar has also worked reasonably well apart from a few periods of weak signal, particularly given the effect sea-spray has had on our stabilizing platform. The wind measurements from the profiler agree well with those from the radiosonde, and will help fill in the gap between the soundings. The stabilizing platform developed a power problem part way through the cruise, so it was shut down and bolted in place after February 20. Initial comparisons show that the profiler is actually doing a fairly good job at measuring the winds, despite the stabilized platform problem. The figures below are a simple example under calmer conditions: the sounding profile is on the left and the concurrent radar wind profiles are on the right.

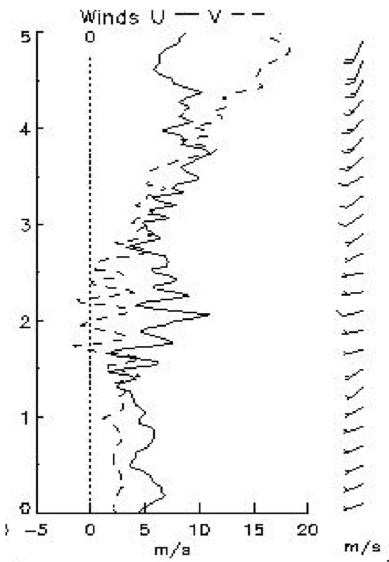


Figure 17. Wind profile of sounding Feb 24, 18:49 UTC.

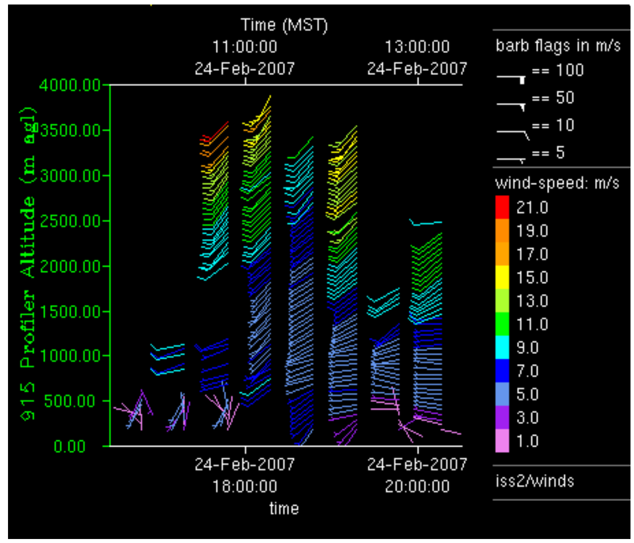


Figure 18. Radar wind profiles around the 18:49 sounding.

There are a few resources available for browsing ISS data in near real-time and after the project. During and after the project, the home page for data and other information is here:

- http://www.eol.ucar.edu/rtf/projects/climode/
- This site hosts plots of the balloon soundings, wind profiles, and temperature profiles. In particular, see the "Sounding Profile Plots" link for balloon sounding profiles which can be more easily compared with the radar wind profiles.

Air-Sea Exchange - Al Plueddemann, Steve Faluotico

The air-sea exchange group operated two systems on this cruise, a set of meteorological sensors on a mast at the bow of the Knorr ("bow-mast system") and meteorological and oceanographic sensors on an instrumented drifter (the Air-Sea Interaction Spar – ASIS). Both systems had a PC-104 based data logger and recorded GPS position, solar radiation, infrared radiation, temperature, pressure, humidity, CO2 and H20 gas, pitch/roll, heading, three dimensional accelerations and winds. The ASIS had an Iridium satellite link to transmit its position and was outfitted with ocean sensors to measure surface wave height, pressure, temperature, conductivity, and currents.

The bow-mast system ran continuously for the duration of the cruise (7-26 February). Spot samples of bow-mast data evaluated several times daily during the cruise revealed no obvious problems with any of the sensors. The complete data set has been recorded, but has yet to be evaluated. A sample of wind speed data from the bow mast during a period of high winds on 24 February is shown in Fig. 19.

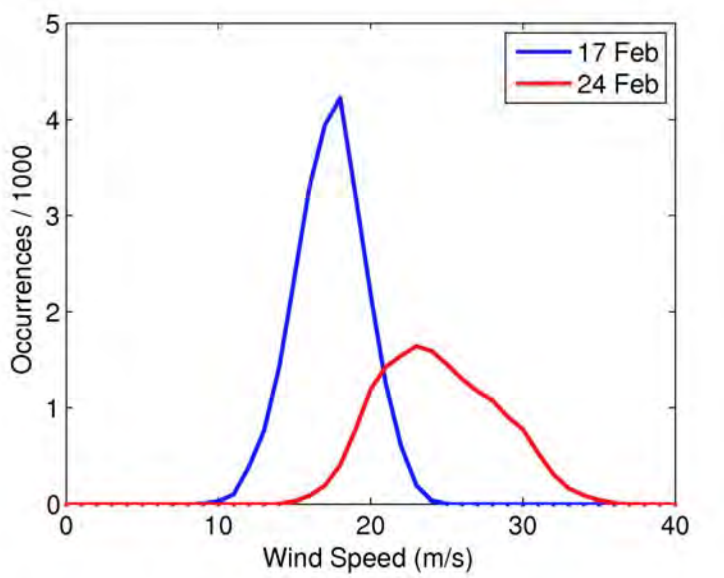


Figure 19. Histogram of sonic anemometer wind speed during 20 min periods. 17 Feb (14:20 to 14:40 UTC): ASIS wind speed during a period of large ocean heat loss. 24 Feb (02:40 to 03:00 UTC): Bow-mast wind speed during a period of high winds.

We encountered two issues with ASIS during transit. First we noticed the buoy battery voltage was dropping far more rapidly than expected. This was traced to the batteries not being wired correctly. We were able to make the required fixes to our spare batteries and then swap them out with the original batteries during a station stop. The second issue we encountered was that the ASIS GPS failed. We decided to take the GPS off of the met mast and put it on ASIS. The system was fully operational by the time of deployment.

The ASIS was successfully deployed on 13 February at 20:40 UTC and ran continuously until data acquisition was stopped at 03:00 UTC on 23 February for file transfer prior to recovery. The buoy remained within the core of the Gulf Stream for most of its drift and moved with a typical speed of about 2 knots. The ASIS drift track along with the track of the EM-Apex drifter, a schematic cruise track, and radiosonde launch locations is shown in Fig. 20.

Spot samples of ASIS data obtained via FreeWave modem link during the cruise revealed that the humidity and air temperature sensor failed prior to 17 February. Evaluation of data files offloaded after ASIS recovery showed the failure at 03:40 UTC on 15 February.

Indications are that all other meteorological sensors ran continuously until recovery. A sample of ASIS wind speed data during a period of strong ocean heat loss is shown in Fig. 19. The air-sea temperature difference was 8 deg, the mean wind speed was 17 m/s, and the sum of latent plus sensible heat loss was estimated at 850 W/m^2. Evaluation of the ocean sensors revealed complete data sets for all except one current meter, which failed at the time of immersion. Near-surface (1.5 m) temperature and salinity during the ASIS drift are shown in Fig. 21.

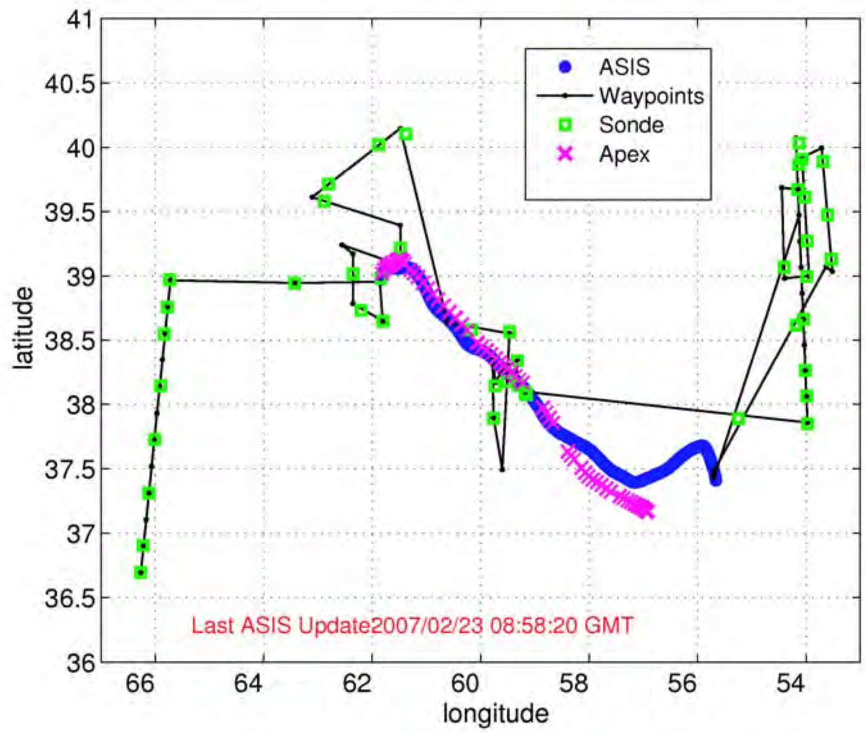


Figure 20. ASIS drift track from GPS (blue), EM-Apex drift track (x), and radiosonde launch locations (squares) along schematic ship track made up of principal waypoints.

The ASIS recovery was expertly done in calm conditions, with no damage to the buoy or instrumentation. Unfortunately on the way to Bermuda the ship encountered severe weather. During the night of 23 February, a large wave was encountered nearly head-on, passed over the starboard rail, and damaged ASIS. Roughly half of the tie-down straps broke, allowing the spar to move. The straps that didn't break tore apart the spar structure when it moved. A heroic effort in the midst of the storm allowed the buoy to be re-secured to the deck and the meteorological sensors to be recovered with minimal damage. The damage to the buoy structure, however, proved to be substantial, and further damage was done by other wave impacts during the transit. The damage will preclude deployment of ASIS on the second leg.

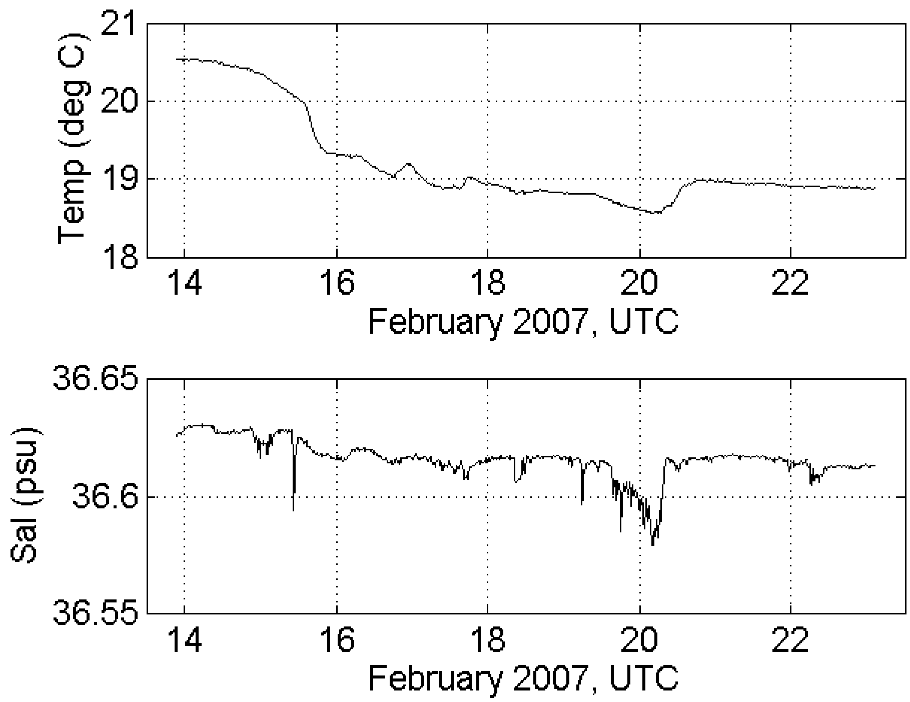


Figure 21. Near-surface (1.5 m) temperature and salinity from the ASIS deployment.

Surface drifters – R. Lumpkin

33 Argos-tracked surface drifting buoys were deployed on leg one of CLIMODE-4 in order to measure mixed layer currents and sub-skin SST. The drifters were Global Drifter Program drifters, drogued at 15m depth with a holey sock drogue. Location and SST observations were provided at irregular intervals with a median spacing of 1.2 hours, interpolated to hourly values for analysis.

The first 18 drifters were deployed in six trios (near-simultaneous deployments of three drifters) along the hydrographic line at 36.5—39°N, 66°W. Four of these trios were south of the Gulf Stream wall, with the fourth trio in the core of the Stream. The fifth and sixth trios were north of the wall, as indicated by their speeds and temperatures (Fig. 22).

The seventh trio of drifters was deployed alongside the ASIS spar buoy on 14 February. One of these three failed after three days.

A pair of drifters was deployed on 16 February within a deep, cold meander that was suspected to be pinching off to form a cold core ring. These drifters completed a cyclonic loop after deployment (Fig. 22).

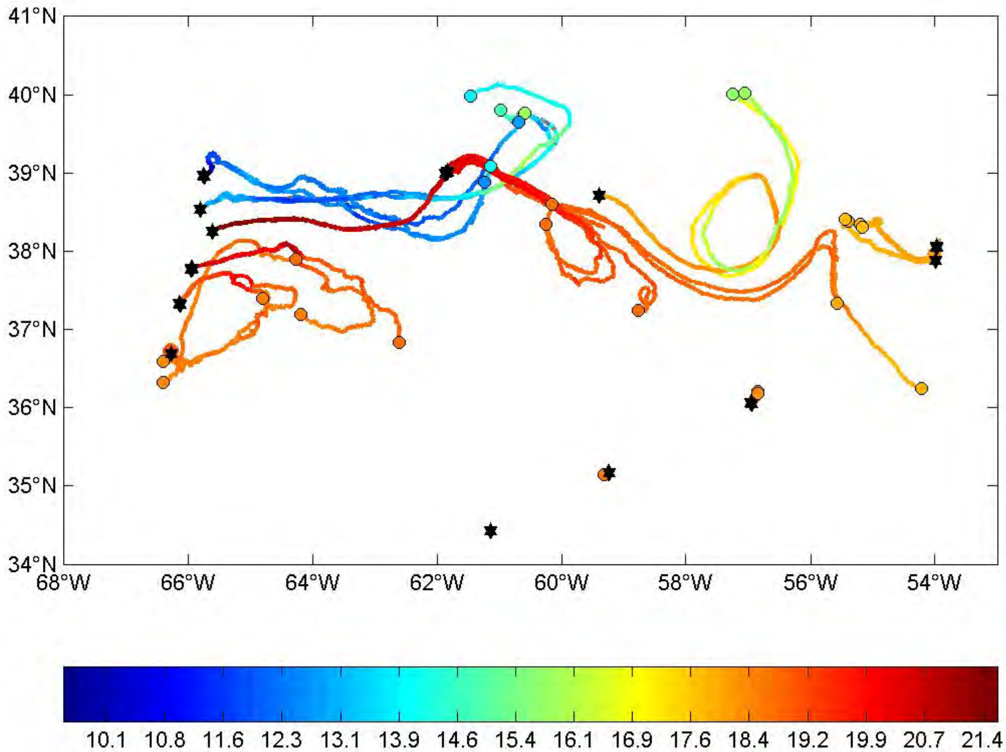


Fig. 22. Drifter measurements of position and SST (shading, °C). Locations of first fix indicated by black stars; positions as of 0050Z 26 February 2007 indicated by bullets.

Two drifter pairs were deployed at the southernmost two CTD stations of the hydrographic section along ~54°W. Contrary to expectations, these four drifters have propagated steadily westward.

The remaining six drifters were deployed in 3 pairs between the final CTD cast and the Economic Exclusive Zone of Bermuda, to sample the recirculation gyre of EDW.

Preliminary analysis of dispersion was conducted for the pairs and trios deployed south of the Gulf Stream wall (Fig. 23). For each cluster of drifters, the mean position and SST as a function of time was removed and the mean-square growth of the measurements were observed. At lags up to three days, dispersion was near zero. Then, from 3—12 days, both zonal and meridional dispersion grew at a hyperballistic rate proportional to $t^{4.5}$. Some evidence of a decrease in this rate is suggested at the longest lags. These results are highly preliminary, as many clusters have not been in the water for more than a few days and thus the results as a function of lag are at present strongly biased by the spatial distribution of the deployments.

drifter	PTT ID	DATE	TIME (UTC)	Lat	Lon	Notes
1	72104	02/11/07	12:29	36º 41.78' N	66º 15.95' W	
2	72110	02/11/07	12:29	36º 41.78' N	66º 15.95' W	failed on deployment
3	72111	02/11/07	12:29	36º 41.78' N	66º 15.95' W	
4	72102	02/11/07	21:56	37º 19.04' N	66º 08.03' W	
5	72103	02/11/07	21:56	37º 19.04' N	66º 08.03' W	
6	72105	02/11/07	21:56	37º 19.04' N	66º 08.03' W	
7	72112	02/12/07	5:10	37º 44.54' N	66º 00.73' W	
8	72126	02/12/07	5:10	37º 44.54' N	66º 00.73' W	
9	72109	02/12/07	5:10	37º 44.54' N	66º 00.73' W	failed 2/15 after 0000Z
10	72113	02/12/07	11:47	38º 09.17' N	65º 52.70' W	Core of Gulf Stream
11	72101	02/12/07	11:47	38º 09.17' N	65º 52.70' W	Core of Gulf Stream
12	72100	02/12/07	11:47	38º 09.17' N	65º 52.70' W	Core of Gulf Stream
13	72077	02/12/07	20:35	38º 32.42' N	65º 48.69' W	
14	72059	02/12/07	20:35	38º 32.42' N	65º 48.69' W	
15	72057	02/12/07	20:35	38º 32.42" N	65º 48.69' W	
16	72058	02/13/07	4:09	38º 58.12' N	65º 44.26' W	
17	72065	02/13/07	4:09	38º 58.12' N	65º 44.26' W	
18	72068	02/13/07	4:09	38º 58.12' N	65º 44.26' W	
19	72055	02/14/07	0:35	38º 58.21' N	68º 51.28' W	Deployed with ASIS
20	72056	02/14/07	0:35	38º 58.21' N	68º 51.28' W	Deployed with ASIS
21	72066	02/14/07	0:35	38º 58.21' N	68º 51.28' W	failed 2/17 after 1800Z
22	72067	02/16/07	11:43	38º 43.98' N	59º 26.53' W	cold meander
23	72078	02/16/07	11:43	38º 43.98' N	59º 26.53' W	cold meander
24	72069	02/19/07	3:05	37º 51.55' N	53º 58.50' W	
25	72079	02/19/07	3:05	37º 51.55' N	53º 58.50' W	
26	72075	02/19/07	7:30	38º 02.58' N	53º 58.46' W	
27	72076	02/19/07	7:30	38º 02.58' N	53º 58.46' W	
28	72099	02/25/07	9:26	36º 04.6' N	56º 57.9' W	Recirculation
29	72108	02/25/07	9:26	36º 04.6' N	56º 57.9' W	"
30	72097	02/26/07	0:27	35º 09.88' N	59º 14.46' W	"
31	72098	02/26/07	0:27	35º 09.88' N	59º 14.46' W	"
32	72106	02/26/07	10:36	34º 25.76' N	61º 08.32' W	"
33	72107	02/26/07	10:36	34º 25.76' N	61º 08.32' W	"

Table 3: drifter deployment locations

The lateral effective diffusivity $\kappa = \frac{1}{2}\frac{d}{dt}\left\langle x'^2 \right\rangle$ grew from <50 m^2/s at lags of 0—3 days, to 500—1000 m^2/s at 3—10 days, to 3000—5000 m^2/s at lags of 10+ days.

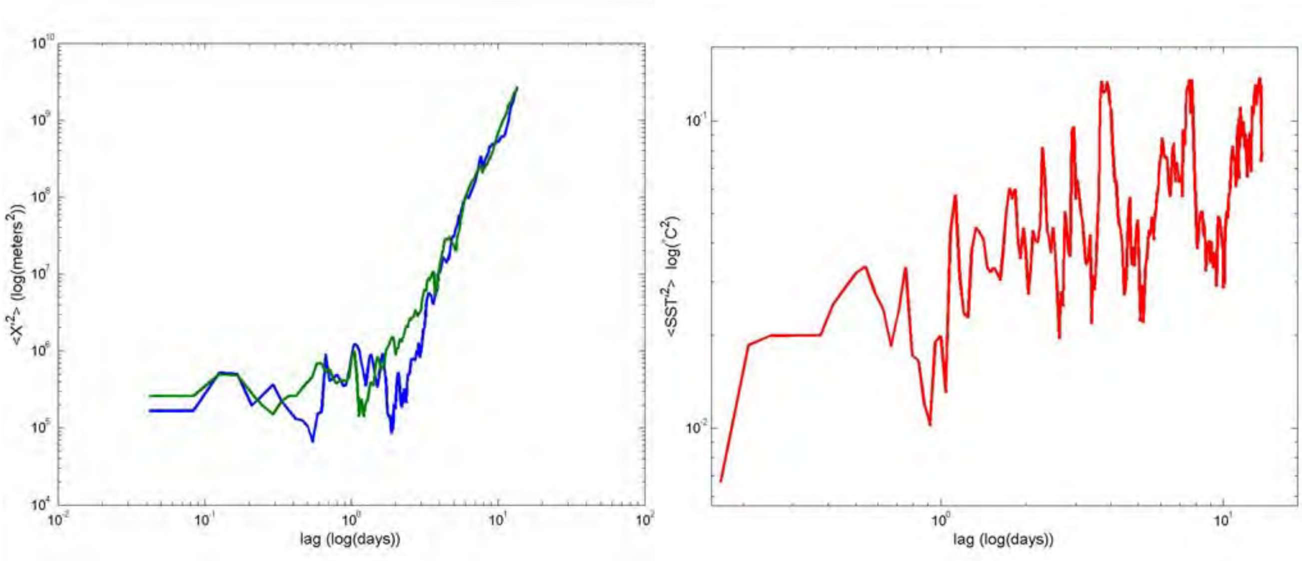


Fig. 23: dispersion (vertical axis) as a function of time (horizontal axis) for zonal (blue) and meridional (green) displacement (left) and sea surface temperature (right).

Floats – J. Lund

University of Washington Float Deployments

The University of Washington sent three Autonomous Profiling Expendable Floats (APEX) designed by Webb Research to be deployed from the *R/V Knorr* (CLIMODE KN188-1). The floats were modified at UW to communicate via an Iridium phone. The Iridium phone modem makes two-way communication possible so that float missions are changeable after deployment. Each float was equipped with a GPS which shares the irdium phone antenna and provides accurate surface positions. The floats were equipped with a Seabird model 41 pumped CTD. Floats 5068 and 5069 were constructed with an Aanderaa Oxygen Optode 3830 sensor. Float 5051 (rafos) did not have the oxygen sensor but was equipped with a hydrophone.

Floats 5068 and 5069 are programmed to detect mode water. Float 5069 is a test platform for a new ice evasion algorithm. Once the float is proved to be operating well, the mode water detection and ice evasion algorithm will be started. The ice evasion algorithm uses mode water detection to determine if there is a possibility of ice at the surface. UW is testing the mode water detection (18 degree water) during the CLIMODE experiment. When floats are deployed in the arctic the mode water temperature threshold will be changed to 1.8 degrees Celsius. It is likely that once the mode water detection is started, float 5069 will not be heard for some months while 18-degree mode water is still forming at the surface.

Dana Swift and Rick Rupan (UW) came to WHOI and loaded the floats aboard the *R/V Knorr*. Together they checked out the floats to insure that there was no damage during shipping. The floats were left in a ready-to-deploy state. The floats are turned on by a hydrostatic pressure switch.

Sea state made the line deployment recommended in the manual impossible. Floats were dropped from the stern into the peak of a wave (approximately 2 feet). This was safer than allowing the float to snap against deployment line and it also prevented the floats from being damaged under the ship.

UW requested that the floats be deployed south of the Gulf Stream near the sound source mooring array. It was also requested that floats 5068 and 5069 be deployed near the new 18 degree mode water. Deployment locations are in the table and figure 24 below.

UW-APL	Date	Time	SN	LAT	lat	LON	lon	Float ID
1	2/11/2007	12:20	2668	36	41.63	66	16.63	5069
2	2/19/2007	3:04	1840	37	51.59	53	58.357	5051
3	2/19/2007	3:07	2669	37	51.55	53	58.46	5068

Bobber Float (TD-Rafos)

Bobbers are Autonomous Profiling Expendable Floats (APEX floats) with TD-RAFOS instrumentation and a modified sampling program. Six bobbers were deployed during the KN188-1 February 2007 CLIMODE Cruise. See figure 25 and the following table for deployment times and locations.

Each Bobber was equipped with a RAFOS hydrophone and a Sea Scan TD (temperature, and pressure) sensor. Bobbers make temperature-depth profiles that are acoustically tracked under water using the arrival time from several sound sources located on subsurface moorings deployed during the November 2005 CLIMODE cruise (OC419).

Bobbers are programmed to seek the 18.5 degree isotherm which is the nominal center of the mode water. They adjust their buoyancy to follow this isotherm. Each day the float listens for 120 minutes starting at 00:00:00 GMT for acoustic pongs from the source moorings. Once every three days the float will bob between the 17 and 20 degrees or 700 meters and surface in order to determine the thickness of the mode water. Every 30 days the float is programmed to make a full ocean profile from 1000 meters to the surface. While at the surface, position and temperature profile data are transmitted via Argos.

Prior to launch floats were checked using the automated LabVIEW software provided by Webb Research Corporation. The software verifies all of the float's systems are functioning properly. As instructed in the APEX manual each float was reset before the launch and completed the auto test. Sea states for the majority of KN188-1 were very rough so Bobbers 1-5 were dropped from the stern into the peak of a wave (approximately 2 feet). This was safer than allowing the float to snap against deployment line and it also prevented the floats from being damaged under the ship. Sea states had decreased during the launch of Bobber #6 which required that it be lowered gently into the water by slipping a line through the dampening ring as suggested by the manufacturer.

KN188-1 Bobber deployments

Bobber	Date	Time	SN	LAT	lat	LON	lon	Argos ID
1	2/10/2007	6:17	2538	37	41.84	61	32.49	39793
2	2/11/2007	12:22	2536	36	41.63	66	16.63	39765
3	2/19/2007	3:10	2379	37	51.54	53	58.53	38604
4	2/25/2007	9:30	2385	36	4.529	56	58.23	39470
5	2/26/2007	0:26	2535	35	09.88	59	14.46	39763
6	2/26/2007	10:44	2523	34	25.66	61	8.52	39473

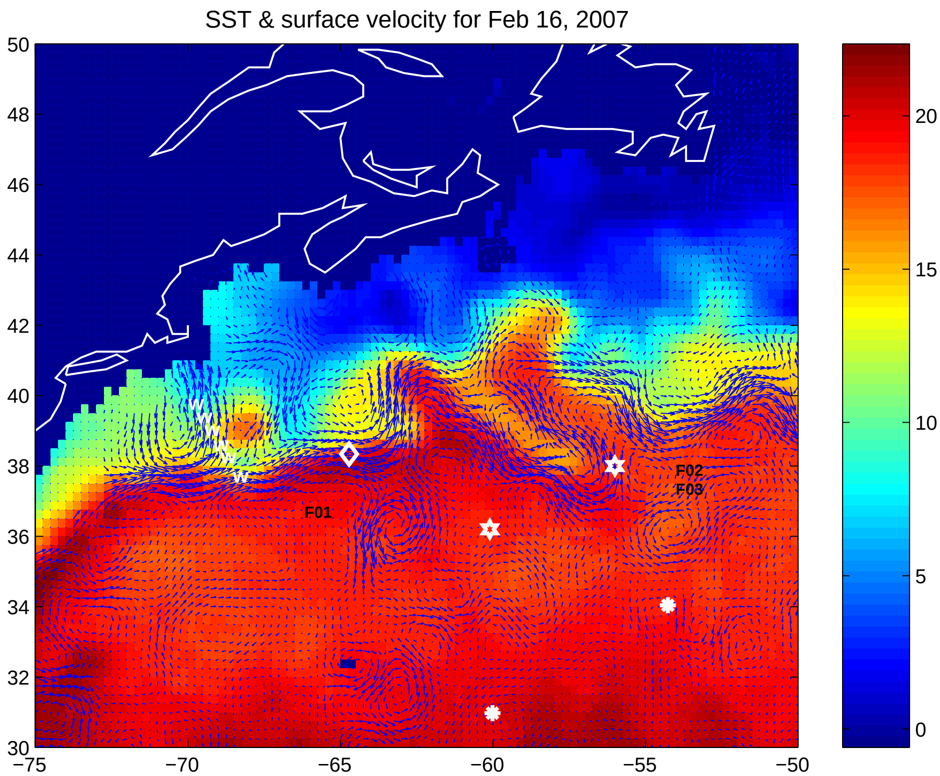


Figure 24, deployment sites for UW floats (P01, P03, & P03)

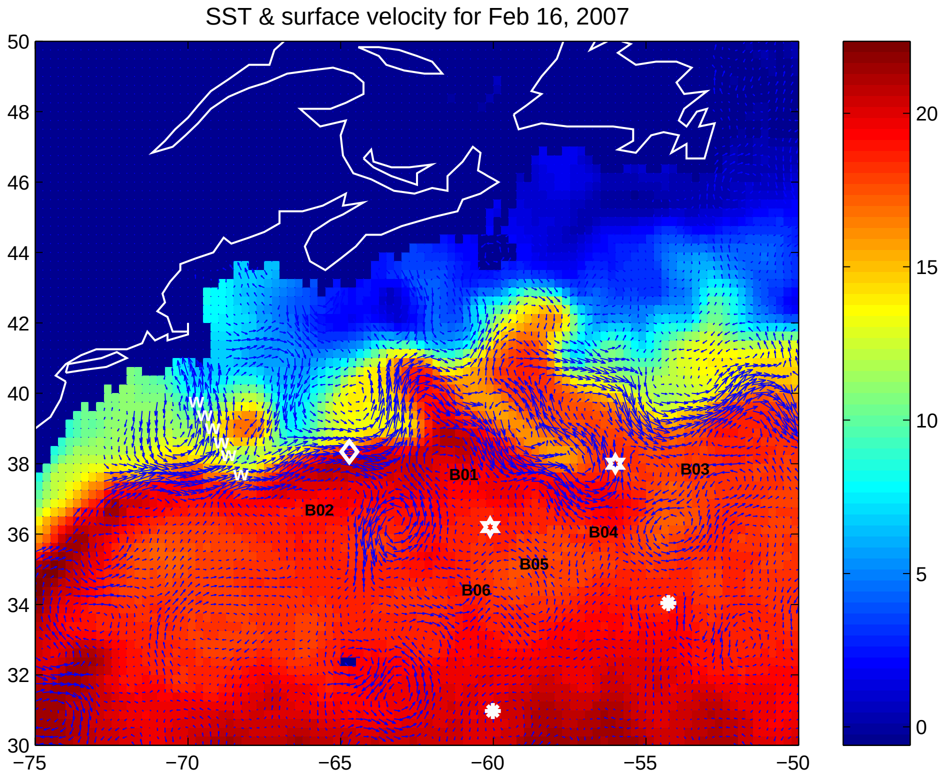


Figure 25, deployment sites for WHOI Bobbers (B01:06)

Students- Kristi Cashman, Andrew Barton, Rebecca Dell

Kristi Cashman, Andrew Barton and Rebecca Dell joined the the CLIMODE 4 Cruise in order to gain experience with in situ oceanographic data collection and a better understanding of the strengths and weaknesses of the resulting data. The students assisted with several aspects of the data collection, including the CTD/hydrography and the SeaSoar. The cruise helped the students to appreciate both the techniques used to collect data as well as the difficulties that arise while collecting data at sea. Difficulties seen in this cruise included mechanical and electronic equipment failures and severe weather conditions. The students were able to observe and assist in equipment repairs, gaining a more sophisticated understanding of some of the central types of oceanographic instruments. Additionally, students were able to observe the decision making processes employed by scientists in the field, and to see the compromises and alterations to the original cruise plan that were necessary. Finally, students had the opportunity to see directly how various types of measurements are coordinated and how each type of data collected compliments the others. For instance, the combination of the CTD and Seasoar allowed for a more complete spatial and temporal sampling of Gulf Stream transects than would be possible with one instrument alone. Students also assisted in the deployment and/or recovery of radiosonde balloons, floats, moorings and drifters.

Table 1, Scientific Personnel

NAME (M/F)	INST/Responsibilty	EMAIL
Terry Joyce (M)	whoi/chief scientist	tjoyce@whoi.edu
John Lund (M)	whoi/ bobbers/seasoar	jlund@whoi.edu
Frank Bahr (M)	whoi/ seasoar	fbahr@whoi.edu
John Toole (M)	whoi/ ASIS	jtoole@whoi.edu
Craig Marquette (M)	whoi/seasoar/FILIS	cmarquette@whoi.edu
Paul Fucile (M)	whoi/seasoar	pfucile@whoi.edu
Jane Dunworth-Baker (F)	whoi/watchstander/sat imagery	jdunworth@whoi.edu
Andrew Barton (M)	whoi/mit/watchstander	adbarton@mit.edu
Ryu Inoue (M)	APL/ microstructure	rinoue@apl.washington.edu
Rick Lumpkin (M)	NOSS/drifters	Rick.Lumpkin@noaa.gov
Kristen Cashman (F)	Duke/nutrients	kristin.cashman@duke.edu
Michael Gregg (M)	APL/ microstructure	gregg@apl.washington.edu
Jack Miller (M)	APL/ microstructure	miller@apl.washington.edu
Dave Winkel (M)	APL/ microstructure	winkel@apl.washington.edu
Andrew Cookson (M)	APL/ microstructure	andrew@apl.washington.edu
Steve Bayer (M)	APL/ microstructure	na
John Kemp (M)	whoi/ASIS	jkemp@whoi.edu
Al Plueddemann (M)	whoi/ASIS	aplueddemann@whoi.edu
Steve Faluotico (M)	whoi/ASIS	sfaluotico@whoi.edu
Marlene Jeffries (F)	DIC	Marlene.Jeffries@bbsr.edu
Susan Becker (F)	sio/salts/oxygen/ctd	susan@odf.ucsd.edu
John Calderwood (M)	sio/ctd/oxygen	jkc@odf.ucsd.edu
Mary Carol Johnson (F)	sio/ctd processor/tech	mary@odf.ucsd.edu
Parisa Nahavandi (F)	sio/ctd/data/salinity	parisa@odf.ucsd.edu
Lou Verstraete (M)	ucar/radiosondes	louvers@ucar.edu
Gary Granger (M)	ucar/radiosondes	granger@ucar.edu
Rebecca Dell (F)	whoi/mit/watchstander	rwdell@mit.edu

Table 2, CLIMODE4-1 Event Log

% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
%										
20070207	1415	41	31.56	-70	40.38	0	0	%	watch	depart whoi
20070207	2021	41	20.48	-69	09.23	0	0	%	ap	adcp calibration run, 10 min
20070208	1950	40	15.59	-63	43.37	0	0	%	ap	met mast test
20070209	2007	39	03.49	-60	18.07	0	0	%	tj	commence surf buoy recovery
20070209	1147	39	02.45	-60	17.34	0	0	%	ap	surf buoy on deck
20070209	1630	38	38.96	-60	17.34	0	0	%	tj	recovery terminated before full recovery
20070210	0419	37	41.69	-61	30.96	1	1	%	tj	start ctd 01
20070210	0600	37	41.76	-61	31.89	0	0	%	tj	end ctd 01
20070210	0612	37	41.76	-61	32.15	0	0	%	pf	RBPM7, lost instrument
20070210	0617	37	41.84	-61	32.48	3	1	%	jl	bobber #2538, large wave deployment
20070210	1813	37	14.75	-63	39.48	0	0	%	mg	amp test station
20070210	1937	37	16.30	-63	41.67	0	0	%	mg	depart test station
20070210	1821	37	14.83	-63	39.70	6	1	%	mg	amp 21182
20070210	1911	37	15.78	-63	41.12	6	2	%	mg	amp 21183
20070211	0724	36	41.65	-66	15.97	0	0	%	rl	ctd 02 cast 1, pump off at 550m
20070211	0823	36	41.86	-66	16.19	6	3	%	mg	amp 21184
20070211	0900	36	41.51	-66	16.05	0	0	%	rl	ctd 02 cast 3, pump off at 500m
20070211	0940	36	41.48	-66	16.20	2	1	%	lv	radiosond 01 #094502
20070211	1025	36	41.57	-66	15.20	1	2	%	sl	ctd o2 cast 5, success
20070211	1211	36	41.44	-66	16.39	0	0	%	rl	end ctd 02
20070211	1229	36	41.76	-66	16.74	4	1	%	rl	Drifters 72104,72110,72111
20070211	1220	36	41.63	-66	16.63	7	1	%	jl	UW float sn2668
20070211	1223	36	41.63	-66	16.63	3	2	%	jl	bobber #2536 argos id 39765
20070211	1353	36	53.88	-66	12.94	1	3	%	tj	start ctd 03
20070211	1505	36	54.00	-6	12.84	0	0	%	TJ	end ctd 03
20070211	1518	36	54.11	-66	13.06	6	4	%	mg	amp 21185 to 510m
20070211	1557	36	54.19	-66	13.52	2	2	%	ap	radiosond 02

20070211	1722	37	06.11	-66	10.31	6	5	%	mg	amp 21186
20070211	1755	37	06.49	-66	11.06	1	4	%	tj	start ctd 04
20070211	1908	37	06.33	-66	11.74	0	0	%	tj	end ctd 04
20070211	2040	37	18.74	-66	07.20	1	5	%	tj/rl	start ctd 05
20070211	2110	37	18.74	-66	07.22	2	3	%	rl	radiosond 03
20070211	2141	37	18.83	-66	07.52	0	0	%	rl	end ctd 05
20070211	2156	37	18.95	-66	07.84	4	2	%	rl	drifters 72102,72103,72105
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070211	2203	37	19.04	-66	08.03	6	6	%	mg	amp 21887
20070211	2357	37	31.12	-66	04.09	6	7	%	mg	amp 21188
20070212	0036	37	31.04	-66	04.83	1	6	%	jt	start ctd 06
20070212	0141	37	31.31	-66	04.09	0	0	%	jt	end ctd 06
20070212	0305	37	43.55	-66	00.93	1	7	%	jt	start ctd 07
20070212	0302	37	43.66	-66	00.58	2	4	%	ap	radiosond 04
20070212	0405	37	44.16	-65	59.51	0	0	%	jt	end ctd 07
20070212	0428	37	43.98	-66	00.27	6	8	%	mg	amp 21189 to 250m, 21190 to 500m
20070212	0510	37	44.54	-66	00.73	4	3	%	rl	drifters 72112,72126,72109
20070212	0651	37	56.21	-65	57.64	6	9	%	mg	amp 21191 to 500m
20070212	0735	37	56.40	-65	57.27	1	8	%	rl	start ctd 08
20070212	0847	37	57.58	-65	54.61	0	0	%	tj	end ctd 08
20070212	1007	38	08.60	-65	53.26	1	9	%	rl	start ctd 09
20070212	1118	38	09.90	-65	51.07	0	0	%	rl	end ctd 09
20070212	1147	38	09.17	-65	52.70	4	4	%	rl	drifters 72113,72101,72100
20070211	1218	38	08.53	-65	54.08	2	5	%	ap	radiosond 05 121652
20070212	1218	38	08.50	-65	54.29	6	10	%	mg	amp 21192 to 500m
20070212	1408	38	20.75	-65	51.96	6	11	%	mg	amp 21193 to 500m
20070212	1500	38	20.89	-65	51.52	1	10	%	tj	start ctd 10
20070212	1553	38	21.34	-65	49.99	0	0	%	tj	end ctd 10
20070212	1730	38	33.05	-65	49.45	6	12	%	mg	amp 21194 to 500m
20070212	1815	38	32.92	-65	49.85	2	6	%	ap	radiosond 06 180514_p.1
20070212	1745	38	32.91	-65	49.86	1	11	%	tj	start ctd 11, frame broke cast 1, cast 2 ok

20070212	2019	38	32.52	-65	48.63	0	0	%	tj	end ctd 11
20070212	2035	38	32.42	-65	48.69	4	5	%	jl	drifters 72077,72059,72057
20070212	2217	38	45.49	-65	46.24	1	12	%	jt	start ctd 12
20070212	2230	38	45.30	-65	46.30	2	7	%	lv	radiosond 07
20070212	2316	38	45.22	-65	46.41	0	0	%	jt	end ctd 12
20070212	2340	38	45.23	-65	46.54	6	13	%	mg	amp 21195 to 500m
20070213	0143	38	58.03	-65	43.39	6	14	%	mg	amp 21196 to 500m
20070213	0215	38	58.20	-65	43.99	2	8	%	lv	radiosond 1624_p.1
20070213	0216	38	58.27	-65	43.99	1	13	%	jt	start ctd 13 to 2000m
20070213	0357	38	58.07	-65	44.11	0	0	%	jt	end ctd 13
20070213	0409	38	58.12	-65	44.26	4	6	%	rl	drifters 72058,72065,72068
20070213	1258	38	56.64	-63	25.50	2	9	%	lv	radiosond 125836_p.1
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=en-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070213	1910	38	57.17	-61	51.49	5	1	%	ap	asis launch site
20070213	2125	38	59.07	-61	50.87	9	1	%		emapex 1636 launched
20070213	2200	38	58.85	-61	50.29	1	14	%	tj/jt	start ctd 14
20070213	2200	38	58.85	-61	50.29	2	10	%	lv	radiosond 2210
20070213	2319	38	59.45	-61	50.39	0	0	%	jt	end ctd 14
20070213	2346	38	59.54	-61	50.43	6	15	%	mg	amp 21197 to 520m
20070214	0035	38	58.21	-61	51.78	4	7	%	rl	drifters 72055,72056,72066
20070214	0300	38	38.92	-61	42.23	2	11	%	lv	radiosond CB-1 031812
20070214	0300	38	38.92	-61	48.23	8	1	%	fb	seasoar launched
20070214	0600	38	44.02	-62	08.96	2	12	%	lv	radiosonde 060732
20070214	0754	38	46.80	-62	20.30	0	0	%	watch	crossed GS wall, turn to seasoar track 2
20070214	0930	39	00.90	-62	21.12	2	12	%	lv	radiosonde 092913
20070214	1130	39	74.89	-62	32.90	0	0	%	watch	seasoar waypoint
20070214	2000	39	12.95	-61	28.83	2	13	%	lv	radiosonde 195333
20070215	0309	39	32.61	-62	37.74	0	0	%	mg	BB150 adcp off, restart
20070215	0415	39	34.80	-62	53.19	2	14	%	gg	radiosonde 042619
20070215	0715	39	42.72	-62	48.09	2	15	%	gg	radiosonde 071304
20070215	1158	39	57.89	-62	04.26	2	16	%	gg	radiosonde no data

20070215	1313	40	01.31	-61	52.87	2	17	%	lv	radiosonde 131440
20070215	1629	40	06.26	-61	22.98	2	18	%	lv	radiosonde 162808
20070216	0500	40	06.00	-61	23.00	0	0	%	ap	asis driveby seasoar at 50m
20070216	0615	38	35.44	-60	20.52	0	0	%	ap	back on seasoar track, seasoar undulating
20070216	0657	38	34.98	-60	09.99	2	19	%	lv	radiosonde 065720
20070216	1022	38	33.91	-59	27.89	2	20	%	lv	radiosonde 102112
20070216	1143	38	43.98	-59	26.53	4	8	%	rl	drifters 72067,72078
20070216	1154	38	45.06	-59	25.32	0	0	%	watch	seasoar waypoint
20070216	1327	38	34.29	-59	27.68	2	21	%	lv	radiosonde 132642
20070216	1624	38	10.61	-59	30.92	2	22	%	lv	radiosonde 162304
20070216	1915	37	47.40	-59	33.76	2	23	%	lv	radiosonde 192203
20070216	2021	37	49.18	-59	37.59	0	0	%	fb	recover seasoar
20070216	2220	37	53.59	-59	45.79	2	24	%	gg	radiosonde 224200
20070217	0232	38	20.20	-59	47.60	1	15	%	rl	start ctd 15
20070217	0345	38	19.25	-59	45.92	0	0	%	rl	end ctd 15
20070217	0417	38	19.15	-59	45.82	6	16	%	mg	amp 21198 550m
20070217	0610	38	08.53	-59	44.06	2	25	%	gg	radiosonde 061320
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070217	0616	38	08.54	-59	44.07	6	17	%	mg	amp 21199
20070217	0654	38	08.72	-59	44.48	1	16	%	rl	start ctd 16
20070217	0807	38	08.13	-59	44.17	0	0	%	rl	end ctd 16
20070217	0938	38	15.42	-59	35.53	1	17	%	rl	start ctd 17
20070217	1043	38	14.68	-59	34.15	0	0	%	el	end ctd 17
20070217	1107	38	14.57	-59	33.97	6	18	%	mg	amp 21200 620m
20070217	1336	38	20.79	-59	19.79	1	18	%	tj	start ctd 18
20070217	1400	38	20.41	-59	19.18	2	27	%	lv	radiosonde 140336
20070217	1440	39	20.04	-59	18.65	0	0	%	tj	end ctd 18
20070217	1727	38	08.99	-59	18.67	1	19	%	tj	start ctd 19
20070217	1844	38	07.61	-59	17.71	0	0	%	tj	end ctd 19
20070217	1740	38	08.80	-59	18.50	2	26	%	gg	radiosonde 174151
20070217	1858	38	07.39	-59	17.74	6	19	%	mg	amp 21201 260m

20070217	2137	38	05.84	-59	10.83	6	20	%	mg	amp 21202 to 260m, 21203 to285m
20070217	2140	38	05.72	-59	10.94	2	28	%	gg/lv	radiosonde 214454
20070217	2212	38	05.38	-59	11.21	1	20	%	rl	start ctd 20
20070217	2320	38	04.27	-59	09.97	0	0	%	rl	end ctd 20
20070217	2344	38	04.06	-59	09.94	6	21	%	mg	amp 21204 600m
20070218	0040	38	04.40	-59	09.65	2	22	%	gg/lv	radiosonde 003811_p
20070218	2345	37	41.40	-53	58.38	6	22	%	mg	amp 21205 570m
20070219	0035	37	59.95	-53	58.38	0	0	%	gg	radiosonde no data
20070219	0050	37	59.94	-53	58.38	1	21	%	jt	start ctd 21
20070219	0253	37	51.63	-53	58.18	0	0	%	jt	end ctd 21
20070219	0304	37	51.59	-53	58.38	7	2	%	jl	UW float 5051 sn 1840
20070219	0307	37	51.55	-53	58.46	7	3	%	jl	uW float 5068 sn2669
20070219	0310	37	51.54	-53	58.53	3	3	%	jl	bobber #3 sn2379 argosid 38604
20070219	0305	37	51.55	-53	58.50	4	9	%	rl	drifters 72069,72079
20070219	0432	38	20.79	-53	59.52	1	22	%	rl	start ctd 22
20070219	0612	38	03.88	-53	58.74	0	0	%	rl	end ctd 22
20070219	0448	38	03.78	-53	59.30	2	30	%	gg	radiosonde 044812
20070219	0628	38	03.79	-53	58.54	6	23	%	mg	amp 21206 620m dicey recovery
20070219	0730	38	02.58	-53	58.46	4	10	%	rl	drifters 72075,72076
20070219	0905	38	15.74	-54	00.82	1	23	%	rl	start ctd 23
20070219	1023	38	15.83	-54	00.84	0	0	%	rl	end ctd 23
20070219	1153	38	27.43	-54	02.06	1	24	%	rl	start ctd 24
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070219	1443	38	39.84	-54	03.47	1	25	%	tj	start ctd 25
20070219	1628	38	39.41	-54	01.24	0	0	%	tj	end ctd 25
20070220	1537	40	04.21	-54	10.90	1	26	%	tj	start ctd 26
20070220	1800	40	01.99	-54	07.58	2	32	%	lv	radiosonde 181051
20070220	1815	40	01.89	-54	07.44	0	0	%	tj	end ctd 26
20070220	1851	40	01.07	-54	07.02	6	24	%	mg	amp 21207 550m
20070220	2255	39	52.31	-54	09.05	1	27	%	jt	start ctd 27
20070220	2316	39	52.01	-54	08.16	2	33	%	gg	radiosonde 231339

20070221	0013	39	51.50	-54	06.30	0	0	%	rl	end ctd 27
20070221	0027	39	51.46	-54	06.31	6	25	%	mg	amp 21208 560m
20070221	0247	39	40.21	-54	08.82	6	26	%	mg	amp 21209 560m
20070221	0322	39	40.19	-54	09.09	1	28	%	jt	start ctd 28
20070221	0459	39	39.39	-54	06.54	0	0	%	jt	end ctd 28
20070221	0327	39	40.15	-54	08.96	2	34	%	gg	radiosonde 032733
20070221	0844	39	40.61	-54	26.81	8	2	%	fb	seasoar launched
20070221	1432	38	03.97	-54	24.41	2	35	%	lv	radiosonde 143001
20070221	1740	38	59.66	-53	59.07	2	36	%	lv	radiosonde 174222
20070221	2014	39	16.00	-53	58.00	2	37	%	lv	radiosonde 201313
20070221	2300	39	36.55	-54	01.36	2	38	%	gg	radiosonde 231021
20070222	0211	39	54.53	-54	04.24	2	39	%	gg	radiosonde 021028
20070222	0505	39	53.48	-53	41.42	2	40	%	gg	radiosonde 050417
20070222	0805	39	28.30	-53	36.20	2	41	%	gg	radiosonde 0805
20070222	1047	39	07.00	-53	32.00	2	42	%	lv	radiosonde 1047
20070222	1143	39	00.96	-53	31.41	0	0	%	tj	begin seasoar recovery
20070222	1257	39	03.80	-53	57.50	0	0	%	rd	seasoar on deck
20070222	1658	38	37.05	-54	10.85	2	43	%	lv	radiosonde 165629
20070222	2300	37	53.10	-55	15.00	2	44	%	gg	radiosonde 230405
20070223	0329	37	28.78	-55	42.33	0	0	%	tj	recover FILIS
20070223	0406	37	26.63	-55	42.54	1	29	%	jt	start ctd 29
20070223	0515	37	25.75	-55	41.98	0	0	%	jt	end ctd 29
20070223	0641	37	24.53	-55	39.62	0	0	%	tj	recover asis
20070223	0652	37	24.49	-55	39.62	6	27	%	mg	amp 21210 1000m
20070223	2112	39	15.33	-54	06.28	1	30	%	jt	start ctd 30
20070223	2226	39	14.97	-54	04.58	0	0	%	jt	end ctd 30
20070223	2126	39	15.78	-54	05.90	2	45	%	gg	radiosonde 2126
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070223	2245	39	14.67	-54	03.95	6	28	%	mg	amp 21211 790m
20070224	0150	39	02.50	-54	05.00	0	0	%	jt	formidable weather conditions head for BDA
20070224	0528	38	54.13	-54	06.03	0	0	%	watch	asis damaged by waves, tower moved to hanger

20070224	1850	38	09.976	-55	19.08	2	46	%	gg	radiosonde 184928
20070224	2340	37	38.42	-56	07.56	2	47	%	gg	radiosonde 2340
20070225	0520	37	52.00	-56	32.00	0	0	%	gg	2 radiosondes, consumed by wind and sea
20070225	0926	36	04.60	-56	57.90	4	11	%	rl	drifters 72099, 72108
20070225	0930	36	04.53	-56	58.23	3	4	%	jl	bobber sn 2385, argos id 39470
20070225	2345	35	12.03	-59	07.83	2	48	%	gg	radiosonde 234234
20070226	0027	35	09.88	-59	14.46	4	12	%	rl	drifters 72098,72097
20070226	0027	35	09.88	-59	14.46	3	5	%	jl	bobber sn 2535 argos id 39763
20070226	0513	34	48.17	-60	08.10	2	49	%	gg	radiosonde 0513
20070226	1036	34	25.76	-61	08.32	4	13	%	rl	drifters 72106,72107
20070226	1044	34	25.66	-61	08.52	3	6	%	jl	bobber sn2523 argosid 39473
20070226	1130	34	19.64	-61	19.11	2	50	%	gg	radiosonde 1130
20070227	1300	32	20.00	-64	45.00	0	0	%	watch	arrive Bermuda (approx)

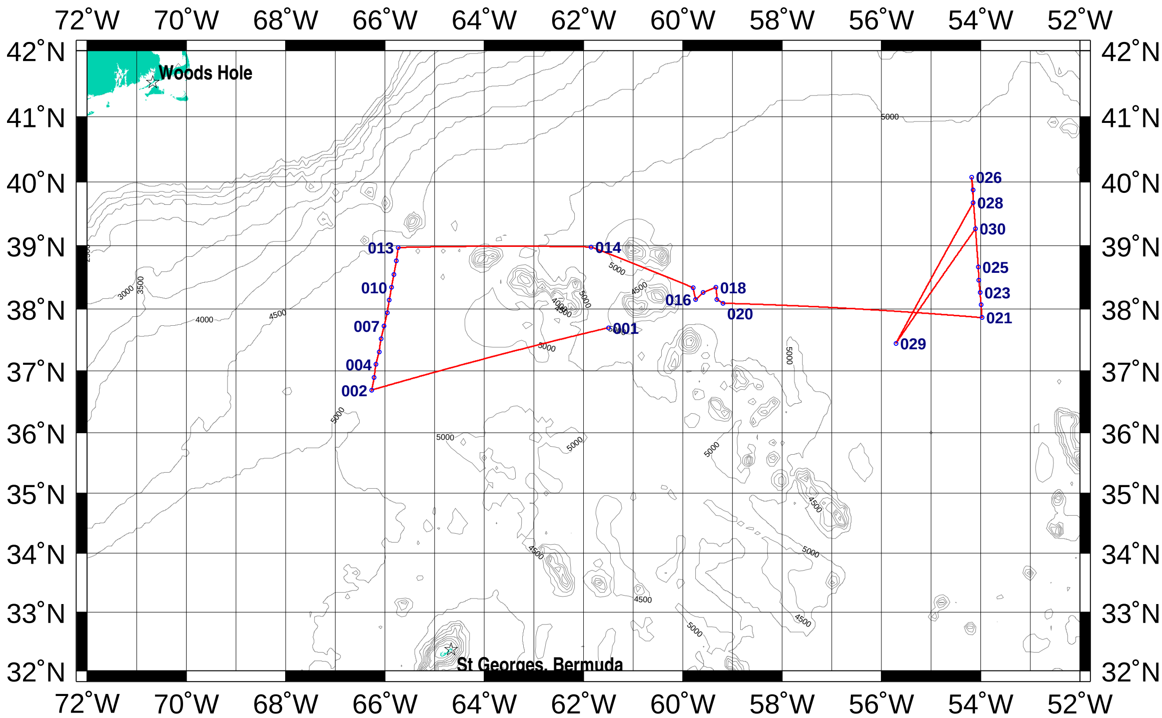
CLIMODE-4 Leg 1

R/V KNORR, KN188-1

7 February 2007 - 27 February 2007

Woods Hole, MA - St.Georges, Bermuda

Chief Scientist: Terrence M. Joyce, WHOI



Appendix 1, CTD/Hydro Data Report
27 February 2007

Data Submitted by:

Shipboard Technical Support

Oceanographic Data Facility / Shipboard Electronics Group

Susan M. Becker, Mary C. Johnson, Parisa Nahavandi / John K. Calderwood

Scripps Institution of Oceanography

La Jolla, Ca. 92093-0214

Summary

A hydrographic survey consisting of CTD/rosette sections across the northeastern branch of the Gulf Stream was carried out during February 2007. The R/V Knorr departed Woods Hole, MA on 7 February 2007. A total of 30 CTD/rosette stations were occupied. An ODF 24-bottle rosette was used successfully during the entire survey. CTD data plus water samples for oxygen, salinity, nutrient and DIC/Total Alkalinity analyses were collected on each cast to 1000 meters, or to 2000 meters for casts on either end of two lines of stations across the Gulf Stream. The cruise ended in St.Georges, Bermuda on 27 February 2007.

Description of CTD/Hydrographic Measurement Techniques (*SIO/STS/ODF+SEG***)**

1. CTD/Hydrographic Measurements Program

The basic CTD/hydrographic measurements consisted of salinity, dissolved oxygen and nutrient measurements made from water samples taken on CTD/rosette casts, plus pressure, temperature, salinity, and dissolved oxygen from CTD profiles. Nutrients were frozen and stored for analysis ashore.

A total of 30 CTD/rosette casts were made: 26 casts to 1000m and 4 casts to 2000m depth. Samples were drawn from 603 bottles out of 688 attempted trips during the casts. The distribution of samples is illustrated in Figures 1.0-1.2.

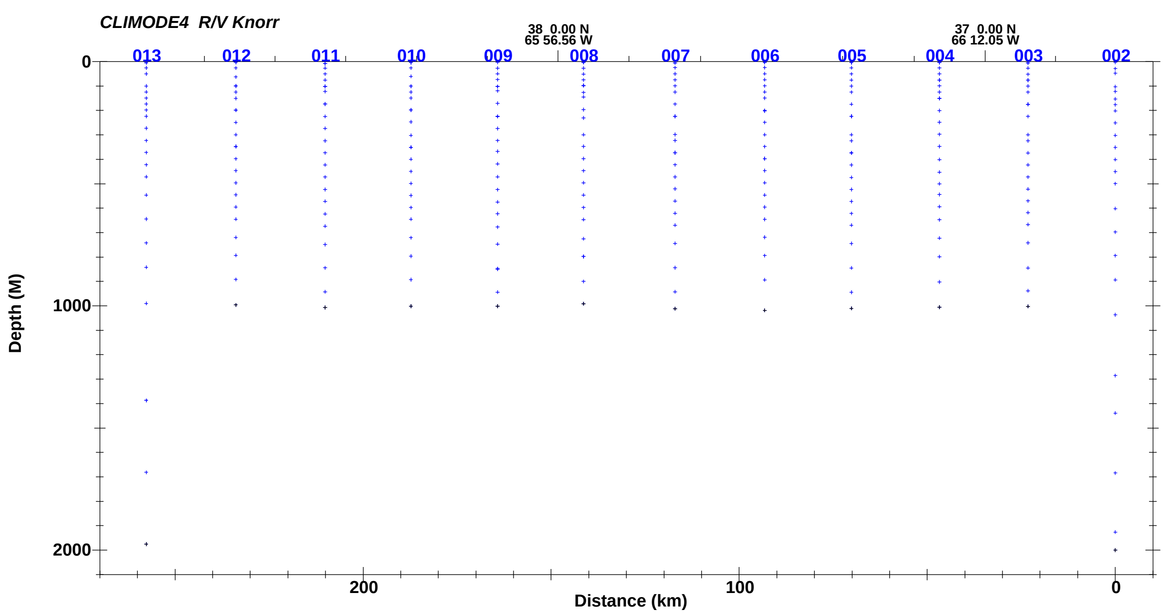


Figure 1.0 Sample distribution, Line 1, stations 2-13.

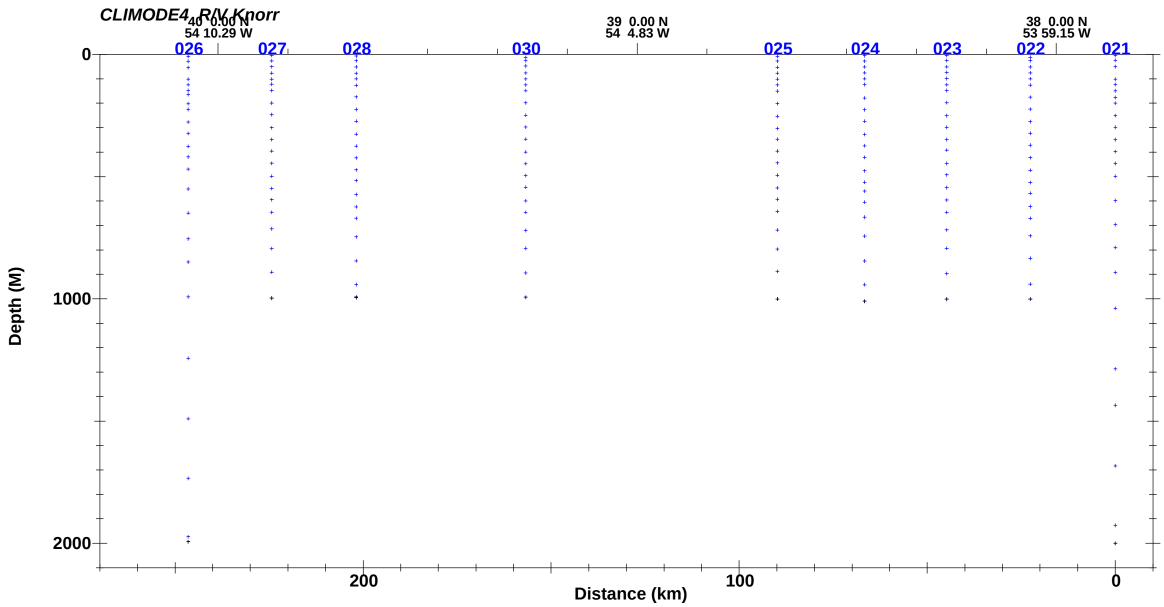


Figure 1.1 Sample distribution, Line 2, stations 21-30 (except 29).

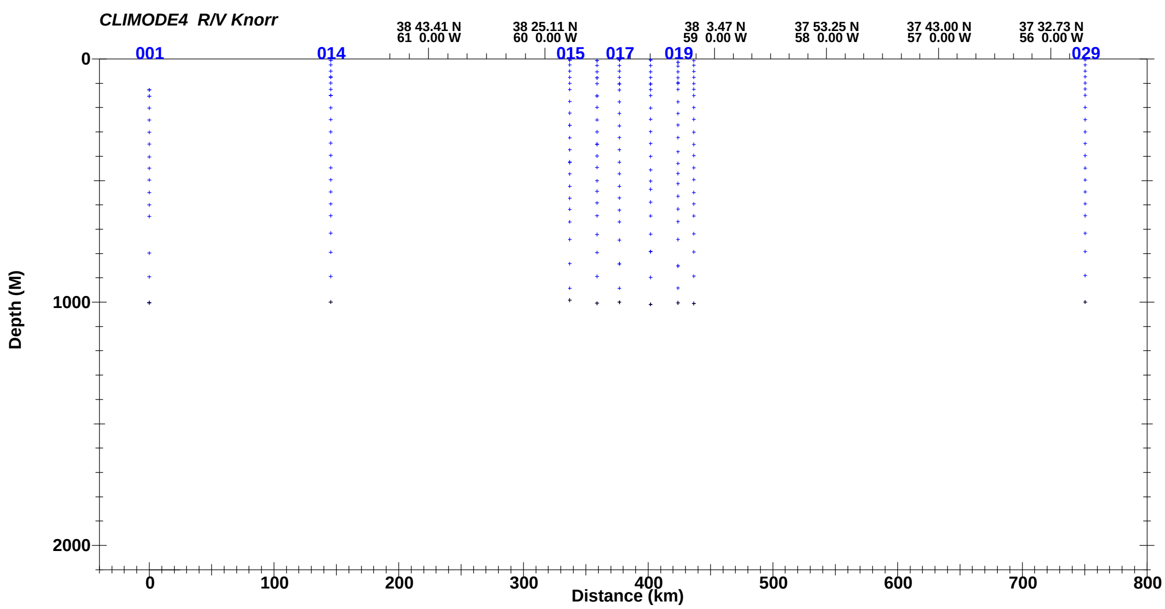


Figure 1.2 Sample distribution, Other stations 1,14-20,29.

1.1. Water Sampling Package

CTD/rosette casts were performed with a package consisting of a 24-bottle rosette frame (ODF), a 24-place pylon (SBE32) and 24 10-liter Bullister bottles (ODF). Underwater electronic components consisted of a Sea-Bird Electronics (SBE) 9*plus* CTD (ODF #878) with dual pumps, dual temperature (SBE3*plus*), dual conductivity (SBE4), dissolved oxygen (SBE43); an SBE35RT Digital Reversing Thermometer; a Seapoint Chlorophyll Fluorometer (SCF) and Simrad altimeter (807). An experimental "GCTD" (for Ray Schmitt) was also mounted in the rosette frame.

The CTD was mounted vertically in an SBE CTD frame attached to the bottom center of the rosette frame. The SBE4 conductivity and SBE3*plus* temperature sensors and their respective pumps were mounted vertically as recommended by SBE. Pump exhausts were attached to inside corners of the CTD cage and directed downward. The entire cage assembly was then mounted on the bottom ring of the rosette frame, offset from center to accommodate the pylon, and also secured to frame struts at the top. THE SBE35RT sensor was mounted vertically, between the CTD temperature sensors, at the same level. The fluorometer was mounted to the CTD, pointing vertically downward, approximately 5cm above the bottom plane of the package. The altimeter was mounted to the outside of the bottom frame ring.

The rosette system was suspended from a UNOLS-standard three-conductor 0.322" electro-mechanical sea cable. The R/V Knorr’s starboard-side Markey winch was used for all casts. Sea cable reterminations were made prior to casts 2/1 (at slip-rings and rosette) and 27/1 (at rosette only).

The deck watch prepared the rosette 10-20 minutes prior to each cast. The bottles were cocked and all valves, vents and lanyards were checked for proper orientation. Once stopped on station, the rosette was moved into position under the starboard-side squirt boom using an air-powered cart and tracks. The CTD was powered-up and the data acquisition system in the main lab started when directed by the deck watch leader. Tag lines were threaded through the rosette frame, syringes were removed from the CTD intake ports and the "GCTD" was powered on. The winch operator was directed by the deck watch leader to raise the package, the boom and rosette were extended outboard and the package quickly lowered into the water. The tag lines were removed and the package was lowered to 10 meters, by which time the sensor pumps had turned on. The winch operator was directed to bring the package back to the surface (0 winch wire-out) and to begin descent. Each rosette cast was lowered to 1000m (or 2000m at either end of the two transects).

The winch operator was directed to stop at each bottle trip depth on the up cast. The CTD console operator waited 10 seconds before tripping a bottle to insure the package wake had dissipated and the bottles were flushed, then an additional 10 seconds after receiving the trip confirmation to allow the SBE35RT temperature sensor time to make a measurement. Then the winch operator was directed to proceed to the next bottle stop. Four sets of standard sampling depths (two each for 1000m and 2000m casts) were used alternately throughout CLIMODE-4 LEG 1.

Recovering the package at the end of the deployment was essentially the reverse of launching, with the additional use of poles and snap-hooks to attach tag lines, and air-tuggers on the tag lines for added safety and stability. The rosette was moved into the forward hangar for sampling. The bottles and rosette were examined before samples were taken, and anything unusual noted on the sample log.

Each bottle on the rosette had a unique identifier number. This bottle identification was maintained independently of the bottle position on the rosette, which was used for sample identification.

Routine CTD maintenance included soaking the conductivity and DO sensors in fresh water between casts to maintain sensor stability. The sensors were stored dry before the first cast due to extremely cold temperatures, and occasionally stored with standard seawater instead of fresh water during the cruise as air temperatures warranted.

Rosette maintenance was performed on a regular basis. O-rings were changed as necessary and bottle maintenance was performed each day to insure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed. Occasionally the carousel "top hat" was removed to clean solenoid faces and latches or polish the action to deal with bottle triggering issues.

All of the O-rings on bottle 2 were changed before station 26 as a possible solution to abnormally high differences between CTD and bottle values for dissolved oxygen and salinity, observed on the 3 previous casts. The problem was more likely mis-tripping due to a carousel latch problem, since high differences or no trip at position 2 were noted on 3 of the next 4 casts.

The top ring of the rosette broke into 3 pieces (at welds) during initial deployment at station 11; no unusual forces were noted to cause this. The package was brought back aboard, the top rosette ring was removed (for the duration of the leg), and then re-deployed. Four top-ring scallops broke off at welds, and were re-fastened with hose clamps.

The cable between the altimeter and CTD was hooked during recovery at station 30, ultimately bending the connector on the altimeter. This is likely repairable, but the altimeter was removed after the cast in anticipation of more casts that were later canceled due to bad sea conditions.

1.2. Underwater Electronics Packages

CTD data were collected with a SBE9*plus* CTD. This instrument provided pressure, dual temperature (SBE3), dual conductivity (SBE4), dissolved oxygen (SBE43), fluorometer (Seapoint SCF) and altimeter (Simrad 807) channels. The CTD supplied a standard SBE-format data stream at a data rate of 24 Hz.

Sea-Bird SBE32 24-place Carousel Water Sampler	S/N 320
Sea-Bird SBE35RT Digital Reversing Thermometer	S/N 35-0011
Sea-Bird SBE9*plus* CTD	S/N 09P91878-0878
Paroscientific Digiquartz Pressure Sensor	S/N 67248
Sea-Bird SBE3*plus* Temperature Sensor	S/N 03P-2309 (Primary)
Sea-Bird SBE3*plus* Temperature Sensor	S/N 03P-2322 (Secondary)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2818 (Primary/C1A, 1/1-2/1)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2765 (Primary/C1B, 2/2-30/1)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2659 (Secondary)
Sea-Bird SBE43 Dissolved Oxygen Sensor	S/N 43-0275 (1/1-2/1)
Sea-Bird SBE43 Dissolved Oxygen Sensor	S/N 43-0875 (2/2-30/1)
Sea-Bird SBE5T Pump	S/N 05-4131 (Primary)
Sea-Bird SBE5T Pump	S/N 05-4132 (Secondary)
Seapoint Fluorometer	S/N SCF2748
Simrad 807 Altimeter	S/N 9711090
SBE11*plus*-v.2 Deck Unit	S/N 11P21561-0621 (Shipboard; 1/1-20/1)
SBE11*plus*-v.2 Deck Unit	S/N 11P21561-0726 (Shipboard; 21/1-30/1)

Table 1.2.0 CLIMODE-4 LEG 1 Rosette Underwater Electronics.

The CTD was outfitted with dual pumps. Primary temperature, conductivity and dissolved oxygen were plumbed on one pump circuit and secondary temperature and conductivity on the other. The sensors were deployed vertically.

The SBE9*plus* CTD and SBE35RT temperature sensor were both connected to the SBE32 24-place pylon providing for single-conductor sea cable operation. The sea cable armor was used for ground (return). Power to the SBE9*plus* CTD was provide through the sea cable from an SBE11 deck unit in the main lab. All sensors, dual temperature and conductivity, oxygen, SBE32 carousel, SBE35RT, Seapoint fluorometer and Simrad altimeter, received power from the CTD.

1.3. Navigation and Bathymetry Data Acquisition

Navigation data were acquired at 1-second intervals from the ship's C-Nav GPS receiver by one of the Linux workstations beginning February 7. Data from the ship's Knudsen 320B/R Echosounder (12 KHz transducer) were acquired and merged with the navigation beginning February 9. The Knudsen bathymetry data were noisy and subject to washing out when the seas were choppy or the ship's bow thruster engaged.

1.4. CTD Data Acquisition and Rosette Operation

The CTD data acquisition system consisted of an SBE-11*plus* (V2) deck unit and three networked generic PC workstations running CentOS Linux. Each PC workstation was configured with a color graphics display, keyboard, trackball and DVD+RW drives. One of the three systems also had 8 additional RS-232 ports via a Comtrol Rocketport PCI serial controller. The systems were connected through a 100BaseTX ethernet switch, which was also connected to the ship's network. These systems were available for real-time operational and CTD data displays, and provided for CTD and hydrographic data management and backup.

One of the workstations was designated the CTD console and was connected to the CTD deck unit via RS-232. The CTD console provided an interface and operational displays for controlling and monitoring a CTD deployment and closing bottles on the rosette.

CTD deployments were initiated by the console watch after the ship had stopped on station. The watch maintained a console operations log containing a description of each deployment, a record of every attempt to close a bottle and any pertinent comments. The deployment and acquisition software presented a short dialog instructing the operator to turn on the deck unit, examine the on screen CTD data displays and to notify the deck watch that this was accomplished.

Once the deck watch had deployed the rosette, the winch operator began the descent. When permitted by sea conditions, the rosette was lowered to 10 meters, raised back to the surface then lowered for the descent. This procedure was adopted to allow the immersion-activated sensor pumps time to start and flush the sensors.

Profiling rates were frequently dictated by sea conditions, but never exceeded 60m/minute with the rosette package.

The progress of the deployment and CTD data quality were monitored through interactive graphics and operational displays. Bottle trip locations were decided and transcribed onto the console and sample logs. The sample log would later be used as an inventory of samples drawn from bottles.

A maximum depth of 1000m was attained on most casts, with a 2000m maximum for the 4 casts at the either end of 2 sections across the Gulf Stream.

Bottles were closed on the up cast by operating an on-screen control. The winch operator was given a target wire-out for the bottle stop, proceeded to that depth and stopped. Bottles were tripped at least 10 seconds after stopping to allow the rosette wake to dissipate and the bottles to flush. The winch operator was instructed to proceed to the next bottle stop at least 10 seconds after closing bottles to allow the SBE35RT calibration temperature sensor time to make a measurement.

After the last bottle was tripped, the console watch directed the deck watch to bring the rosette on deck. Once on deck, the console watch terminated the data acquisition, turned off the deck unit and assisted with rosette sampling.

1.5. CTD Data Processing

Shipboard CTD data acquisition was the first stage in shipboard processing. Raw CTD data were converted to engineering units, filtered, response-corrected, calibrated and decimated to a more manageable 0.5 second time-series. The laboratory calibrations for pressure, temperature and conductivity were applied at this time. The 0.5 second time-series data were used for real-time graphics during deployments, and were the source for CTD pressure, temperature and conductivity associated with each rosette bottle. Both the raw 24hz data and the 0.5 second time-series were stored for subsequent processing steps.

At the completion of a deployment, a series of processing steps were performed automatically. The 0.5 second time-series data were checked for consistency, clean sensor response and calibration shifts. A 2 decibar pressure-series was generated from the down cast data whenever possible, where the CTD sensors saw the water before the rosette disturbed it. Only two casts had surface data extrapolated more than 8 decibars due to sea conditions and not being able to yoyo back to the surface after sensors stabilized. Both the 2 decibar pressure-series and 0.5 second time-series data were made available for downloading, plotting and reporting on the shipboard cruise website.

CTD data were routinely examined for sensor problems, calibration shifts and deployment or operational problems. The primary and secondary temperature sensors (SBE3*plus*) were compared to each other and to the SBE35RT temperature sensor. CTD conductivity sensors (SBE4C) were compared with each other and with check-sample conductivity values to determine if any corrections were warranted. The CTD dissolved oxygen sensor (SBE43) data were calibrated to check-sample data. Additional deep theta-S and theta-O_2 comparisons were made between down and up casts as well as with adjacent deployments.

CTD data were collected successfully at all 30 stations occupied. Problems specific to the CTD signal, sensors or data are listed in Table 1.5.0.

Station/Cast	Problem/Comment	Solution
1/1	CTD signal cutouts/spikes/pumps off and on/missed trip confirmations from 735db up cast, increasing until no usable signal at 125db up; cast aborted 125db up, deck unit blew a fuse before cast terminated.	Recovered two 128db trips from raw data; short found at slip-rings/lab cable connection, wire reterminated at slip-rings and rosette after cast. Despiked noisy CTD data affecting bottle trips.
	No 10m yoyo at surface down cast due to rough seas.	Pressure-sequenced data after sensors somewhat stabilized, top 6 db extrapolated.
	CTD-C1 10mS/cm too high during cast.	Error in correction coefficients fixed, cast re-averaged.
	CTD sensors stored dry before first station due to sub-freezing Ts in hangar.	Despiked excessively noisy T/C data in top 70db.
	CTDOXY signal noisy, pegged out top 100+db, deeper data a bit better.	Try one more cast to see if signal improves.
	No upcast bottle o2 data above 127db.	Fit CTDOXY from 127db to bottom, quality code 4 for top 126db and 1014-1018db.
2/1	CTD-C1 cut out/both pumps off at 545db down; pumps back on at 280db upcast.	Noticed pumps off at 1280m down, ABORT cast. Replaced CTD-C1 sensor with spare after recovery.
	CTDOXY trace still looked bad until 100+db (almost 0 raw signal).	Replaced with spare CTDOXY sensor after cast.
2/2	CTDOXY looks fine. CTD-C1 cut out/both pumps off 487db down, back on 316db up, all signals good.	Abort cast at 487db. Replaced cables between CTD/CTD-C1 and CTD/CTD-T1 after cast.
9/1	CTD-T1 signal lost 696db down, back on 528db up cast. CTD-C1 jumped/temporarily unstable at same spots.	Replaced cable between CTD/CTD-T1 before next cast (with cable changed out after station 2/2). Used CTD-T2/CTD-C2 for primary sensors this cast.
16/1-17/1	Kinks in wire caused by rough seas increasing.	Mechanical termination shifted up 10m at rosette end after one of these casts.
18/1	No 10m yoyo at surface down cast due to rough seas.	Pressure-sequenced data after sensors stabilized, top 8 db extrapolated.
19/1	No 10m yoyo at surface down cast surface due to rough seas.	Pressure-sequenced data after sensors stabilized, top 10 db extrapolated.
21/1	Problem initiating acquisition, CTD signal/software could not communicate.	Booted acquisition computer, switched to spare Deck Unit, and talked to Deck Unit through SeaSave software; combination proved successful.
26/1	Major signal noise during up cast beginning 422db bottle stop.	Right-angle kink in wire: cut off ~30 ft. of wire and reterminated at rosette end after cast. Despiked noisy CTD data affecting bottle trips.
30/1	Altimeter cable snagged by taglines on recovery, bent connector on altimeter end.	Removed altimeter after cast, repair pending.

Table 1.5.0 CLIMODE-4 LEG 1 CTD Data Comments and Problems

1.6. CTD Sensor Laboratory Calibrations

Laboratory calibrations of the SBE pressure, temperature, conductivity, dissolved oxygen and digital Reversing Thermometer sensors were performed prior to CLIMODE-4 LEG 1. The calibration dates are listed in table 1.6.0.

Sensor	S/N	Calibration Date	Calibration Facility
Paroscientific Digiquartz Pressure	67248	19-Dec-2006	SIO/STS
Sea-Bird SBE3*plus* T1 Temperature	03P-2309	14-Dec-2006	SIO/STS
Sea-Bird SBE3*plus* T2 Temperature	03P-2322	14-Dec-2006	SIO/STS
Sea-Bird SBE4C C1A Conductivity	04-2818	05-Dec-2006	SBE
Sea-Bird SBE4C C1B Conductivity	04-2765	05-Dec-2006	SBE
Sea-Bird SBE4C C2 Conductivity	04-2659	05-Dec-2006	SBE
Sea-Bird SBE43 Dissolved Oxygen	43-0275	(13-Jan-2007-N/A)	SBE
Sea-Bird SBE43 Dissolved Oxygen	43-0875	(18-Jan-2007-N/A)	SBE
Sea-Bird SBE35RT Dig.Reversing Therm.	35-0011	29-Dec-2006	SBE

Table 1.6.0 CLIMODE-4 LEG 1 CTD sensor laboratory calibrations.

1.7. CTD Shipboard Calibration Procedures

CTD #878 was used for all CTD casts on Climode-4 Leg 1. The CTD was deployed with all sensors and pumps aligned vertically, as recommended by SBE. The primary temperature and conductivity sensors (T1 and C1B) were used for CTD data reported for all but two casts. Conductivity sensor C1A was used for station 1 only; it was changed out as a first attempt to fix a problem on aborted station 2 casts that turned out to be a cabling problem. The secondary temperature and conductivity sensors (T2 and C2) were used for station 9 reported CTD data, but typically served only as calibration checks for the primary sensors. The SBE35RT Digital Reversing Thermometer (S/N 35-0011) served as an independent calibration check for temperature. *In-situ* salinity and dissolved O_2 check samples collected during each cast were used to calibrate the conductivity and dissolved O_2 sensors.

1.7.1. CTD Pressure

The Paroscientific Digiquartz pressure transducer (CTD 878, Pressure S/N 67248) was calibrated in December 2006 at the SIO/STS Calibration Facility. Coefficients derived from the calibration were applied to convert raw pressure frequencies to corrected pressures during each cast. Residual pressure offsets (the CTD pressures just before submersion and just after coming out of the water) were examined to check for calibration shifts. Offsets varied between -0.4 to +0.3db; no adjustments to the calculated pressures were warranted during Leg 1.

1.7.2. CTD Temperature

The same SBE3*plus* primary and secondary temperature sensors (T1-S/N 03P-2309 and T2-S/N 03P-2322) served for all of Leg 1. Calibration coefficients derived from the pre-cruise calibrations in December 2006 were applied to raw primary and secondary temperature data during each cast.

The SBE35RT Digital Reversing Thermometer is an internally recording temperature sensor that operates independently of the CTD. It is triggered by the SBE32 pylon in response to a bottle trip. According to the Manufacturer's specifications the typical stability is 0.001° C/year. The SBE35RT used on CLIMODE-4 LEG 1 (S/N 35-0011) was calibrated in December 2006.

Two independent metrics of calibration accuracy were examined. T1 and T2 were compared, and the SBE35RT temperatures were compared to both T1 and T2 at each rosette trip.

Calibration accuracy was first examined by tabulating T1-T2, SBE35RT-T1 and SBE35RT-T2 differences over a range of pressures (at bottle trip locations) for stations 1-30, and for just the four 2000m casts (2,13,21 and 26). The differences showed no drift with station number (time), and less than 0.001° C difference from 0-2000db during Climode-4 Leg 1. SBE35RT-T1 or -T2 differences indicated T1 had a slight offset, and T2 essentially did not shift. A T1 offset was determined, based on SBE35RT-T1 differences outside of higher gradient areas (pressures less than 35db and deeper than 980db) for all 30 stations. T1 was corrected by applying an offset of -0.0004656° C for stations 1-30, except station 9 (which is reported using the T2/C2 sensor pair, and was not offset). This brought both SBE3*plus* sensors to within 0.0005° C of each other and the SBE35RT at all pressures.

The residual differences for temperatures are summarized in figures 1.7.2.0 through 1.7.2.4. A 4,2 standard deviation rejection filter was applied to the differences before plotting, to eliminate larger values in higher-gradient regions.

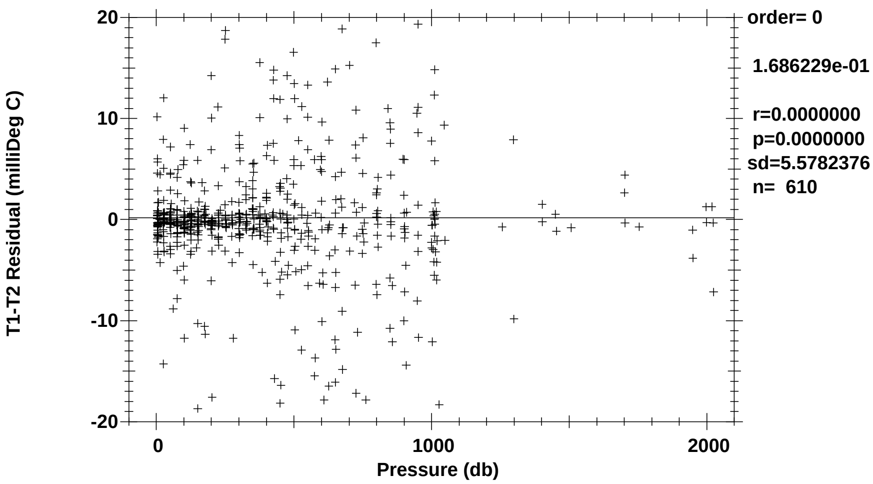


Figure 1.7.2.0 Climode-4 Leg 1 T1-T2 vs pressure, all pressures.

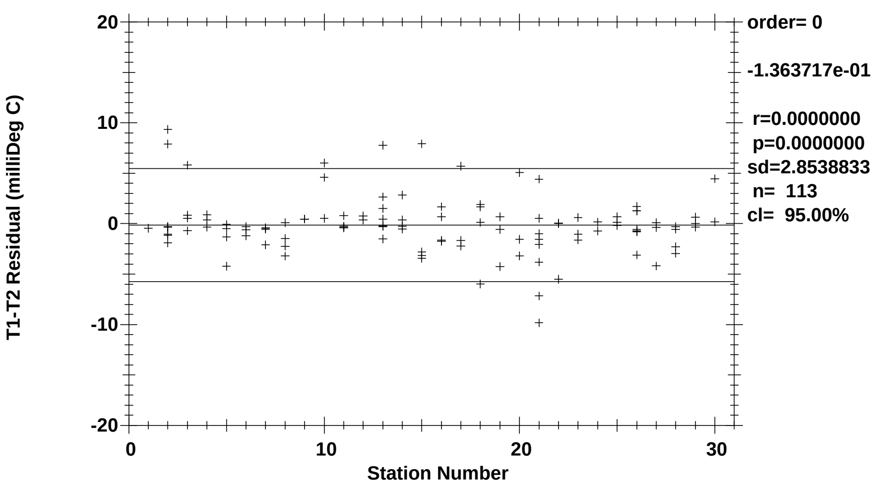


Figure 1.7.2.1 Climode-4 Leg 1 T1-T2 vs station, p<35db or p>980db.

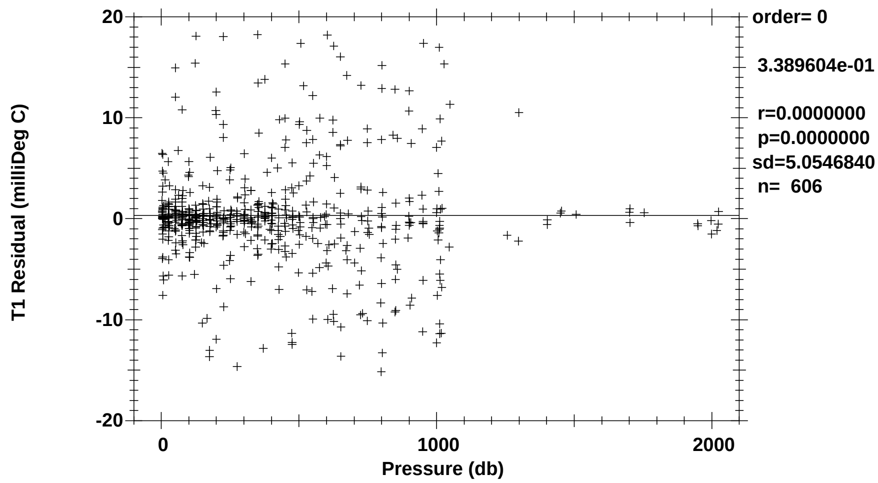


Figure 1.7.2.2 Climode-4 Leg 1 SBE35RT-T1 vs pressure, all pressures.

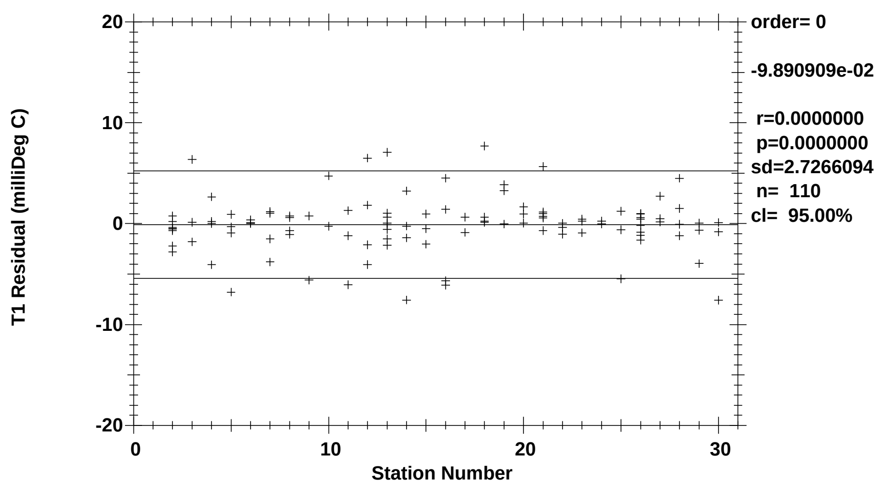


Figure 1.7.2.3 Climode-4 Leg 1 SBE35RT-T1 vs station, p<35db or p>980db.

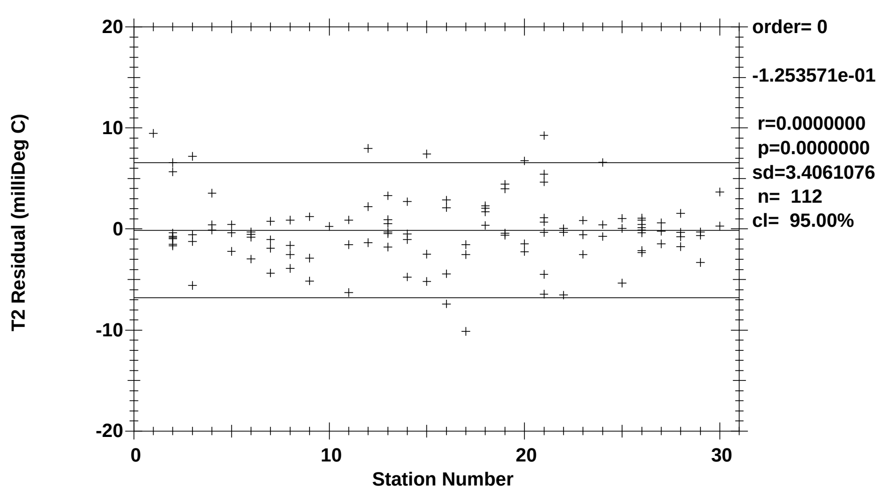


Figure 1.7.2.4 Climode-4 Leg 1 SBE35RT-T2 vs station, p<35db or p>980db.

The 95% confi dence limit for the mean lower-gradient differences is ±0.0057° C for T1-T2, and ±0.0055° C for SBE35RT-T1.

1.7.3. CTD Conductivity

Two primary SBE4C conductivity sensors (C1A-S/N 04-2818 for station 1, C1B-S/N 04-2765 for stations 2-30) and one secondary SBE4C conductivity sensor (C2-S/N 04-2659 for all casts) served for the entire cruise. Conductivity sensor calibration coefficients derived from the pre-cruise calibrations were applied to raw primary and secondary conductivities.

Comparisons between the primary and secondary sensors, and between each sensor vs check sample conductivities calculated from bottle salinities, were used to derive conductivity corrections.

The salinometer standard dial was stable for the first 22 casts, then re-set 29 units lower before stations 23/24 were run and back up 15 units for stations 25-30. A drop in bottle-CTD differences of about -0.004 mS/cm for stations 23/24 and -0.002 mS/cm for stations 25-30, was apparent on plots. The difference in Autosal standby numbers for those casts shows the standard dial drop could account for these drops, so stations 23-30 were excluded when determining final conductivity offsets.

C1B and C2 (the conductivity sensors used for all but the first cast) were fairly consistent with each other at all pressures/conductivities. Lower-gradient bottle-C1B and bottle-C2 differences both showed first-order slopes as a function of conductivity, on the order of -0.002mS/cm from 32-52 mS/cm. Conductivity slopes were applied to both C1B and C2, based on fits of bottle differences above 200db or below 980db (to exclude higher-gradient values) from just the four 2000m casts (slopes calculated using all the casts were biased more toward the top 1000m, and a bit steeper; they did not fit the 2000m differences as well).

After the slopes were applied, the differences were again checked, using stations 2-22 only. Bottle-C1B showed a strong +0.0005 mS/cm residual offset for the 0-1000m differences, and bottle-C2 indicated an additional +0.001 mS/cm was needed. The C1B-C2 differences were nearly 0, so it was decided to add a more conservative +0.0005 mS/cm to both conductivity offsets to keep them aligned.

Station 1 was the only station to use sensor C1A. The C1B slope was applied to C1A, since C2 also had a similar slope. Residual C1A-C2 conductivity differences for station 1 were compared to those for C1B-C2 on stations 2 and 3, since C2 was common to all casts. An additional +0.001 mS/cm was applied to station 1 to normalize the differences to those of other casts.

Lower-gradient conductivity differences, after applying shipboard corrections, are summarized in figures 1.7.3.0-1.7.3.3. Note that a 4,2 standard deviation rejection filter was applied to the differences before plotting, to eliminate a few higher-gradient values that fell within the specified pressure ranges.

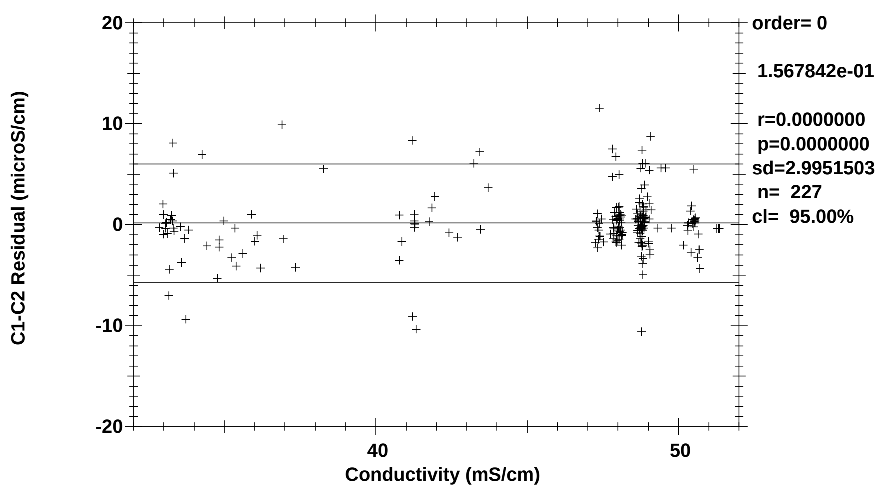


Figure 1.7.3.0 Climode-4 Leg 1 C1-C2 vs Conductivity, p<200db or p>980db.

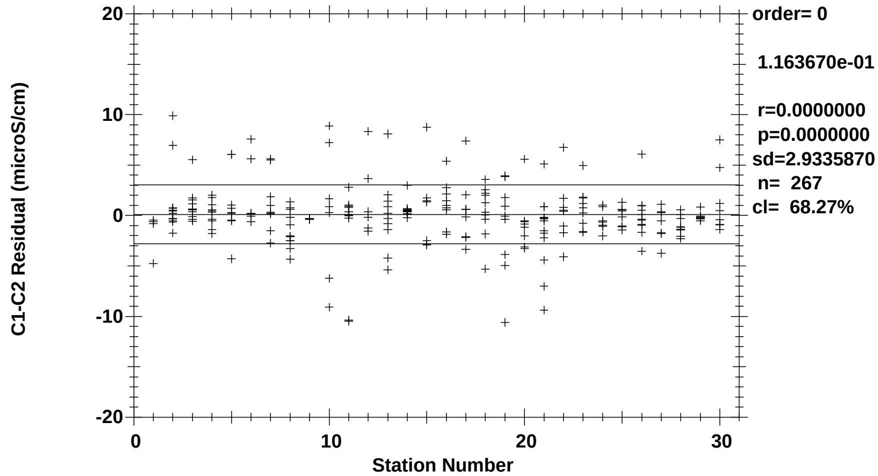


Figure 1.7.3.1 Climode-4 Leg 1 C1-C2 vs station, p<200db or p>980db.

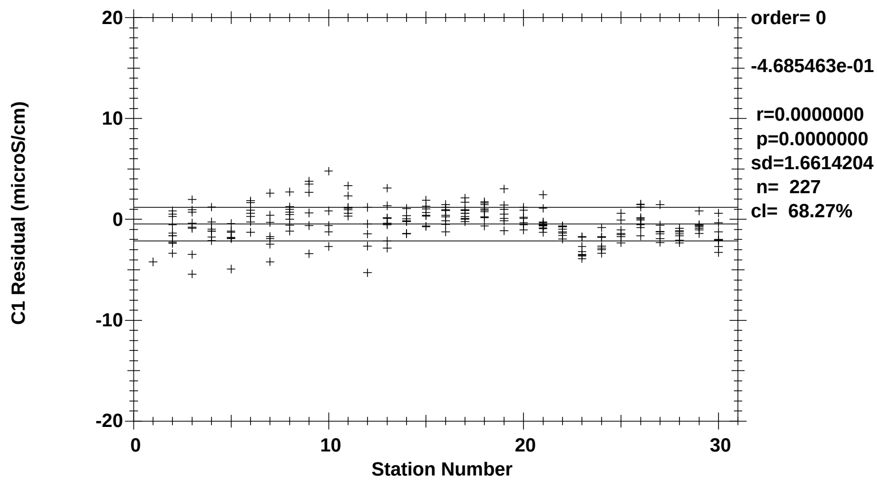


Figure 1.7.3.2 Climode-4 Leg 1 Bottle-C1 vs station, p<200db or p>980db.

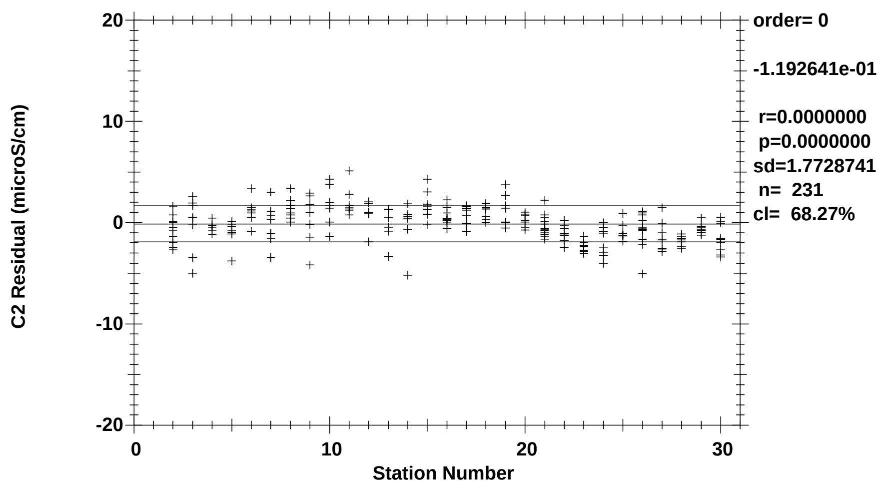


Figure 1.7.3.3 Climode-4 Leg 1 Bottle-C2 vs station, p<200db or p>980db.

Sensor	Offset	Slope (as f(x))	x
Pressure	0	none	
T1	-0.0004655	none	
T2	0	none	
C1A	0.00418765	-9.13936e-5	(C1B)
C1B	0.00318765	-9.13936e-5	C1B
C2	0.00413233	-1.17275e-4	C2

Table 1.7.3.0 Climode-4 Leg 1 Summary of CTD T/C Corrections.

Bottle minus CTD salinity residuals, after applying shipboard T1/C1 and T2/C2 corrections, are summarized in figures 1.7.3.4 through 1.7.3.6.

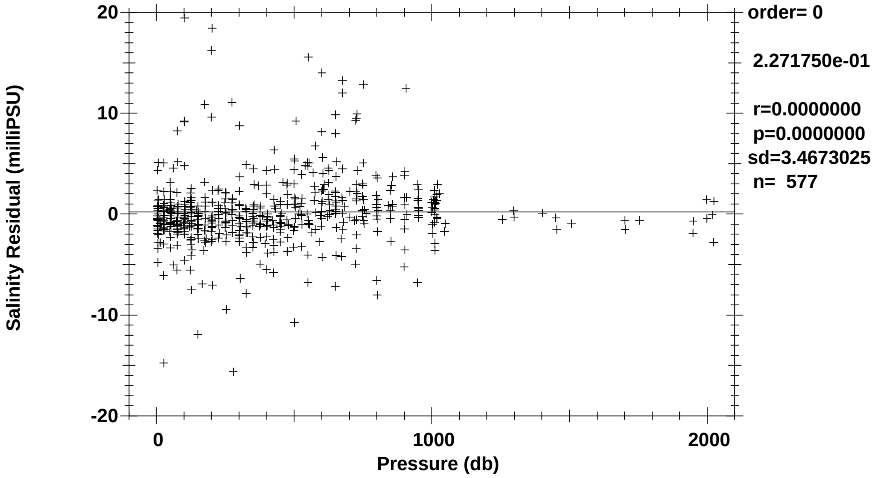


Figure 1.7.3.4 Climode-4 Leg 1 Salinity residuals vs pressure, all pressures.

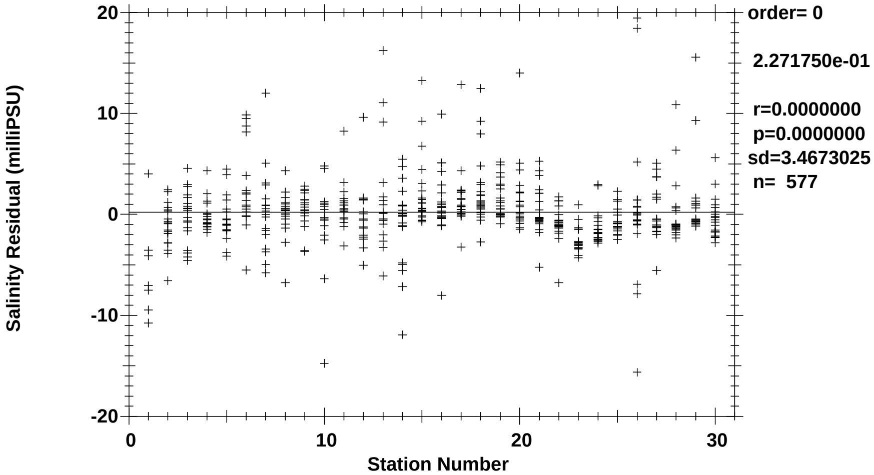


Figure 1.7.3.5 Climode-4 Leg 1 Salinity residuals vs station, all pressures.

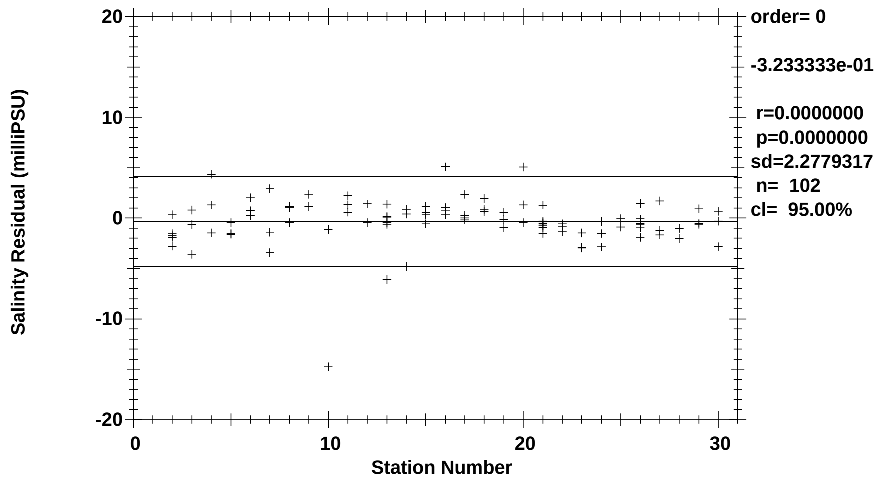


Figure 1.7.3.6 Climode-4 Leg 1 Salinity residuals vs station, p<35db or p>980db.

Figure 1.7.3.6 represents an estimate of the salinity accuracy on Climode-4 Leg 1. The 95% confidence limit is ±0.0046 PSU relative to the lower-gradient bottle salts.

1.7.4. CTD Dissolved Oxygen

Two SBE43 dissolved O_2 sensors (DO-A S/N 43-0275, station 1; DO-B S/N 43-0875, stations 2-30) were used during this leg. The DO sensor was plumbed into the primary T1/C1 pump circuit after C1. Down cast data were used for all casts.

The DO sensor calibration method used for this cruise matched down cast pressure-series CTD O_2 data to up cast bottle trips along isopycnal surfaces. Residual differences between the *in-situ* check sample values and CTD O_2 were minimized using a non-linear least-squares fitting procedure.

The fitting procedure determined the calibration coefficients for the sensor model conversion equation, and was accomplished in stages. The time constants for the exponential terms in the model were first determined for the sensor. These time constants are sensor-specific but applicable to an entire cruise. Next, casts were fit individually to check sample oxygen data. CTD data were refit if bottle oxygen data changed by 0.005ml/l or more after bottle data were recalculated with smoothed standards/blanks. Deep theta-O_2 overlays of nearby stations were compared to ensure data consistency. Down and up cast differences were also considered when bottle data in shallower areas disagreed. CTD O_2 data were converted from ml/l to umol/kg units after fitting.

Bottom bottle O_2 data were occasionally missing or coded "questionable" due to tripping, sampling or analytical problems. Deep theta-O_2 comparisons were used to estimate a bottom value for fitting where possible, typically helping to optimize the fit through other deep bottles.

Figures 1.7.4.0-1.7.4.2 show the residual differences between bottle and calibrated CTD O_2 where both CTD and bottle oxygen data are coded "acceptable".

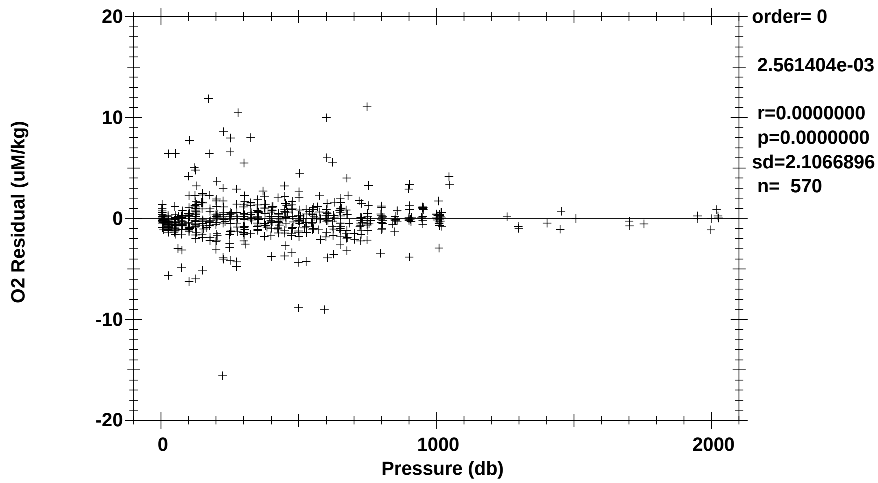


Figure 1.7.4.0 O_2 residuals vs pressure, all pressures.

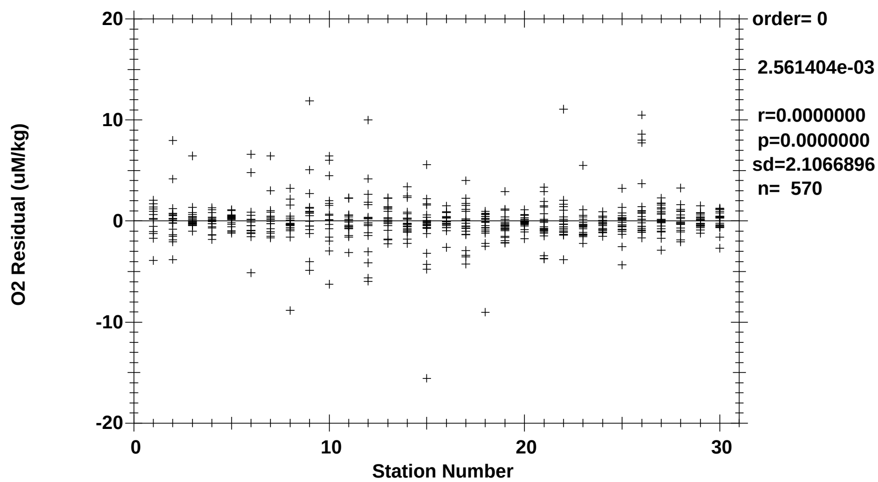


Figure 1.7.4.1 O_2 residuals vs station, all pressures.

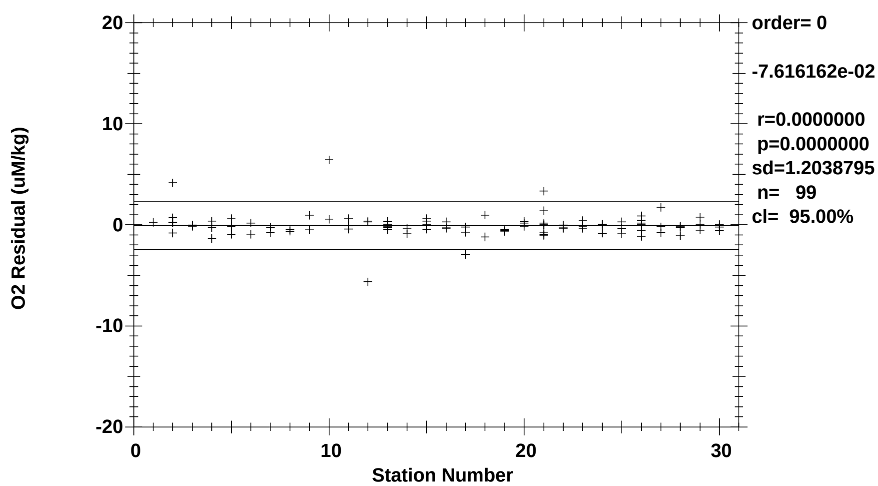


Figure 1.7.4.2 O_2 residuals vs station, p>500db .

The standard deviations of 2.107 umol/kg for all oxygens and 1.868 umol/kg for deep oxygens are only presented as general indicators of goodness of fit. STS makes no claims regarding the precision or accuracy of CTD dissolved O_2 data.

The general form of the STS O_2 conversion equation for Clark cells follows Brown and Morrison [Brow78] and Millard [Mill82], [Owen85]. STS models membrane and sensor temperatures with lagged CTD temperatures and a lagged thermal gradient. *In-situ* pressure and temperature are filtered to match the sensor response. Time-constants for the pressure response τ_p, two temperature responses τ_{Ts} and τ_{Tf}, and thermal gradient response τ_{dT} are fitting parameters. The thermal gradient term is derived by low-pass filtering the difference between the fast response (T_f) and slow response (T_s) temperatures. This term is SBE43-specific and corrects a non-linearity introduced by analog thermal compensation in the sensor. The O_c gradient, dO_c/dt, is approximated by low-pass filtering 1st-order O_c differences. This gradient term attempts to correct for reduction of species other than O_2 at the sensor cathode. The time-constant for this filter, τ_{og}, is a fitting parameter. Dissolved O_2 concentration is then calculated:

$$O_{2ml/l} = [c_1 O_c + c_2] \cdot f_{sat}(S,T,P) \cdot e^{(c_3 P_l + c_4 T_f + c_5 T_s + c_6 \frac{dO_c}{dt} + c_7 dT)} \qquad (1.7.4.0)$$

where:

$O_{2ml/l}$	= Dissolved O_2 concentration in ml/l;
O_c	= Sensor current (μamps);
$f_{sat}(S,T,P)$	= O_2 saturation concentration at S,T,P (ml/l);
S	= Salinity at O_2 response-time (PSUs);
T	= Temperature at O_2 response-time (° C);
P	= Pressure at O_2 response-time (decibars);
P_l	= Low-pass filtered pressure (decibars);
T_f	= Fast low-pass filtered temperature (° C);
T_s	= Slow low-pass filtered temperature (° C);
$\frac{dO_c}{dt}$	= Sensor current gradient (μamps/secs);
dT	= low-pass filtered thermal gradient (T_f - T_s).

The time-constants and coefficients used to correct Climode-4 Leg 1 CTD Oxygen data are listed in table 1.7.4.0.

Table 1.7.4.0 Summary of Climode-4 Leg 1 CTD Oxygen Time Constants
(time constants in seconds)

Temperature		Pressure	O_2 Gradient	dT Gradient
Fast(τ_{Tf})	Slow(τ_{Ts})	(τ_p)	(τ_{og})	(τdT)
12.00	120.00	0.04	2.00	400.00

Table 1.7.4.1 Climode-4 Leg 1: Conversion Equation Coefficients for CTD Oxygen
(refer to Equation 1.7.4.0)

Sta/ Cast	O_c Slope (c_1)	Offset (c_2)	P_l coeff (c_3)	T_f coeff (c_4)	T_s coeff (c_5)	$\frac{dO_c}{dt}$ coeff (c_6)	T_{dT} coeff (c_7)
1/1	-1.1745e-04	1.8789e-01	-2.4478e-01	3.1841e+00	-1.6955e-04	4.6538e-06	0.9486660
2/3	4.2377e-04	2.7125e-03	1.6958e-03	-2.2426e-01	1.6560e-04	1.8764e-06	-0.0174792
3/1	3.3531e-04	3.4165e-02	-2.2225e-02	-1.0919e-01	1.5367e-04	-3.5042e-07	-0.0473943
4/1	4.4102e-04	2.2693e-03	-2.9332e-04	-2.2462e-01	1.2516e-04	1.3666e-06	-0.0370380
5/1	3.4554e-04	2.8843e-02	-2.1163e-02	-6.8052e-02	1.0045e-04	1.3073e-06	-0.0330765
6/1	4.5159e-04	1.0685e-02	-9.1024e-03	-2.4223e-01	1.2452e-04	1.2018e-06	-0.0441379
7/1	3.7417e-04	1.4635e-02	-5.5953e-03	-1.7766e-01	1.1657e-04	-8.4304e-07	-0.0984374
8/1	5.1349e-04	-1.6027e-02	1.5143e-02	-3.4088e-01	-5.4805e-05	-7.2752e-07	-0.1165380
9/1	4.3027e-04	4.2560e-02	-4.7019e-02	-6.3587e-02	-1.7061e-06	2.1004e-06	-0.0103594
10/1	9.4176e-04	-1.1249e-03	-4.9617e-02	-3.2304e-01	-3.2808e-04	1.0163e-06	0.1472660

Sta/ Cast	O_c Slope (c_1)	Offset (c_2)	P_l coeff (c_3)	T_f coeff (c_4)	T_s coeff (c_5)	$\frac{dO_c}{dt}$ coeff (c_6)	T_{dT} coeff (c_7)
11/1	4.2961e-04	-2.8899e-03	5.0669e-03	-2.0493e-01	1.5426e-04	1.9635e-06	-0.0025820
12/1	5.4029e-04	-1.2035e-03	-2.4977e-02	-1.5175e-01	-2.2569e-05	1.4674e-06	0.0477859
13/1	4.1459e-04	1.2314e-02	-7.8674e-03	-1.8023e-01	1.4741e-04	7.8280e-08	-0.0253085
14/1	4.0192e-04	-7.3111e-03	1.3565e-02	-1.9876e-01	9.0990e-05	4.7372e-07	-0.0801280
15/1	4.6984e-04	-1.4137e-02	1.3317e-02	-2.4733e-01	1.4139e-04	1.4966e-06	0.0040428
16/1	3.1786e-04	2.5302e-02	-7.8618e-03	-1.3832e-01	1.3626e-04	6.0955e-07	-0.1384370
17/1	4.0644e-04	-1.4242e-02	2.2833e-02	-2.4178e-01	1.3926e-04	4.0118e-07	-0.0808534
18/1	4.2033e-04	9.0798e-04	3.5641e-03	-2.1500e-01	1.4961e-04	2.2036e-06	-0.0343997
19/1	2.9203e-04	2.8705e-02	-6.2151e-03	-1.3323e-01	1.3780e-04	1.7944e-06	-0.1986610
20/1	5.3206e-04	-2.4283e-02	1.7626e-02	-2.9449e-01	1.4123e-04	3.6798e-07	0.0612347
21/1	4.3254e-04	2.2475e-02	-2.1468e-02	-1.7719e-01	1.2675e-04	3.0747e-06	-0.0027363
22/1	4.4233e-04	-4.7456e-03	6.3378e-03	-2.1723e-01	1.3537e-04	1.4820e-06	-0.0185315
23/1	3.7889e-04	1.2667e-02	-4.6876e-03	-1.5754e-01	1.3482e-04	7.7545e-09	-0.0638025
24/1	3.5994e-04	3.1800e-02	-1.9940e-02	-1.5957e-01	1.1174e-04	1.8409e-06	-0.1331320
25/1	4.0678e-04	2.0064e-02	-1.5672e-02	-1.7018e-01	1.1066e-04	2.9220e-06	-0.0644904
26/1	4.2556e-04	3.8939e-03	-1.9449e-03	-1.7445e-01	1.3190e-04	7.6936e-07	-0.0027296
27/1	4.7761e-04	-1.7448e-02	1.3521e-02	-2.1239e-01	8.9855e-05	-1.4647e-07	0.0446175
28/1	4.0883e-04	2.0203e-02	-1.3147e-02	-2.1653e-01	1.4789e-04	6.4560e-07	-0.0971966
29/1	4.5233e-04	1.1257e-03	-7.0374e-04	-2.1861e-01	1.2700e-04	1.1765e-06	-0.0091114
30/1	3.7292e-04	1.6462e-02	-6.4803e-03	-1.6953e-01	1.2927e-04	-5.0913e-07	-0.0897090

1.8. Bottle Sampling

At the end of each rosette deployment water samples were drawn from the bottles in the following order:

- O_2
- DIC/Total Alkalinity
- Nutrients
- Salinity

The 24-place 10-liter rosette was used on all casts. Six carousel latches (3/7/11/15/19/23 - every 4th) that release lanyards and subsequently trip bottles malfunctioned early in the expedition, 4 of them beginning station 1. The problem was investigated after the first trans-sect and traced to bolts that fastened the carousel to its mounting ring: they were protruding ~1/8" into the space behind the faulty latches. The bolts were shortened and replaced. Bottle 9 also malfunctioned on stations 9-13; its repair involved cleaning of peeling parts. One other bottle latch with a broken plastic trigger release (position 2) was replaced with another from the WHOI backup carousel. The only tripping problem thereafter was bottle 2, which was apparently mis-tripping (or not tripping) on most casts from stations 23-30. A likely culprit is the replacement carousel trigger release in that position, which will be checked before Leg 2 begins.

The correspondence between individual sample containers and the rosette bottle position (1-24) from which the sample was drawn was recorded on the sample log for the cast. This log also included any comments or anomalous conditions noted about the rosette and bottles. One member of the sampling team was designated the *sample cop*, whose sole responsibility was to maintain this log and insure that sampling progressed in the proper drawing order.

Normal sampling practice included opening the drain valve and then closing it and opening the air vent on the bottle, indicating an air leak if water escaped. This observation together with other diagnostic comments (e.g., "lanyard caught in lid", "valve left open") that might later prove useful in determining sample integrity were routinely noted on the sample log. Drawing oxygen samples also involved taking the sample draw temperature from the bottle. The temperature was noted on the sample log and was sometimes useful in determining leaking or mis-tripped bottles.

Once individual samples had been drawn and properly prepared, they were distributed for analysis. Oxygen and salinity analyses were performed on computer-assisted (PC) analytical equipment networked to the data processing computer for centralized data management. Nutrient samples were frozen and stored for later analysis ashore. DIC/Total Alkalinity samples were poisoned and stored for post-cruise analysis.

1.9. Bottle Data Processing

Water samples collected and properties analyzed shipboard were managed centrally in a relational database (PostgreSQL-8.0.8-1) run on one of the Linux workstations. A web service (OpenAcs-5.2.3 and AOLServer-4.0.10-2) front-end provided ship-wide access to CTD and water sample data. Web-based facilities included on-demand arbitrary property-property plots and vertical sections as well as data uploads and downloads.

The Sample Log (and any diagnostic comments) was entered into the database once sampling was completed. Quality flags associated with sampled properties were set to indicate that the property had been sampled, and sample container identifications were noted where applicable (e.g., oxygen flask number).

Analytical results were provided on a regular basis by the analytical groups and incorporated into the database. These results included a quality code associated with each measured value and followed the coding scheme developed for the World Ocean Circulation Experiment (WOCE) Hydrographic Programme (WHP) [Joyc94].

Various consistency checks and detailed examination of the data continued throughout the cruise.

1.10. Salinity Analysis

Equipment and Techniques

A Guildline Autosal Model 8400A salinometer (S/N 48-266), located in the analytical lab, was used for all salinity measurements. The salinometer was modified by ODF to contain an interface for computer-aided measurement. The water bath temperature was set at 24° C for the entire cruise and lab temperature was maintained at a value near 24° C +/- 2° C.

The salinity analyses were performed after samples had equilibrated to laboratory temperature, usually within 8-54 hours after collection. The salinometers were standardized for each group of analyses (usually 1-2 casts, up to ~48 samples) using at least two fresh vials of standard seawater per group. Salinometer measurements were made by computer, where the analyst was prompted by software to change samples and flush.

Sampling and Data Processing

597 salinity measurements were made and approximately 40 vials of standard water (SSW) were used. Salinity data was used as an additional calibration check for the CTD.

Salinity samples were drawn into 200 ml Kimax high-alumina borosilicate bottles, which were rinsed three times with sample prior to filling. The bottles were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. Prior to sample collection, inserts were inspected for proper fit and loose inserts replaced to insure an airtight seal. The draw time and equilibration time were logged for all casts. Laboratory temperatures were logged at the beginning and end of each run.

PSS-78 salinity [UNES81] was calculated for each sample from the measured conductivity ratios. The difference (if any) between the initial vial of standard water and the next one run as an unknown was applied as a linear function of elapsed run time to the data. The corrected salinity data were then incorporated into the cruise database. Salinometer 48-266 had problems with the Standby/Read switch: the "Suppression" (first 2 digits of the Conductivity ratio) was not displaying the true setting, showing zeros instead.Operating the switch again would correct the problem. The estimated accuracy of bottle salinities run at sea is usually better than ±0.002 PSU relative to the particular standard seawater batch used.

The standard dial setting on the Autosal was changed by -29 units before the run for stations 23/24 samples, and back up +15 units for stations 25-30. There was about a -0.002 mS/cm dip in bottle-CTD conductivity differences noted at station 22. Stations 23-24 showed approx. -0.004 mS/cm shift, relative to the first 21 casts, which could be accounted for entirely by the difference in standby numbers between the two standard dial settings.

Laboratory Temperature

The temperature of the laboratory used for the analyses ranged from 22° C to 24° C. The air temperature during any particular run varied less than 1° C.

Standards

IAPSO Standard Seawater (SSW) Batch P-147 was used to standardize all stations.

1.11. Oxygen Analysis

Equipment and Techniques

Dissolved oxygen analyses were performed with an ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by PC LabView software. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. ODF used a whole-bottle modified-Winkler titration following the technique of Carpenter [Carp65] with modifications by Culberson *et al.* [Culb91], but with higher concentrations of potassium iodate standard (~0.012N) and thiosulfate solution (~55 gm/l). Pre-made liquid potassium iodate standards were run once a day approximately every 4 stations, unless changes were made to system or reagents. Reagent/distilled water blanks were determined every day or more often if a change in reagents required it to account for presence of oxidizing or reducing agents. The auto-titrator performed well.

Sampling and Data Processing

587 oxygen measurements were made. Samples were collected for dissolved oxygen analyses soon after the rosette was brought on board. Using a Tygon and silicone drawing tube, nominal 125ml volume-calibrated iodine flasks were rinsed 3 times with minimal agitation, then filled and allowed to overflow for at least 3 flask volumes. The sample drawing temperatures were measured with a small platinum resistance thermometer embedded in the drawing tube. These temperatures were used to calculate uM/kg concentrations, and as a diagnostic check of bottle integrity. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice (10-12 inversions) to assure thorough dispersion of the precipitate, once immediately after drawing, and then again after about 20 minutes.

The samples were analyzed within 1-2 hours of collection, and the data incorporated into the cruise database.

Thiosulfate normalities were calculated from each standardization and corrected to 20° C. The 20° C normalities and the blanks were plotted versus time and were reviewed for possible problems.

The blanks and thiosulfate normalities for each batch of thiosulfate were smoothed (linear fits) and the oxygen values recalculated.

A noisy endpoint was occasionally acquired during the analyses, usually due to small water-bath contaminations. These endpoints were checked and recalculated using STS/ODF designed software.

Volumetric Calibration

Oxygen flask volumes were determined gravimetrically with degassed deionized water to determine flask volumes at STS/ODF's chemistry laboratory. This is done once before using flasks for the first time and periodically thereafter when a suspect volume is detected. The volumetric flasks used in preparing standards were volume-calibrated by the same method, as was the 10 ml Dosimat buret used to dispense standard iodate solution.

Standards

Liquid potassium iodate standards were prepared in 6 liter batches and bottled in sterile glass bottles at STS/ODF's chemistry laboratory prior to the expedition. The normality of the liquid standard was determined at ODF by calculation from weight. Two standard batches were used during climode4.1. Potassium iodate was obtained from Acros Chemical Co. and was reported by the supplier to be 98% pure. The second standard was supplied by Alfa Aesar and has a reported purity of 99.4-100.4%. Tests at ODF indicate no difference between these 2 batches. All other reagents were "reagent grade" and were tested for levels of oxidizing and reducing impurities prior to use.

1.12. Nutrient Analysis

Equipment and Techniques

Nutrient analyses (phosphate, silicate, nitrate, nitrite, and ammonia) will be performed ashore on an ODF-modified 5-channel Technicon AutoAnalyzer II.

The methods used are described by Gordon *et al.* [Gord92]. The analog outputs from each of the five colorimeter channels are digitized and logged automatically by computer (PC) at 2-second intervals.

Silicate is analyzed using the technique of Armstrong *et al.* [Arms67]. An acidic solution of ammonium molybdate is added to a seawater sample to produce silicomolybdic acid which then reduces to silicomolybdous acid (a blue compound) following the addition of stannous chloride. Tartaric acid is also added to impede PO_4 color development. The sample is passed through a 15mm flowcell and the absorbence are measured at 660nm.

A modification of the Armstrong *et al.* [Arms67] procedure is used for the analysis of nitrate and nitrite. For the nitrate analysis, the seawater sample is passed through a cadmium reduction column where nitrate is quantitatively reduced to nitrite. Sulfanilamide is introduced to the sample stream followed by N-(1-naphthyl)ethylenediamine dihydrochloride which couple to form a red azo dye. The stream is then passed through a 15mm flowcell and the absorbence measured at 540nm. The same technique is employed for nitrite analysis, except the cadmium column is bypassed, and a 50mm flowcell is used for measurement.

Phosphate is analyzed using a modification of the Bernhardt and Wilhelms [Bern67] technique. An acidic solution of ammonium molybdate is added to the sample to produce phosphomolybdic acid, then reduced to phosphomolybdous acid (a blue compound) following the addition of dihydrazine sulfate. The reaction product is heated to ~55° C to enhance color development, then passed through a 50mm flowcell and the absorbence measured at 820nm.

Ammonium is analyzed via the Berthelot reaction in which hypochlorous acid and phenol react with ammonium in an alkaline solution to form indophenol blue. The sample is passed through a 50 mm flowcell and measured at 640nm. This method is a modification of the procedure by Koroleff [Koro70].

Explicit corrections for *carryover* in nutrient analyses are not made. In a typical AutoAnalyzer system, sample to sample carryover is ~1-2% of the concentration difference between samples. This effect is minimized by running samples in order of increasing depth such that concentration differences between samples are minimized. The initial surface samples could be run twice or a low nutrient sea water sample run ahead of the surface sample since these samples generally follow standard peaks.

Sampling and Data Processing

Nutrient samples are drawn into 30 ml polypropylene, screw-capped tubes. The tubes come pre-sterilized from the factory and are rinsed 2-3 times before filling. The samples were frozen until analysis.

Standardizations are performed at the beginning and end of each group of analyses with an intermediate concentration mixed nutrient standard prepared prior to each run from a secondary standard in a low-nutrient seawater matrix. The secondary standards are prepared by dilution from primary standard solutions. Dry standards are pre-weighed at the laboratory at ODF. Sets of 7 different standard concentrations are analyzed periodically to determine any deviation from linearity as a function of absorbence for each nutrient analysis. A correction for non-linearity is applied to the final nutrient concentrations when necessary. A correction for the difference in refractive indices of pure distilled water and seawater is periodically determined and applied where necessary.

After each group of samples is analyzed, the raw data file is processed to produce another file of response factors, baseline values, and absorbences. Computer-produced absorbence readings are checked for accuracy against values taken from a strip chart recording. The data are then added to the cruise database.

Nutrients, reported in micromoles per kilogram, are converted from micromoles per liter by dividing by sample density calculated at 1 atm pressure (0 db), *in situ* salinity, and a per-analysis measured laboratory temperature.

Standards

Primary standards for silicate (Na_2SiF_6) and nitrite ($NaNO_2$) were obtained from Johnson Matthey Chemical Co.; the supplier reported purities of >98% and 97%, respectively. Primary standards for nitrate (KNO_3) and phosphate (KH_2PO_4) were obtained from Fisher Chemical Co.; the supplier reported purities of 99.999% and 99.999%, respectively. Ammonia primary standard ($(NH_4)_2SO_4$) is obtained from Fisher Scientific; the supplier reports purities of 99.99%.

1.13. Bottle Data Quality Code Summary and Comments

This section contains WOCE quality codes [Joyc94] used during this cruise, and remarks regarding bottle data.

Property	1	2	3	4	5	6	7	8	9	Total
Bottle	0	594	3	6	0	0	0	0	85	688
Salinity	0	577	20	0	3	0	0	0	0	600
O_2	0	571	6	10	4	0	0	0	0	591
SiO_3	437	0	0	0	0	0	0	0	0	437
NO_3	437	0	0	0	0	0	0	0	0	437
NO_2	437	0	0	0	0	0	0	0	0	437
PO_4	437	0	0	0	0	0	0	0	0	437
DIC	451	0	0	0	0	0	0	0	0	451
TAlk	451	0	0	0	0	0	0	0	0	451

Table 1.13.0 Climode-4 Leg 1 Water Sample Quality Code Summary

Comments from the Sample Logs and the results of STS/ODF's investigations are included in this report. Units stated in these comments are degrees Celsius for temperature, Practical Salinity Units for salinity, and unless otherwise noted and milliliters per liter for oxygen The sample number is the cast number times 100 plus the bottle number.

Table 1.13.1 Climode-4 Leg 1 Bottle Quality Codes and Comments

Station /Cast	Sample No.	Property	Quality Code	Comment
1/1	101	o2	5	overtitrate did not work, lost sample.
1/1	101	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.02 PSU. Code salt questionable.
1/1	102	reft	3	SBE35RT-CTDT1 or SBE35-CTDT2 differences are -0.035/-0.025 deg.C. Code SBE35RT questionable.
1/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.045 PSU. Code salt questionable.
1/1	103	bottle	9	Bottle did not close. No sample taken.

Station /Cast	Sample No.	Property	Quality Code	Comment
1/1	104	reft	3	SBE35RT-CTDT1 or SBE35-CTDT2 difference is -0.035 deg.C. Code SBE35RT questionable.
1/1	104	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.025 PSU. Code salt questionable.
1/1	107	bottle	9	Bottle did not close. No sample taken.
1/1	109	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.045 PSU. Code salt questionable.
1/1	110	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.025 PSU. Code salt questionable.
1/1	111	bottle	9	Bottle did not close. No sample taken.
1/1	111	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	111	ctds2	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	112	CTDT2	7	Spiking at CTD trip, CTDTEMP ok after despike.
1/1	112	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.185 PSU. Code salt questionable.
1/1	113	CTDPRS	7	Spiking at CTD trip, CTDPRESS ok after despike.
1/1	113	CTDS1	7	Spiking at CTD trip, CTDSALT ok after despiking CTDPRESS.
1/1	114	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	114	CTDT1	7	Spiking at CTD trip, CTDTEMP ok after despike.
1/1	115	bottle	9	Bottle did not close. No sample taken.
1/1	115	CTDPRS	7	Spiking at CTD trip, CTDPRESS ok after despike.
1/1	115	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	115	ctds2	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	116	CTDPRS	7	Spiking at CTD trip, CTDPRESS ok after despike.
1/1	116	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	116	ctds2	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	116	CTDT1	7	Spiking at CTD trip, CTDTEMP/CTDSALT ok after despike.
1/1	116	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.02 PSU. Code salt questionable.
1/1	117	CTDPRS	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	117	CTDS1	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	117	ctds2	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	117	CTDT1	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	117	CTDT2	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	118	CTDPRS	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	118	CTDS1	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	118	ctds2	3	Signal mostly noise at CTD trip, data pulled from unaveraged data; Bottle-CTDS2/CTDS1-CTDS2 differences -0.05 PSU, code questionable.
1/1	118	CTDT1	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	118	CTDT2	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
2/3	303	bottle	9	Bottle did not close. No sample taken.
2/3	304	salt	2	Wrong Autosal suppression range (1.9), changed to 2.0. Value acceptable.
2/3	305	salt	2	Wrong Autosal suppression range (1.9), changed to 2.0. Value acceptable.
2/3	308	o2	2	Overtitrate, value acceptable.
2/3	311	bottle	9	Bottle did not close. No sample taken.
2/3	315	bottle	9	Bottle did not close. No sample taken.
2/3	319	bottle	9	Bottle did not close. No sample taken.
2/3	323	bottle	9	Bottle did not close. No sample taken.
3/1	103	bottle	9	Bottle did not close. No sample taken.
3/1	111	bottle	9	Bottle did not close. No sample taken.
3/1	115	bottle	9	Bottle did not close. No sample taken.
3/1	117	o2	2	slower titration than normal, value acceptable.
3/1	118	o2	2	slower titration than normal, value acceptable.
3/1	119	bottle	9	Bottle did not close. No sample taken.
3/1	123	bottle	9	Bottle did not close. No sample taken.

Station /Cast	Sample No.	Property	Quality Code	Comment
4/1	101	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 difference is -0.04 deg.C in high gradient. Code CTDT2 questionable.
4/1	101	salt	2	Wrong Autosal suppression range (1.9), changed to 2.0. Value acceptable.
4/1	103	bottle	9	Bottle did not close. No sample taken.
4/1	107	bottle	9	Bottle did not close. No sample taken.
4/1	111	bottle	9	Bottle did not close. No sample taken.
4/1	115	bottle	9	Bottle did not close. No sample taken.
4/1	118	o2	4	Overtitration 2x (O2), bottle value +0.45 ml/l high, code bad.
4/1	119	bottle	9	Bottle did not close. No sample taken.
4/1	123	bottle	9	Bottle did not close. No sample taken.
5/1	103	bottle	9	Bottle did not close. No sample taken.
5/1	107	bottle	9	Bottle did not close. No sample taken.
5/1	111	bottle	9	Bottle did not close. No sample taken.
5/1	115	bottle	9	Bottle did not close. No sample taken.
5/1	119	bottle	9	Bottle did not close. No sample taken.
5/1	123	bottle	9	Bottle did not close. No sample taken.
6/1	101	o2	4	Overtitrated (2x). Value is high compared to nearby casts on theta-o2, Code bad.
6/1	102	o2	4	Overtitrated, "lost sample". Value is high compared to nearby casts on theta-o2, Code bad.
6/1	103	bottle	9	Bottle did not close. No sample taken.
6/1	107	bottle	9	Bottle did not close. No sample taken.
6/1	111	bottle	9	Bottle did not close. No sample taken.
6/1	112	salt	5	Bottle popped during analysis, lost sample.
6/1	115	bottle	9	Bottle did not close. No sample taken.
6/1	119	bottle	9	Bottle did not close. No sample taken.
6/1	123	bottle	9	Bottle did not close. No sample taken.
7/1	103	bottle	9	Bottle did not close. No sample taken.
7/1	104	o2	2	Overtitrate, original endpoint 0.0002 lower. Value acceptable.
7/1	106	o2	2	Analyst observed: endpoint could be 0.0002 lower. Value acceptable.
7/1	107	bottle	9	Bottle did not close. No sample taken.
7/1	108	o2	5	Abort overtitration, lost sample.
7/1	110	o2	2	Overtitrate. Value acceptable.
7/1	111	bottle	9	Bottle did not close. No sample taken.
7/1	115	bottle	9	Bottle did not close. No sample taken.
7/1	119	bottle	9	Bottle did not close. No sample taken.
7/1	123	bottle	9	Bottle did not close. No sample taken.
8/1	101	CTDOXY	3	Cast sat at bottom for 2 minutes, CTDOXY signal dropped off bottom few db.
8/1	102	o2	2	Overtitrate. Value acceptable.
8/1	103	bottle	9	Bottle did not close. No sample taken.
8/1	107	bottle	9	Bottle did not close. No sample taken.
8/1	111	bottle	9	Bottle did not close. No sample taken.
8/1	115	bottle	9	Bottle did not close. No sample taken.
8/1	119	bottle	9	Bottle did not close. No sample taken.
8/1	123	bottle	9	Bottle did not close. No sample taken.
9/1	101	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	101	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	102	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	102	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.

Station /Cast	Sample No.	Property	Quality Code	Comment
9/1	103	bottle	9	Bottle did not close. No sample taken.
9/1	103	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	103	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	104	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	104	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	105	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	105	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	106	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	106	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	107	bottle	9	Bottle did not close. No sample taken.
9/1	107	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	107	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	108	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	108	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	109	bottle	9	Bottle did not close. No sample taken.
9/1	109	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	111	bottle	9	Bottle did not close. No sample taken.
9/1	113	o2	4	Overtitrate (O2), bottle value +0.6 ml/l high, code bad.
9/1	115	bottle	9	Bottle did not close. No sample taken.
9/1	119	bottle	9	Bottle did not close. No sample taken.
9/1	123	bottle	9	Bottle did not close. No sample taken.
10/1	101	o2	3	Overtitration (2x) questionable (O2). Value seems 0.25 ml/l high, based on theta-o2 comparison with station 9. Code questionable.
10/1	101	salt	5	Sample lost due to folder renaming.
10/1	102	salt	5	Sample lost due to folder renaming.
10/1	103	bottle	9	Bottle did not close. No sample taken.
10/1	107	bottle	9	Bottle did not close. No sample taken.
10/1	109	bottle	9	Bottle did not close. No sample taken.
10/1	111	bottle	9	Bottle did not close. No sample taken.
10/1	112	reft	5	Tripped too soon after btl 11 trip, SBE35 Temp for btl 24 lost.
10/1	115	bottle	9	Bottle did not close. No sample taken.
10/1	116	reft	5	Tripped too soon after btl 15 trip, SBE35 Temp for btl 24 lost.
10/1	119	bottle	9	Bottle did not close. No sample taken.
10/1	120	reft	5	Tripped too soon after btl 19 trip, SBE35 Temp for btl 24 lost.
10/1	122	ctdc1	3	Bottle-CTDS1 or CTDS2-CTDS1 difference is -0.015 PSU, CTDC1-CTDC2 is +0.09 mS/cm. Code CTDC1 questionable.
10/1	122	CTDS1	3	Bottle-CTDS1 or CTDS2-CTDS1 difference is -0.015 PSU, CTDC1-CTDC2 is +0.09 mS/cm. Code CTDS1 questionable.
10/1	123	bottle	9	Bottle did not close. No sample taken.
10/1	124	reft	5	Tripped too soon after btl 23 trip, SBE35 Temp for btl 24 lost.
11/1	101	o2	2	Overtitrate (O2), Value acceptable.
11/1	103	bottle	9	Bottle did not close. No sample taken.
11/1	107	bottle	9	Bottle did not close. No sample taken.
11/1	108	o2	2	Overtitrate (O2), Value acceptable.

Station /Cast	Sample No.	Property	Quality Code	Comment
11/1	109	bottle	9	Bottle did not close. No sample taken.
11/1	111	bottle	9	Bottle did not close. No sample taken.
11/1	115	bottle	9	Bottle did not close. No sample taken.
11/1	118	o2	5	Sample lost.
11/1	119	bottle	9	Bottle did not close. No sample taken.
11/1	123	bottle	9	Bottle did not close. No sample taken.
12/1	103	bottle	9	Bottle did not close. No sample taken.
12/1	107	bottle	9	Bottle did not close. No sample taken.
12/1	109	bottle	9	Bottle did not close. No sample taken.
12/1	111	bottle	9	Bottle did not close. No sample taken.
12/1	115	bottle	9	Bottle did not close. No sample taken.
12/1	118	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.07/+0.035 PSU in high gradient. Code salt questionable.
12/1	119	bottle	9	Bottle did not close. No sample taken.
12/1	121	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
12/1	121	CTDT1	7	Spiking at CTD trip, CTDTEMP ok after despike.
12/1	122	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.02 PSU. Code salt questionable.
12/1	123	bottle	9	Bottle did not close. No sample taken.
13/1	101	CTDOXY	1	Not calibrated yet.
13/1	102	CTDOXY	1	Not calibrated yet.
13/1	103	bottle	9	Bottle did not close. No sample taken.
13/1	103	CTDOXY	1	Not calibrated yet.
13/1	104	CTDOXY	1	Not calibrated yet.
13/1	105	CTDOXY	1	Not calibrated yet.
13/1	106	CTDOXY	1	Not calibrated yet.
13/1	107	bottle	9	Bottle did not close. No sample taken.
13/1	107	CTDOXY	1	Not calibrated yet.
13/1	108	CTDOXY	1	Not calibrated yet.
13/1	109	bottle	9	Bottle did not close. No sample taken.
13/1	109	CTDOXY	1	Not calibrated yet.
13/1	110	CTDOXY	1	Not calibrated yet.
13/1	111	bottle	9	Bottle did not close. No sample taken.
13/1	111	CTDOXY	1	Not calibrated yet.
13/1	112	CTDOXY	1	Not calibrated yet.
13/1	113	CTDOXY	1	Not calibrated yet.
13/1	114	CTDOXY	1	Not calibrated yet.
13/1	114	reft	3	SBE35RT-CTDT1 or -CTDT1 differences are +0.065/+0.095 deg.C. Code CTDT1 questionable.
13/1	115	bottle	9	Bottle did not close. No sample taken.
13/1	115	CTDOXY	1	Not calibrated yet.
13/1	116	CTDOXY	1	Not calibrated yet.
13/1	116	CTDT2	3	SBE35RT-CTDT2/CTDT1-CTDT2 differences are +0.12/+0.11 deg.C. Code CTDT1 questionable.
13/1	117	CTDOXY	1	Not calibrated yet.
13/1	118	CTDOXY	1	Not calibrated yet.
13/1	119	bottle	9	Bottle did not close. No sample taken.
13/1	119	CTDOXY	1	Not calibrated yet.
13/1	120	CTDOXY	1	Not calibrated yet.
13/1	120	ctds2	3	High gradient at CTD trip, Bottle-CTDS2 and CTDS1-CTDS2 are -0.19 PSU. Code CTDS2 questionable.

Station /Cast	Sample No.	Property	Quality Code	Comment
13/1	120	CTDT2	3	High gradient at CTD trip, SBE35-CTDT2 difference is -0.70 deg.C, CTDT1-CTDT2 is -0.67 deg.C. Code CTDT2 questionable.
13/1	121	CTDOXY	1	Not calibrated yet.
13/1	121	reft	3	SBE35RT-CTDT1 or -CTDT1 difference is +0.09 deg.C. Code SBE35RT questionable.
13/1	122	CTDOXY	1	Not calibrated yet.
13/1	123	bottle	9	Bottle did not close. No sample taken.
13/1	123	CTDOXY	1	Not calibrated yet.
13/1	124	CTDOXY	1	Not calibrated yet.
14/1	101	o2	5	Abort sample/OT, lost sample.
14/1	111	bottle	9	Bottle lanyard hooked during recovery, emptied bottle. No samples taken.
14/1	112	o2	4	Overtitration 2x (O2), bottle value +0.40 ml/l high, code bad.
14/1	124	bottle	3	Bottle leaking, top vent not closed. No samples taken.
15/1	108	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.025 PSU. Code salt questionable.
15/1	115	o2	2	Bottle oxygen low compared to downcast, but matches upcast. Acceptable.
15/1	116	o2	2	Bottle oxygen low compared to downcast, but matches upcast. Acceptable.
16/1	102	CTDT1	3	SBE35-CTDT1 or CTDT2-CTDT1 differences are -0.03/-0.05 deg.C. Code CTDT1 questionable.
16/1	103	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 differences are +0.045/+0.065 deg.C in high gradient. Code CTDT2 questionable.
16/1	104	ctds2	3	Bottle-CTDS2 or CTDS1-CTDS2 difference is +0.025 PSU. Code CTDS2 questionable.
16/1	104	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 difference is +0.065+ deg.C in high gradient. Code CTDT2 questionable.
16/1	104	o2	2	Overtitration. Value is acceptable.
16/1	107	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 differences are -0.025/-0.05 deg.C in high gradient. Code CTDT2 questionable.
16/1	113	o2	2	"endpoint ˜0.5427". Value within 0.003ml/l with either endpoint, acceptable.
16/1	115	o2	4	"lost sample." Value is +0.75 ml/l high compared to CTDOXY, Code bad.
16/1	116	o2	3	Value is +0.40 ml/l high compared to CTDOXY, Code questionable.
16/1	118	bottle	3	Bottle lanyard hooked during recovery, contaminated bottle. No gas samples taken.
16/1	121	o2	2	Overtitration. Value is acceptable.
18/1	101	o2	4	OT 0.5620 2 x ot still no good. Value is +0.50 ml/l high, code bad.
18/1	102	CTDT1	3	SBE35RT-CTDT1/CTDT2-CTDT1 differences are -0.065/-0.08 deg.C. Code CTDT1 questionable.
18/1	102	o2	2	OT 0.4064 ot end point looks good. Value is acceptable.
18/1	124	bottle	9	Purposely tripped two at same pressure. No samples taken.
19/1	104	bottle	9	Purposely tripped two at same pressure. No samples taken.
19/1	119	bottle	9	Purposely tripped two at same pressure. No samples taken.
19/1	124	bottle	9	Purposely tripped two at same pressure. No samples taken.
20/1	102	CTDT2	3	SBE35RT-CTDT2 or CTDT1-CTDT2 difference is +0.05 deg.C. Code CTDT2 questionable.
20/1	106	salt	2	Bottle-CTDS1 or -CTDS2 difference is +0.015/+0.02 PSU in high gradient. Salt acceptable.
20/1	108	ctds2	2	High gradient at CTD trip, Bottle-CTDS2 and CTDS1-CTDS2 difference is +0.01 to +0.015 deg.C, CTDS2 acceptable.
20/1	114	o2	2	Overtitration. Value is acceptable.
20/1	118	o2	2	Overtitration. Value is acceptable.
21/1	105	o2	2	"endpoint ˜0.59875", orig. value is acceptable.
21/1	109	o2	2	overtitration, value is acceptable.

Station /Cast	Sample No.	Property	Quality Code	Comment
21/1	111	CTDT1	3	SBE35-CTDT1 or CTDT2-CTDT1 differences are +0.06/+0.075 deg.C. Code CTDT1 questionable.
21/1	116	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 difference is -0.03 deg.C. Code CTDT2 questionable.
21/1	116	o2	4	overtitration, "too quick addition added 3 mls lost sample". Value is 1.1 ml/l high, code bad.
21/1	119	o2	4	overtitration, "lost sample". Value is 0.5 ml/l high, code bad.
22/1	101	o2	2	"ep ˜ 0.4725"; value is acceptable.
22/1	113	o2	2	"ep 0.4618"; value is acceptable.
22/1	114	o2	2	"Overtitration, volts low 1st ep suspect"; value is acceptable.
23/1	101	o2	2	"missed endpoint, correct 0.4415"; used corrected endpoint in data fi le.
23/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-29) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
23/1	102	o2	3	"missed endpoint, correct 0.3708"; with either endpoint, value is 0.2 ml/l high, code questionable. Changed O-rings on bottle 2 prior to sta.26.
23/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.05 PSU. Code salt questionable. Changed O-rings on bottle 2 prior to sta.26.
23/1	114	o2	2	"Overtitrated 0.5164, 1st endpoint wild scatter"; used corrected endpoint in data fi le.
24/1	101	CTDT1	3	SBE35RT-CTDT1 or CTDT2-CTDT1 differences are -0.055/-0.06 deg.C. Code CTDT1 questionable.
24/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-29) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
24/1	102	o2	3	value is 0.2 ml/l high compared to CTDOXY, code questionable. Changed O-rings on bottle 2 prior to sta.26.
24/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.15 PSU. Code salt questionable. Changed O-rings on bottle 2 prior to sta.26.
24/1	105	o2	2	"Overtitrated, 0.3921"; value is acceptable.
24/1	106	o2	2	"Overtitrated, 0.4335"; value is acceptable.
24/1	119	o2	2	"wrong endpoint, correct is .5077", used corrected endpoint in data fi le.
25/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-30) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
25/1	102	o2	3	value is 0.3 ml/l high compared to CTDOXY, code questionable. Changed O-rings on bottle 2 prior to sta.26.
25/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.025 PSU. Code salt questionable. Changed O-rings on bottle 2 prior to sta.26.
25/1	106	o2	2	"Overtitrated, 0.4429"; value is acceptable.
25/1	115	o2	2	"Overtitrated, 0.5375"; value is acceptable.
25/1	121	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.02 PSU. Code salt questionable.
26/1	102	bottle	2	O-rings changed out prior to cast, high bottle oxys,salts this bottle for previous 3 casts.
26/1	109	CTDT1	3	SBE35RT-CTDT1 or CTDT2-CTDT1 differences are +0.125/+0.085 deg.C. Code CTDT1 questionable.
26/1	114	CTDS1	7	Spiking and missing data at CTD trip, due to kink in wire. CTDC1/CTDS1 ok after despike.
26/1	114	CTDT1	7	Spiking and missing data at CTD trip, due to kink in wire. CTDT1 ok after despike.

Station /Cast	Sample No.	Property	Quality Code	Comment
26/1	115	CTDS1	7	Spiking and missing data at CTD trip, due to kink in wire. CTDC1/CTDS1 ok after despike.
26/1	115	reft	3	SBE35RT-CTDT1 or -CTDT2 difference is -0.07-0.08 deg.C. Code SBE35RT questionable.
26/1	116	CTDS1	7	Spiking and missing data at CTD trip, due to kink in wire. CTDC1/CTDS1 ok after despike.
26/1	116	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.11-0.12 PSU. Code salt questionable.
26/1	119	bottle	9	Bottle did not close. No sample taken.
26/1	121	bottle	3	SSSG tech saw top of btl 21 open during recovery.
27/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-30) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
27/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.035 PSU. Code salt questionable.
27/1	107	CTDT2	3	SBE35RT-CTDT2 or CTDT1-CTDT2 differences are +0.05/+0.08 deg.C. Code CTDT2 questionable.
27/1	107	reft	3	SBE35RT-CTDT1 or SBE35RT-CTDT2 differences are +0.13/+0.05 deg.C. Code SBE35RT questionable.
27/1	113	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.02-0.04 PSU. Code salt questionable.
28/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-29) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
28/1	105	o2	2	Overtitration 0.3634. Value is acceptable.
28/1	113	o2	2	Overtitration 0.5132. Value is acceptable.
28/1	117	o2	4	"Overtitration 0.5863; 5mls of io3 added for OT not 1ml". Value +1.9 ml/l high vs nearby or CTDOXY, code bad.
29/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-29) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
29/1	102	o2	3	Bottle o2 is +0.5 ml/l vs CTDOXY. Code bottle o2 questionable.
29/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.10 PSU. Code salt questionable.
29/1	110	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.035 PSU. Code salt questionable.
29/1	116	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.025 PSU. Code salt questionable.

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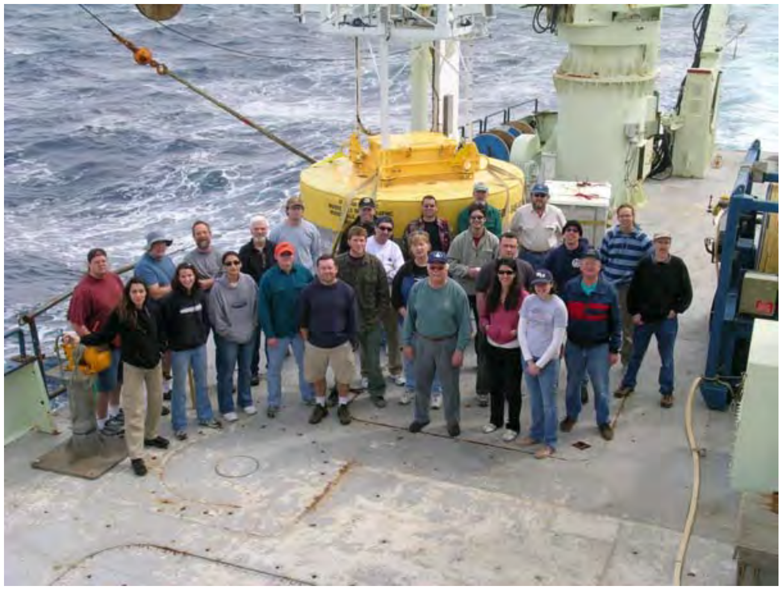
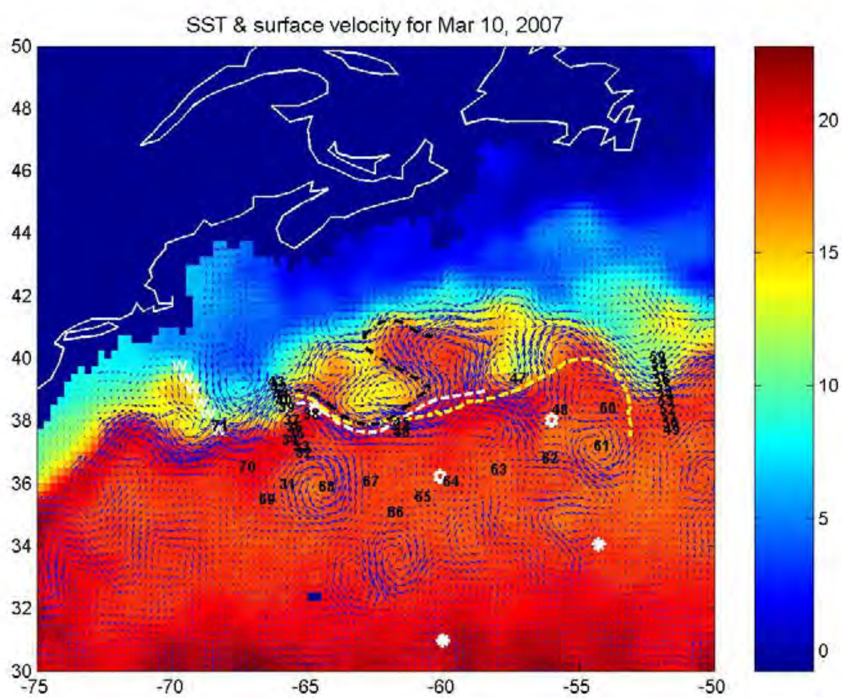
Cruise Report, CLIMODE 4, Leg 2:
2 – 22 March 2007, R/V Knorr





Cruise Summary

This cruise on the Research Vessel Knorr is the second of two legs of wintertime observations in the CLIvar Mode water Dynamics Experiment (CLIMODE, www.climode.org). The goal of these winter cruises is to obtain data during an following wintertime cooling over the CLIMODE region, the formation of a major water mnass of the N. Atlantic Ocean, Eighteen Degree Water (EDW), and to deploy instrumentation (floats and drifters) that will report back the evolution of the EDW. The report will refer at several points to the cruise report from Leg 1 and will not repeat many of the introductory discussion that can be found there.

In this report, we will discuss a variety of different measurements made on the cruise & who the participants were. Here we summarize: the 26 members of the scientific collected 41 CTD casts, all but 5 were to 1000m depth, those 5 were to 2000m, deployed 100 radiosondes, 21 surface drifters, and 8 bobber floats. In addition, we deployed an EM-Apex profiling float, which was later recovered in addition to the EM-Apex float deployed on leg 1. Unlike leg 1, there was no time lost to weather.

Thanks go out to the Captain Sheasley, Bo'sun Liarikos, Steward Da Lomba and all of the crew of the R/V Knorr for helping make this a successful cruise. Thanks also go to Kathie Kelley & her APL/UW team, James Girton and others at UW/APL for shoreside support of the4 EM-Apex work, and Roger Samelson & the OSU group, for providing the satellite and high resolution weather forecasting data we used continuously for planning and interpreting our shipboard measurements. HighSeasNet was essential in this communication linkage. The 26 members of the scientific party & their duties on the vessel are listed in Table 1. The group includes 5 graduate students and 2 Coast Guard shipboard technician in training for the USCGC Healy. A cruise/event summary table is found in Table 2. The ODF group from Scripps, has prepared a CTD/hydro report, which is contained in an Appendix.

Cruise Narrative by T. Joyce

The Knorr departed the dock in St. George's Bermuda at 0900 on 2 March and headed north to occupy a western, upstream CTD section across the Gulf Stream. During this section, all the remaining surface drifters were launched, as well as 4 bobbers.. The third mate injured his hand near the northern end of the section and needed to be evacuated and exchanged. After deploying the EM-Apex float, we decided to return to Woods Hole and make an exchange by small boat for a new third mate. At this point we also picked up one of the science team who, due to weather delays, missed the boat in Bermuda. This exchange occurred in sub-freezing temperatures and snow on the night of 7 March. When the Knorr returned to the work area an deployed the SeaSoar for survey 1, approximately 30 hrs had been lost in the personnel exchange.

During the first SeaSoar survey, the ship passed directly over the mooring site for the surface discus buoy, which had broken loose and had been recovered on Leg 1. We determined that both releases were satill at the anchor site in the upright; thus some part of the lower portion of the mooring must have parted.

Three CTD stations (44, 45 & 46) were taken following the EM-Apex float 1633 recently launched, and the ship moved downstream and began SeaSoar survey 2, east of a large Gulf Stream meander. Surface drifter tacks and subsequently the track of the EM-Apex float confirmed that most of the Gulf Stream was passing to the south of the meander, with only the northern portion of the flow turning northward around the meander. Two CTD casts (47 & 48) were made near this survey and the ship re-positioned for the downstream CTD section (stas. 49:59) followed by a final SeaSoar survey on the eastern flank of another northward meander (Figure 1). The EM-Apex float 1633 was then recovered and the ship moved into the northern Sargasso Sea to occupy a number of CTD stations heading westward. It was during this westward track that the EM-Apex float 1636 deployed on Leg 1 was recovered. The final 3 stations were along a trackline between Cape Cod and Bermuda, during which shipboard ADCP were collected defining the Gulf Stream location and surface transport. The ship arrived in Woods Hole at 1800Z on 22 March.

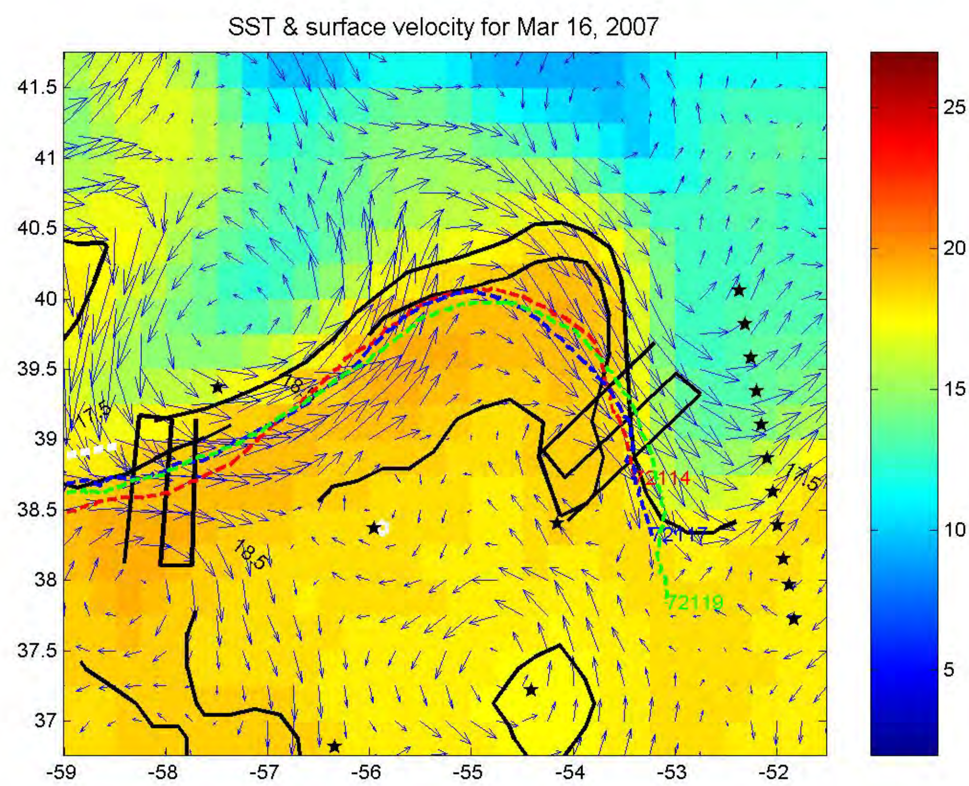


Figure 1. SST and surface velocity image from 16 March with overlays showing CTD stations (stars), SeaSoar tracks (solid black lines) Surface drifter (colored dashed lines) and EM-Apex float 1633 tracks (white dashed line). This shows the last 2 SeaSoar surveys and the downstream CTD section during Leg 2.

SeaSoar & Shipboard ADCP – F. Bahr, L. Thomas

We continued the collection of shipboard acoustic Doppler current profiles from the Knorr's 75KHz "Ocean Surveyor" (RDI) with the settings from the end of the last leg, including 16m vertical bins. Bottom tracking was turned on for the departure from Bermuda, and again for the departure from Tarpaulin Cove near WHOI (it was too rough on the way in to Tarpaulin Cove for ADCP data collection). There was again some loss of ADCP coverage due to poor weather conditions, but much less so than during leg 1.

SeaSoar was deployed for three grids during this leg of the cruise, from 3/8, 9:06 to 3/9, 14:30, from 3/10 20:54 to 3/12 10:59, and again from 3/15 3:31 to 3/16 16:48. The oxygen sensor was not working correctly for the first deployment on this cruise. We replaced it with a spare graciously provided by the Scripps CTD group (John Calderwood).

With winds exceeding 40 knots, conditions on the originally scheduled recovery time following our second survey were too rough to proceed. We waited for about 6 hours for wind and seas to calm down, with the ship sailing at reduced speed on a course that was reasonable given the sea state. Unable to achieve the usual profiling range with about 6 knots tow speed, we used the time for rapid "shallow water" dives between 20 and 150m.

Shortly after launching SeaSoar for our third grid, we encountered drop-outs in the CTD data stream. They occurred at roughly the same spot in the flight path, shortly after the vehicle started to dive. At this point, vehicle pitch is largest (nose down), and cable tension reach a maximum (based on previously collected tension cell records - our CLIMODE setup did not include a tension cell). It may also coincide with the Seasoar bridal lifting off to its horizontal stop points. With the possibility of leakage in our oil-filled termination box excluded based on the post-recovery inspection, we speculate that the tow cable had been damaged during the rough recovery after grid 2. At that time, the cable had experienced a sharp shock loading during an abrupt ship heave when SeaSoar was at the surface. At one point during grid 3, every dive triggered a short data loss of a few seconds. Eventually we lost all communications with the vehicle. Fortunately, replacing the CTD underwater cable fuse brought the system back to life. Much to my amazement, instead of getting worse, the errors slowly disappeared after that, and there was not a single data drop-out during the last nine hours of the deployment.

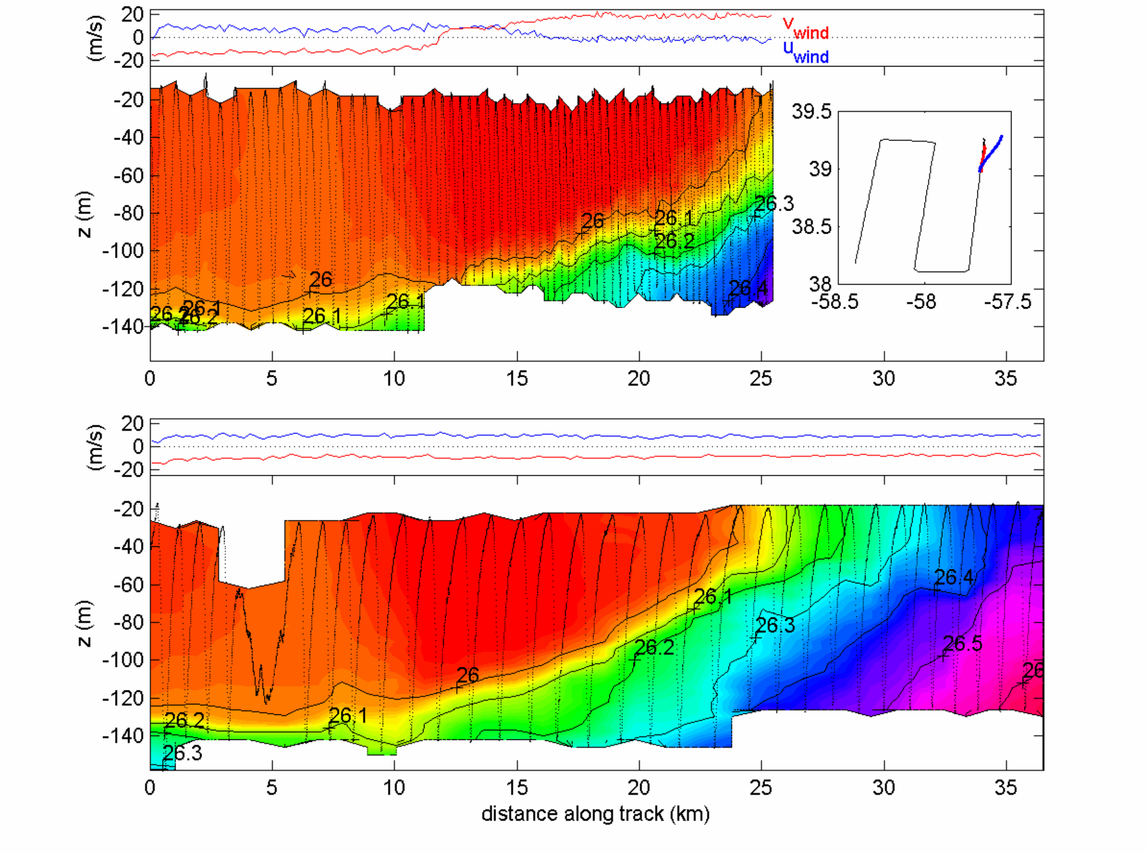


Figure 2. Cross-sections of the density on the southward (top) and northward (bottom) high resolution SeaSoar transects. The trajectory of the SeaSoar is plotted with black dots and density contours are separated by 0.1 kg/m^3 (black) and 0.01 kg/m^3 (colored). The inset in the top panel shows the locations of the southward (red) and northward (blue) transects along with the path of the SeaSoar taken during survey 2 (black). Above each panel the northward (red) and eastward (blue) components of the wind from shipboard meteorological measurements are plotted.

CTD/Hydrogrpahy – T. Joyce

A total of 41 CTD stations were occupied on this leg; all included a fluorometer (uncalibrated) and a dissolved oxygen sensor (calibrated). Two sections were made: and upstream section (32:43), downstream section (49:59), a large-scale east-west transect of the northern Sargasso Sea (60:70). The remaining stations were made in or around the Gulf Stream following the float/drifters. Unlike the upstream section on Leg 1, Leg2 2 CTDs both up and downstream had well ventilated EDW layers, with low stratification and high oxygen (Figure 3). Since the float that we tracked on Leg 2: 1633, was already profiling Temperature and Salinity, we did not routinely sample near the float(s) with a CTD. In this regard, Leg 2 differs from Leg 1. Interestingly, up until the last day of the cruise, none of the surface drifters deployed on Leg 2 made the passage between the last SeaSoar survey and the eastward CTD section: only a distance of 70-80 nm.

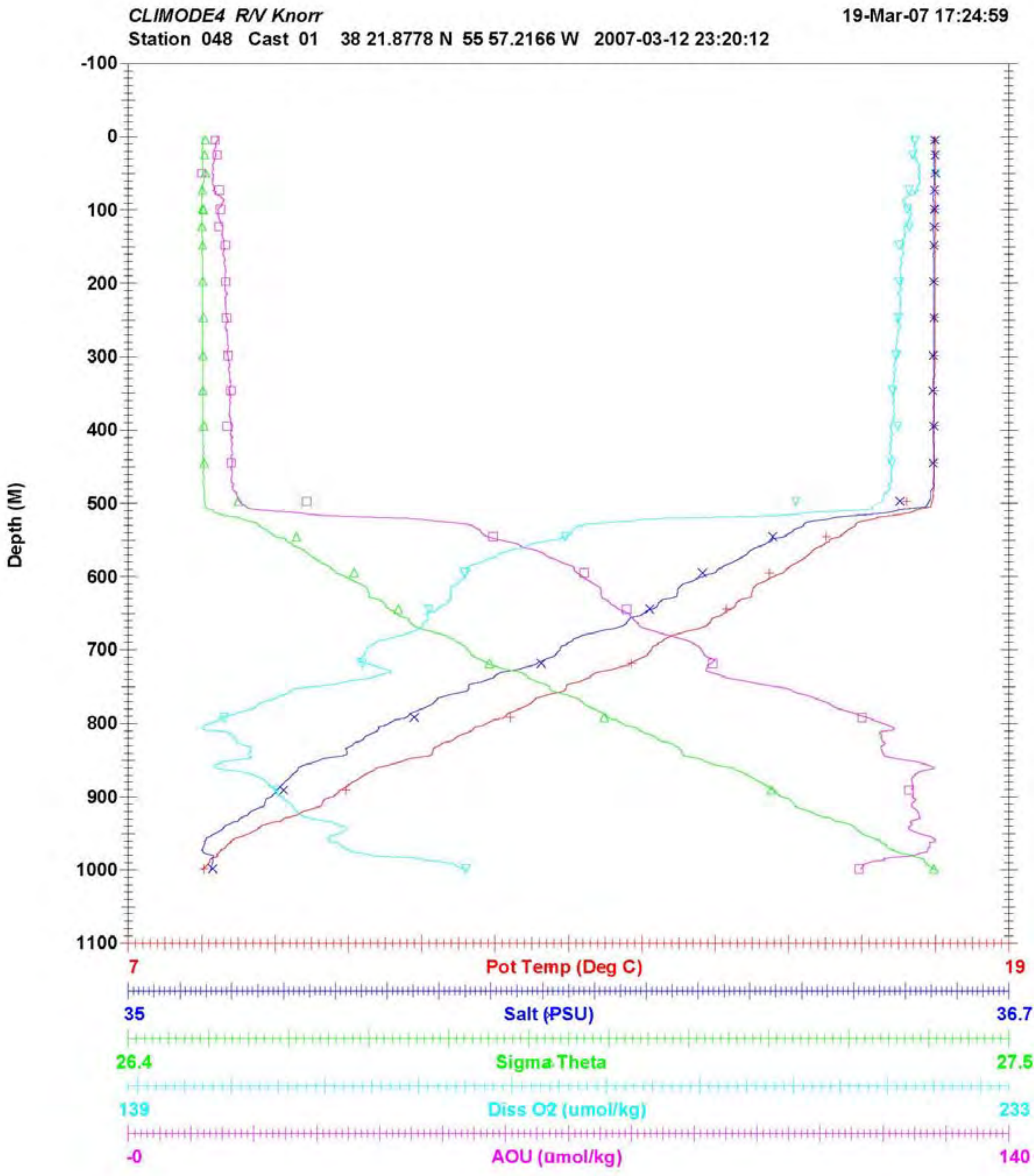


Figure 3. Profiles for CTD48, the station with one of the deepest layers of newly ventilated EDW on Leg 2. Note the low AOU and the highly saturated (97-98%) oxygen in this newly-formed water mass.

CO_2 – N. Bates (contributed by A. Anderson)

DIC/TA and underway $p$$CO_2$

A total of 788 seawater samples were collected from selected Niskin bottles and depths (0 to 1000 m) at each hydrocast station for the analysis of dissolved inorganic carbon (DIC) and total alkalinity (TA). In addition, 134 underway surface seawater samples (see Figure and Table) were collected from the ships uncontaminated seawater flow-through system every 1 to 4 hours depending on the ships activity. The highest sampling frequency of these samples was conducted during water column profiling with SEASOAR. An autonomous CO_2 sensor (SAMI-43, Sunburst sensors, MT) was connected to the seawater flow-through system with the objective to measure pCO_2 in the surface seawater every 15 minutes. Unfortunately, this instrument failed during the first leg of this cruise (Knorr 188-1) and attempts to repair it during the second leg (Knorr 188-2) proved unsuccessful.

All seawater samples collected during Knorr 188-2 will be shipped and analyzed at the CO_2-lab at the Bermuda Institute of Ocean Sciences (BIOS). DIC will be analyzed using SOMMA ($\pm$0.4 μmol kg^{-1}) or VINDTA 3C ($\pm$0.3 μmol kg^{-1}) coloumetric systems and TA will be analyzed based on potentiometric acid titrations using a VINDTA titration system ($\pm$0.4 μmol kg^{-1}) (http://www.bios.edu/Labs/co2lab/research/CO2_instrumentation.html).

Methodology

Hydrocast samples
DIC and TA samples were drawn into 200 ml Kimax brand glass sample bottles immediately after samples for dissolved oxygen (DO) had been drawn from the Niskin bottle holding the sample. The glass bottles were rinsed three times with an approximate volume of 30 to 50 cm^3 of sample prior to filling the bottle from the bottom using Tygon® tubing attached to the spigot of the Niskin bottle. The sample bottle was allowed to overflow with sample approximately one full bottle volume before the tubing carefully was removed. Care was taken to avoid turbulence and to make sure no air bubbles were trapped in the sample. A headspace of approximately 1% of the total volume was left to allow for water expansion during shipping and storage. Once all samples for a cast had been collected, the samples were poisoned by adding 100 μL saturated solution of mercuric chloride (HgCl) in order to prevent further biological activity and production of CO_2. To assure a thight seal and to prevent atmospheric equilibration of the samples, each bottleneck had prior to sampling been taped with Teflon® tape. The screw-on caps were sealed tightly.

Underway samples
DIC and TA underway samples were collected and treated in a similar manner as described under *Hydrocast samples*. Tygon® tubing was attached to a tube directly connected to the uncontaminated seawater flow-through system (seawater was pumped from approximately 5 m depth near the bow of the ship). Seawater was allowed to flush

for a couple of minutes before rinsing the bottle and collecting the sample as previously described. During rough seas, it was difficult to collect samples completely free of bubbles. Samples were collected at approximately 4, 3, 2 or 1 hour intervals as long as the ship was underway. The selected interval was arbitrary depending on the science activity and the number of bottles required for upcoming hydrocasts.

Sampling personnel and affiliation
Andreas Andersson, Bermuda Institute of Ocean Sciences (BIOS)
Charles Bartlett, U.S. coast guard
Neven-Stjepan Fuckar, Princeton University
Otmar Olsina, Florida State University

Underway autonomuous pCO_2 samples
An autonomouous SAMI-43 CO_2 sensor (Sunburst sensors, MT, USA) was installed and attached to the seawater flow-through system during Knorr 188-1 with the purpose to continuously measure surface seawater $p\mathrm{CO_2}$ every 15 min. The system was successfully launched on February 7 using a Dell laptop computer and a standard RS232 serial cable. On February 27, establishment of communication failed when trying to upload the data during the transition between leg 1 and leg 2. After technical assistance from the manufacturer, it was concluded that the sensor was not running and that the battery only held 6-8V compared to the required minimum of 9V. The SAMI system was powered with an external power supply and the data from leg 1 could be offloaded. The data revealed that the system had been initiated on January 17 and continuously measured $p\mathrm{CO_2}$ until it was terminated on February 11 (4 days in to leg 1). Since the SAMI has no indicator to tell whether it is running or not, it was impossible for the operator on leg 1 to detect this failure unless the system had been continuously connected to a laptop computer. In order to power the SAMI system with an external power supply during leg 2, a four-pin impulse connector was modified to fit this purpose. Despite successful powering of the system, successful communication between the laptop and the sensor as well as observations that measurements were taking place, the data output was corrupt and of no scientific value. The system will be sent back to the manufacturer for complete error diagnostics and overhaul.

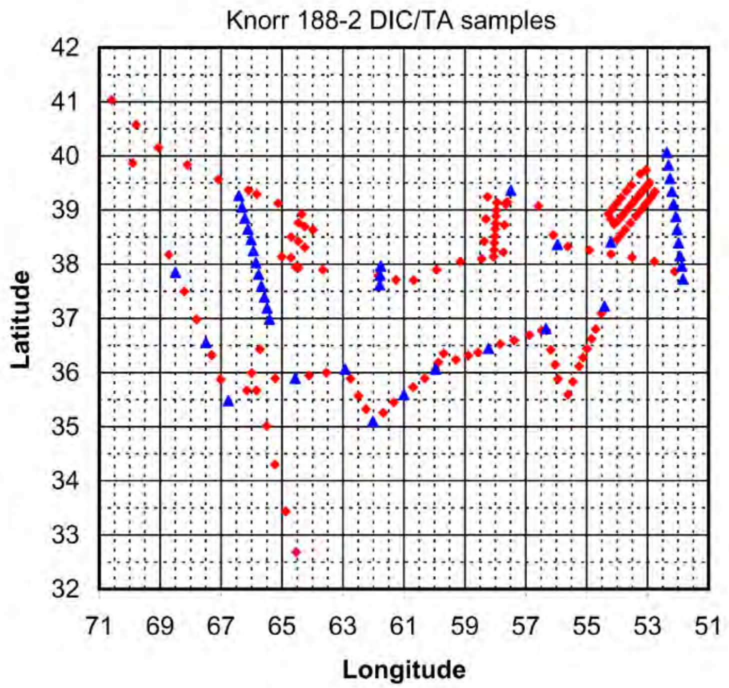


Figure 4. Positions of hydrocast stations (blue) and underway surface seawater samples (red) collected for the analysis of DIC and TA.

Table. Positions of underway surface seawater samples collected for the analysis of DIC and TA

	Sample	LATITUDE		LONGITUDE			
Date - Time GMT	UW 188-2	Deg	Min	Deg	Min	T (°C)	S
2007-03-02 15:28	1	32	41.14	64	32.24	19.07	36.27
2007-03-02 19:26	2	33	26.24	64	52.83	19.18	36.19
2007-03-03 00:01	3	34	18.00	65	14.00	18.49	36.33
2007-03-03 04:00	4	35	0.84	65	30.54	18.18	36.34
2007-03-03 08:10	5	35	40.21	65	50.29	18.13	36.26
2007-03-03 12:00	6	35	59.62	65	59.86	-	-
2007-03-03 16:29	7	36	25.73	65	43.77	18.20	35.84
2007-03-07 06:14	8	41	1.88	70	35.70	3.73	32.52
2007-03-07 10:07	9	40	34.37	69	47.49	3.52	32.78
2007-03-07 14:00	10	40	9.18	69	3.37	5.17	32.61
2007-03-07 18:02	11	39	50.08	68	6.47	4.11	32.20
2007-03-07 22:07	12	39	34.04	67	5.21	4.75	32.41
2007-03-08 02:03	13	39	22.04	66	6.02	7.94	33.37
2007-03-08 03:13	14	39	17.72	65	49.77	12.43	34.72

2007-03-08 06:02	15	39	7.54	65	7.55	13.65	34.87
2007-03-08 09:11	16	38	55.46	64	21.38	16.04	35.64
2007-03-08 12:04	17	38	45.92	64	27.57	20.05	35.88
2007-03-08 14:52	18	38	30.33	64	42.27	21.37	35.93
2007-03-08 18:16	19	38	8.44	65	0.78	20.15	35.90
2007-03-08 21:07	20	38	7.35	64	42.37	19.83	35.86
2007-03-09 00:11	21	38	25.34	64	28.01	20.78	35.91
2007-03-09 03:07	22	38	41.66	64	14.92	17.84	35.58
2007-03-09 06:04	23	38	38.27	63	59.17	15.77	35.40
2007-03-09 09:03	24	38	18.61	64	15.30	20.36	35.90
2007-03-09 12:10	25	37	56.83	64	33.11	18.57	35.90
2007-03-09 15:01	26	37	56.16	64	27.37	18.64	35.86
2007-03-09 18:03	27	37	53.72	63	39.57	20.39	36.15
2007-03-09 23:50	28	37	47.46	61	50.40	20.49	36.09
2007-03-10 09:53	29	37	42.65	61	15.49	18.95	36.05
2007-03-10 12:08	30	37	42.27	60	40.70	18.33	36.17
2007-03-10 15:08	31	37	53.98	59	55.79	18.84	36.13
2007-03-10 18:13	32	38	3.03	59	8.62	20.66	36.14
2007-03-10 21:02	33	38	6.09	58	26.77	20.44	36.07
2007-03-11 00:00	34	38	25.32	58	21.96	19.78	36.07
2007-03-11 02:58	35	38	49.93	58	18.58	20.33	36.11
2007-03-11 06:01	36	39	14.72	58	15.22	16.10	35.50
2007-03-11 08:30	37	39	8.51	57	56.81	17.75	35.71
2007-03-11 10:01	38	38	59.90	57	57.77	19.92	36.18
2007-03-11 11:01	39	38	53.33	57	58.49	20.20	36.14
2007-03-11 12:08	40	38	45.39	57	59.37	20.08	36.11
2007-03-11 13:01	41	38	38.99	58	0.08	20.17	36.11
2007-03-11 14:07	42	38	31.11	58	0.94	20.05	36.11
2007-03-11 15:05	43	38	23.90	58	1.74	19.82	36.05
2007-03-11 16:11	44	38	15.66	58	2.64	19.80	35.78
2007-03-11 17:04	45	38	8.49	58	3.43	19.77	35.88
2007-03-11 20:01	46	38	13.34	57	44.09	19.74	35.81
2007-03-11 23:22	47	38	43.26	57	41.76	20.11	35.76
2007-03-12 02:07	48	39	7.41	57	39.83	20.29	35.73
2007-03-12 06:03	49	39	6.45	57	39.57	19.06	35.90
2007-03-12 09:00	50	39	8.94	57	36.38	20.07	35.83
2007-03-12 18:32	51	39	4.56	56	35.07	20.13	35.89
2007-03-12 22:04	52	38	32.50	56	6.04	17.92	36.09
2007-03-13 02:13	53	38	19.59	55	37.00	18.46	35.92
2007-03-13 05:10	54	38	15.72	54	54.74	17.76	36.09

2007-03-13 08:13	55	38	11.19	54	12.16	17.88	36.20
2007-03-13 11:02	56	38	7.46	53	30.88	18.15	36.06
2007-03-13 14:05	57	38	3.05	52	46.48	17.95	36.04
2007-03-13 17:02	58	37	52.18	52	6.60	17.82	36.06
2007-03-15 02:29	59	39	44.34	53	3.01	15.05	35.76
2007-03-15 04:08	60	39	39.92	53	14.54	16.33	35.81
2007-03-15 06:03	61	39	27.84	53	31.89	16.81	36.03
2007-03-15 07:03	62	39	20.91	53	41.72	18.43	35.99
2007-03-15 08:12	63	39	13.49	53	52.31	19.30	36.15
2007-03-15 09:13	64	39	7.23	54	1.26	19.20	36.15
2007-03-15 10:03	65	39	1.99	54	8.68	18.75	36.15
2007-03-15 11:07	66	38	55.89	54	17.34	18.48	36.12
2007-03-15 12:02	67	38	50.70	54	12.74	18.72	36.12
2007-03-15 13:06	68	38	44.51	54	5.81	18.79	36.13
2007-03-15 14:07	69	38	47.75	53	58.97	18.77	36.18
2007-03-15 15:10	70	38	52.28	53	52.34	19.35	36.19
2007-03-15 16:06	71	38	56.01	53	46.86	19.32	36.17
2007-03-15 17:01	72	38	59.08	53	42.35	17.68	35.78
2007-03-15 18:02	73	39	2.81	53	36.85	16.85	35.86
2007-03-15 19:00	74	39	6.29	53	31.74	16.14	35.88
2007-03-15 19:53	75	39	9.59	53	26.90	16.40	35.78
2007-03-15 21:15	76	39	13.88	53	20.56	19.25	36.06
2007-03-15 22:16	77	39	17.28	53	15.53	19.19	36.02
2007-03-15 23:06	78	39	20.27	53	11.24	18.98	35.99
2007-03-16 00:07	79	39	23.50	53	6.46	16.71	35.54
2007-03-16 01:05	80	39	27.63	53	0.37	5.15	32.80
2007-03-16 01:40	81	39	27.51	52	59.40	5.13	32.61
2007-03-16 02:06	82	39	25.82	53	1.54	5.37	32.71
2007-03-16 02:38	83	39	23.77	53	4.98	5.65	32.80
2007-03-16 03:12	84	39	25.92	53	2.88	5.40	32.64
2007-03-16 04:09	85	39	30.26	52	56.60	5.21	32.71
2007-03-16 06:03	86	39	20.19	52	45.77	5.75	32.81
2007-03-16 07:00	87	39	15.26	52	51.33	5.04	32.54
2007-03-16 07:57	88	39	10.73	52	57.86	6.16	32.82
2007-03-16 08:55	89	39	5.78	53	5.00	16.03	35.23
2007-03-16 09:59	90	38	59.63	53	13.88	19.60	35.88
2007-03-16 11:00	91	38	53.14	53	23.21	19.73	35.86
2007-03-16 12:05	92	38	45.75	53	33.89	19.32	35.82
2007-03-16 13:05	93	38	38.68	53	44.01	16.88	35.61
2007-03-16 14:03	94	38	32.82	53	52.38	17.12	35.59

2007-03-16 15:02	95	38	27.68	53	59.83	19.19	35.85
2007-03-17 03:38	96	37	5.47	54	31.04	17.23	35.96
2007-03-17 05:36	97	36	48.22	54	42.44	17.69	36.03
2007-03-17 06:50	98	36	37.17	54	50.50	18.49	36.13
2007-03-17 08:03	99	36	26.23	54	59.43	18.39	36.15
2007-03-17 09:07	100	36	16.62	55	7.20	18.50	36.15
2007-03-17 10:14	101	36	6.94	55	14.86	18.46	36.16
2007-03-17 12:12	102	35	49.97	55	26.93	18.48	36.13
2007-03-17 14:05	103	35	35.65	55	36.83	18.69	36.11
2007-03-17 16:21	104	35	52.78	55	56.32	18.24	36.13
2007-03-17 18:04	105	36	8.82	56	2.27	18.14	36.05
2007-03-17 19:55	106	36	25.19	56	10.87	18.29	36.08
2007-03-17 22:04	107	36	47.18	56	19.59	18.30	36.04
2007-03-18 00:05	108	36	46.58	56	28.71	18.46	36.07
2007-03-18 01:58	109	36	41.50	56	52.77	18.42	36.06
2007-03-18 04:04	110	36	35.45	57	22.85	18.56	36.05
2007-03-18 06:01	111	36	31.40	57	50.37	18.47	36.08
2007-03-18 10:40	112	36	22.22	58	34.16	18.34	36.09
2007-03-18 12:07	113	36	18.85	58	53.22	18.30	36.11
2007-03-18 14:00	114	36	14.33	59	17.42	18.08	36.03
2007-03-18 16:23	115	36	21.11	59	41.46	19.57	36.04
2007-03-18 18:04	116	36	11.40	59	52.19	19.27	35.73
2007-03-18 20:07	117	36	3.31	59	57.55	18.89	35.81
2007-03-18 22:10	118	35	53.50	60	18.68	18.28	35.80
2007-03-19 00:12	119	35	43.92	60	41.81	18.27	35.86
2007-03-19 05:02	120	35	26.87	61	20.30	18.30	35.80
2007-03-19 07:03	121	35	15.40	61	40.72	18.26	35.69
2007-03-19 12:29	122	35	19.34	62	14.72	18.61	35.81
2007-03-19 14:36	123	35	34.18	62	29.41	18.44	35.80
2007-03-19 17:07	124	35	53.36	62	45.11	19.63	35.81
2007-03-19 22:40	125	35	59.91	63	32.66	18.25	35.83
2007-03-20 01:15	126	35	56.72	64	6.74	18.14	35.89
2007-03-20 07:53	127	35	53.47	65	13.26	17.73	36.04
2007-03-20 12:22	128	35	40.22	66	9.38	17.16	35.85
2007-03-20 19:09	129	35	52.37	67	1.18	19.17	36.07
2007-03-20 22:54	130	36	19.32	67	18.45	19.04	36.04
2007-03-21 03:12	131	36	59.02	67	48.38	20.85	35.81
2007-03-21 06:17	132	37	29.74	68	12.57	11.49	33.58

Nutrient Sampling – (S. Lozier, contributed by A. Dave)

The physical, chemical, and biological dynamics surrounding the formation of EDW exert a powerful influence on primary productivity in the surface waters that lie 'down-stream' of the formation region. The spatial and temporal extent of deep convective mixing in the north-west of the subtropical gyre each spring determines the amount of nutrients that are mined from sub-nutricline waters. Subsequent biological utilization of upwelled nutrients sets the nutrient concentrations of the subsurface reservoir that is formed as EDW is subducted and advected around the gyre. Interannual changes in atmospheric and upper-ocean conditions at the EDW formation region contribute to the observed variability in patterns of primary productivity across the subtropical gyre. Any attempt to characterize this variability must address the influence of EDW and the processes at work during its formation.

The nutrient sampling program in the CLIMODE 4 cruise has obtained samples that will allow us pursue three primary objectives: to characterize the nutrient structure of waters in the STMW formation region at the time of mode water formation, to determine the level of nutrient depletion due to biological utilization and finally to resolve the processes that affect nutrients in EDW as it is advected eastward by the Gulf Stream.

A full description of the nutrient sampling conducted during the previous leg of this cruise can be found in the 1st leg report. Briefly, seawater samples from the surface and between ~100m and ~800m depth were gathered from 30 CTD stations and stored in pre-sterilized polypropylene bottles before being frozen. During the second leg samples for nutrients were collected in the same manner at an additional 41 CTD stations. The CTD casts for the second leg were made along 2 sections across the Gulf Stream, at ~65W and 52W, and at points within the Gulf Stream that were coincident with SeaSoar surveys and an EM-Apex float recovery. In addition casts were made at selected points in waters south of the stream, including at two existing CLIMODE moorings. The frozen nutrient samples from each of the Leg 1 and Leg 2 stations will be packed in dry ice and shipped to Scripps Institution of oceanography for analysis by Susan Becker.

EM-APEX - J. Toole

This subprogram of CLIMODE is focused on acquiring quasi-Lagrangian observations of finescale temperature, salinity and velocity variability in the upper ocean. The Leg 1 cruise report provides background to the 2007 observational program and describes the instrumentation utilized. EM-Apex float number 1636 that was deployed during Leg 1 remained at sea during the Bermuda port stop. Destruction of the ASIS buoy by wave action at the end of Leg 1 prevented redeployment of the FILIS instrument on Leg 2. It was therefore decided to use the second EM-Apex float as the reference point for the shipboard measurement program. Upon completion of the upstream hydrographic section, EM-Apex float number 1633 was deployed on the section line near the velocity axis of the Gulf Stream, just prior to Knorr's diversion to Woods Hole to offload the injured crew member.

The drift tracks of both profiling floats are shown below. EMA-1633 rapidly moved east with the Gulf Stream while EMA-1636 slowed, moved south of the jet and turned back to the west during Leg 2.

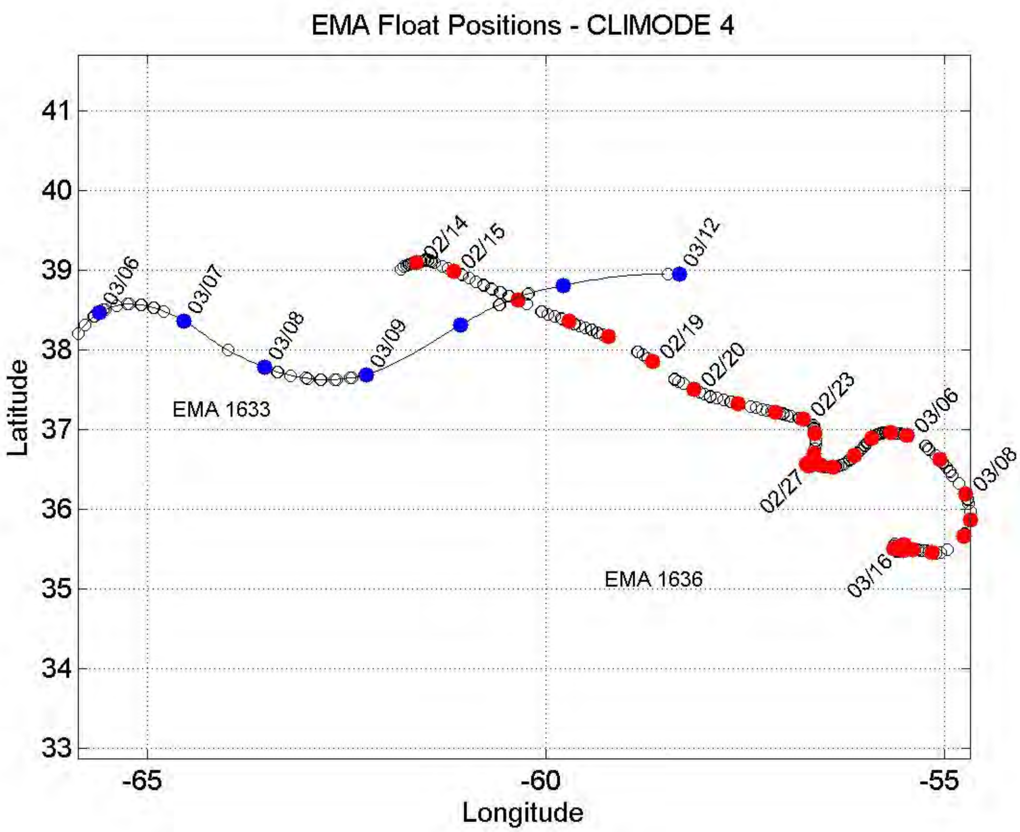


Figure 5. Drift tracks of the two EM-Apex floats during the winter 2007 CLIMODE cruises. GPS position fixes are marked by open circles; the colored symbols mark 1-day intervals.

Although programmed to telemeter GPS position fixes each time they surfaced, EMA-1633 frequently failed to report valid position data, particularly at times of rough weather. Consequently, the Leg 2 shipboard sampling was guided chiefly by satellite sea surface temperature and geostrophic velocity maps.

On March 11 with future ship sampling planned well to the east, it was decided attempt recovery of EMA-1633 the following day. The command to the float for it to remain at the surface was issued that night and the ship was directed to head for a DR position the following morning. Unfortunately, during the night, the antenna system supporting the Knorr's link to Highseasnet went down making it impossible to access float position data electronically. We resorted to Iridium phone calls to James Girton in Seattle to obtain position data. The fast drift speed of the float (>4 knots) and rough seas made it difficult to locate the instrument. Eventually antenna functionality was restored and the collection of position fixes allowed us to home in on the float. It was eventually sighted and brought safely aboard. During its week-long deployment, EMA-1633 returned 90 temperature, salinity and velocity profiles between the surface and 550 m depth.

After completion of the final, downstream hydrographic section of Leg 2, the Knorr was directed back to the west with widely-spaced CTD stations planned along the southern recirculation gyre. Recovery of EMA-1636 was scheduled for the morning of March 17. This time, the Highseasnet remained fully operational, the float drift was much slower, and with winds below 10 knots, the seas were down. We were able to drive right up to the predicted float position and quickly locate it. Recovery followed without incident. During the 31-day deployment, EMA-1636 returned a total of 468 temperature, salinity and velocity profiles between the surface and 550 m depth.

EM-Apex data overview

During the course of its one-month drift, EMA-1636 transitioned from warm, relatively shallow mixed layers characteristic of the Gulf Stream Warm Core to very deep surface layers with temperatures between 18 and 18.5 C. In contrast, float EMA-1633 was only deployed for a week. However, in that time, the mixed layer cooled significantly and deepened by some 25 m. Distinguishing between changes due to local air-sea exchange and those resulting from differential motion between the float and the water will be an important research topic.

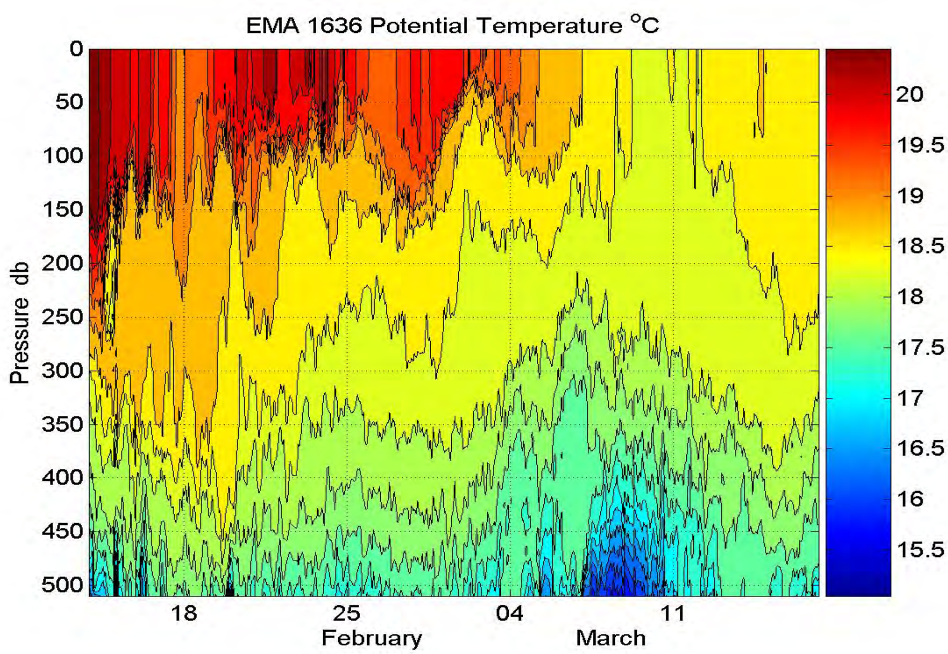


Figure 6. Depth-time contour plot of potential temperature based on profile data obtained by EM-Apex float 1636.

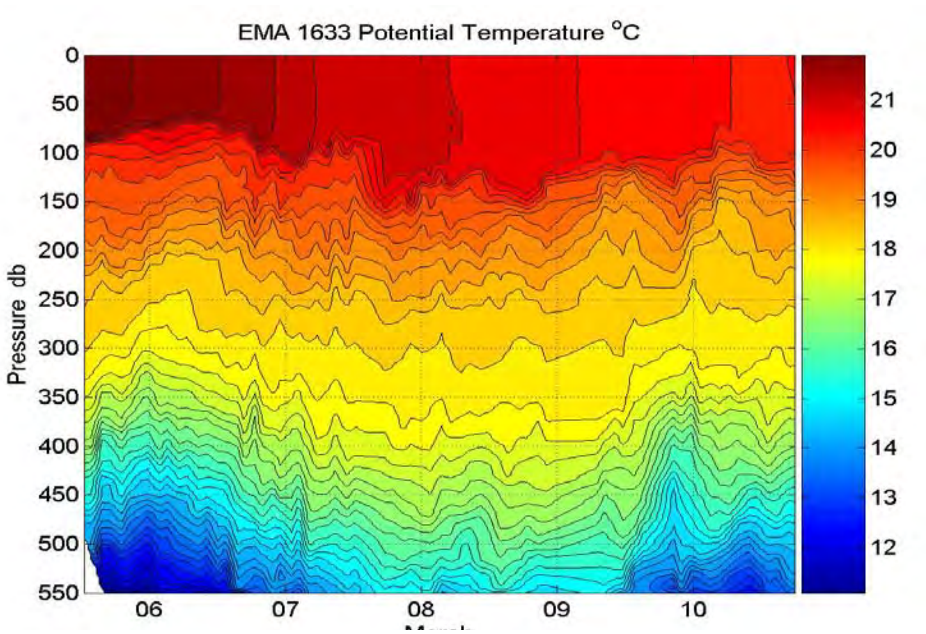


Figure 7. Depth-time contour plot of potential temperature based on profile data from EM-Apex float 1633.

MIT/WHOI Joint Program student Katie Silverthorne will be analyzing these observations in conjunction with various mixed layer models to understand the evolution of the upper ocean during the winter 2007 CLIMODE cruises.

We thank Drs. Tom Sanford and James Girton (Applied Physics Laboratory, University of Washington) for providing the EM-Apex floats used in CLIMODE and their associate, John Dunlap, for facilitating access to the processed data from these instruments.

Figure 8. Inspecting EM-Apex float 1636 after recovery. Note the flexible bails mounted on either side of the float body for recovery.

Air-Sea Exchange – Jim Edson, Jon Ware

The air-sea exchange group operated the set of meteorological sensors on the bow mast of the Knorr during the second leg of the CLIMODE cruise. The meteorological sensors on the bow mast of the Knorr included two direct covariance flux systems (DCFS) to measure momentum, heat, moisture, and radiative (solar and IR) fluxes using sonic anemometers/thermometers, infrared hygrometers and radiometers. The bow sensors also measured mean air temperature, humidity, pressure, wind speed, wind direction, and sea surface temperature using a downward looking radiometer. Nearly all system ran continuously from March 1-22. One of the sensors measuring air temperature, pressure and humidity began to fail on March 3, but was replaced by a backup sensor that same day. Preliminary analysis from both legs continued throughout the cruise. The data analysis included computation of the heat and momentum fluxes using the COARE 3.0 bulk flux algorithm. These results indicate that the combined sensible and latent heat loss from the ocean **averaged** 450 W/m^2 during the first leg and 310 W/m^2 during the second leg as shown in figure 9. The surface stress averaged 0.40 and 0.24 N/m2 during legs 1 and 2, respectively (figure 10). The maximum total heat flux during the six-week cruise reached nearly 1400 W/m^2 during a cold air outbreak in Leg 2, while the maximum surface stress reach 1.6 N/m^2 in near hurricane force winds in Leg 1. Initial estimates of the direct covariance fluxes using the DCFS data from leg 1 are in good agreement with the bulk estimates.

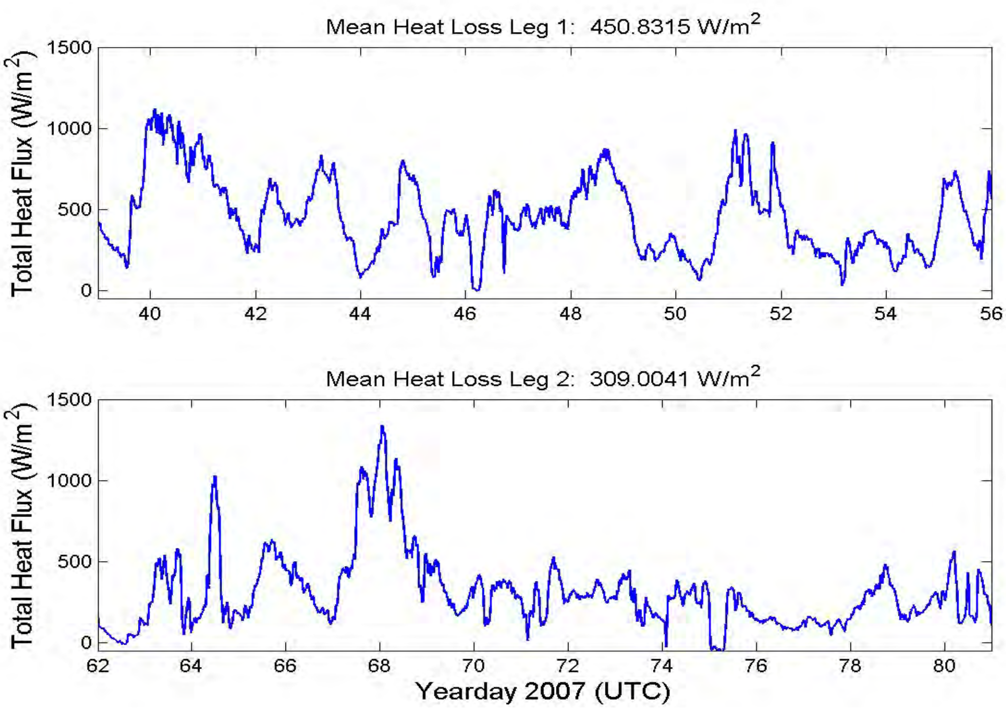


Figure 9. Time series of the total (latent and sensible) heat fluxes computed using the COARE 3.0 bulk flux algorithm. The top and bottom panels show the results from Leg 1 and 2, respectively.

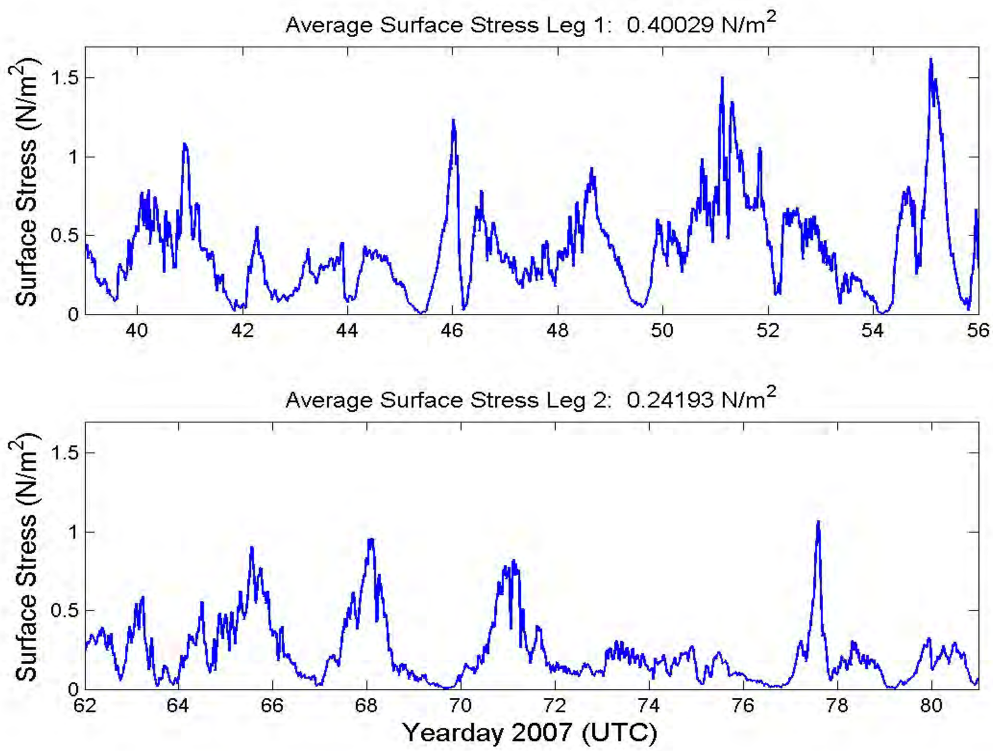


Figure 1. Time series of the surface Stress computed using the COARE 3.0 bulk flux algorithm. The top and bottom panels show the results from Leg 1 and 2, respectively.

Atmospheric Profiling (NCAR) – W. Brown, L. Tudor

The National Center for Atmospheric Research (NCAR) operated a balloon borne radiosonde sounding system and a wind profiler for CLIMODE. The wind profiler is a 915 MHz clear-air radar and measures wind and atmospheric reflectivity in a column above the radar. The radar also includes a Radio Acoustic Sounding System (RASS) to measure virtual temperature aloft. The radiosondes were typically launched at three to six hourly intervals, whereas the wind profiler operated continuously. These instruments are components of an ISS (Integrated Sounding System) in NCAR's Earth Observing Laboratory (EOL). The ISS measurements for CLIMODE are available on the web at http://www.eol.ucar.edu/rtf/projects/climode/

Radiosonde sounding system

NCAR operated a GAUS (GPS Advanced Upper-air Sounding) system launching 100 balloon borne radiosondes. Approximately 80% of the soundings reached 100 mb (about 16 km), and about half of those went above 50 mb (approx. 20 km).

An interesting feature of many of the soundings was the multiple layers. An example is shown in figure 1. The bump at 1 km in the temperature and humidity profiles is the characteristic temperature inversion at the top of the boundary layer. Notice there are other unexpected inversions in the temperature profile. These represent layers of air warmed or cooled elsewhere, probably by blowing over warm or cold pools of water to the east and north. Similar features were observed in many of the soundings, and these will provide valuable clues about the exchange and transport of heat in the atmosphere around the Gulf Stream.

Wind Profiler

The wind profiler worked very well for this cruise. During the first cruise there was a problem with sea spray in some of the cables, disabling the stabilized platform that keeps the antenna steady. Repairs were carried out in Bermuda and the platform operated normally during the second cruise. There was also a problem with the radar's coherent integrator cards that degraded the performance of RASS during the first cruise. These cards were replaced in Bermuda and so RASS operated normally during the second cruise.

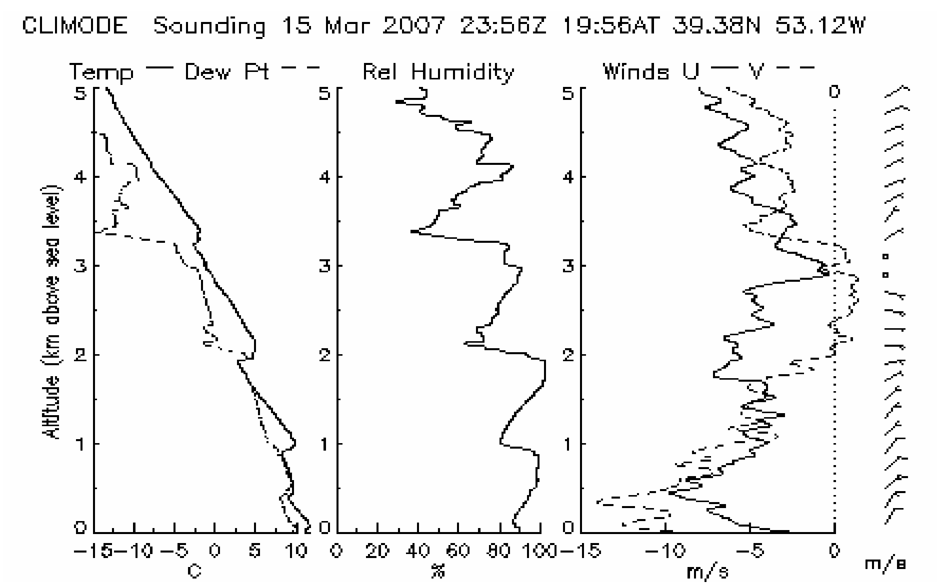


Figure 11: Profiles of temperature (and dew point temperature), relative humidity, and wind (eastward U, and northward V) as functions of altitude for a radiosonde sounding launched at 2356 UTC on March 15. The wind barbs at the far right show the direction the wind has come from (here mainly east or northeasterly).

There have been preliminary performance and accuracy checks of the wind profiler measurements as compared with the radiosondes. The wind measurements agreed with the radiosonde wind measurements to within about 2 m/s (standard deviation), which is a reasonable agreement given that the radiosondes and ship drift some distance apart during the observations. Wind measurements were available up to an altitude of 1500 meters at least half of the time, and when there was precipitation present, measurements extended through the precip, sometimes to 5 km.   The wind profiler doesn't provide the depth of coverage of the radiosondes, however does provide the continuous coverage of the boundary layer that would be prohibitively expensive with radiosondes.

An example of the measurements made by the wind profiler is shown in figure 12.   The upper panel shows SNR (Signal to Noise Ratio) which indicates the reflectivity of the atmosphere over 48 hours from 0 UTC on March 15.   Reflectivity is a complicated function of humidity, temperature, and turbulence. Here we can use it to trace the evolution of layers in the atmosphere. For example, the sounding in the figure above was made at about 0 UTC on the 16th (approximately where the Day 075 line is on the plot). Some of the inversions in the sounding figure correspond to the layers in the SNR plot. The lower panel shows the winds measured by the profiler; on the 15th the winds were mainly northeasterly, turning to northerlies on the 16th. The wind profiler provides a means of tracking the inversion layers and the winds between soundings.

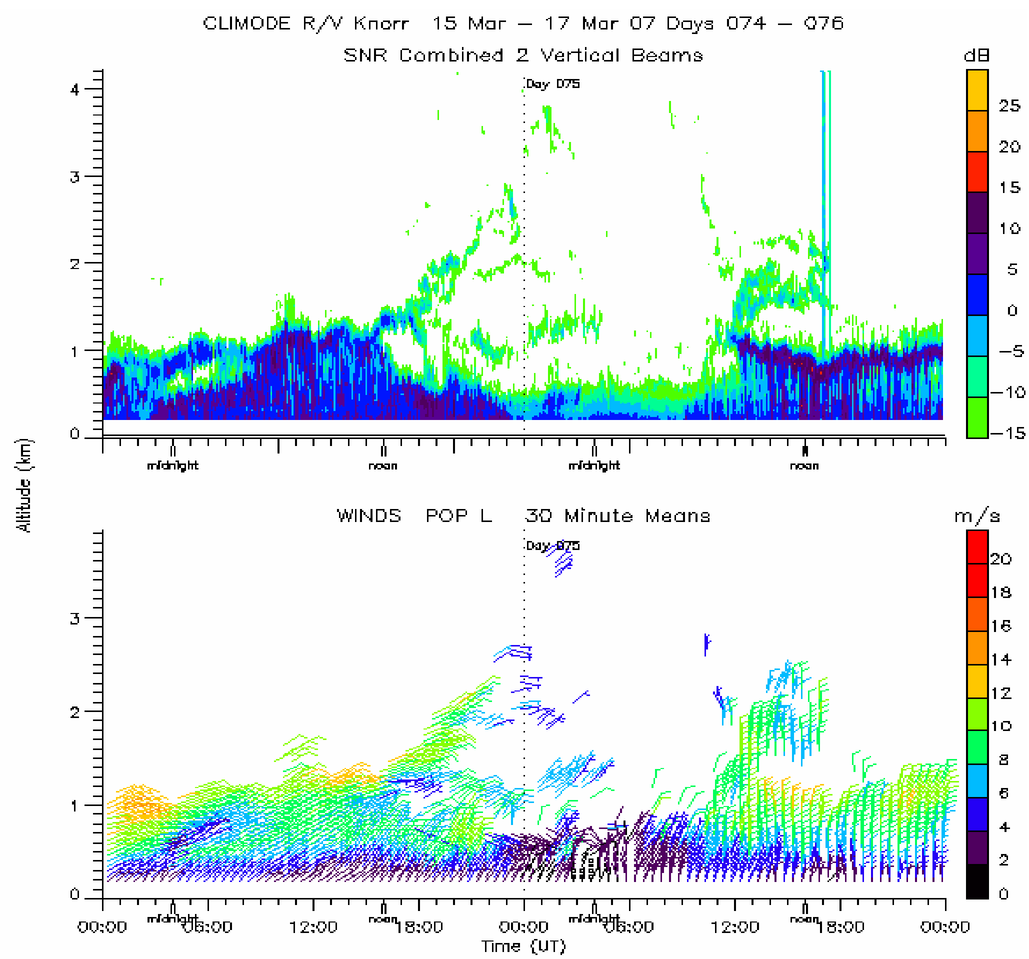


Figure 12. .   Wind profiler observations from 0 UTC on March 15 to 0 UTC March 17. The upper panel shows SNR (Signal to Noise Ratio) and the lower panel shows wind barbs (30 minute averages, color coded by speed) as functions of altitude. The barbs indicate the direction the wind is from.

The imet sea surface temperature for the same time period is plotted in figure 3. Notice how the temperature drops substantially between about 0 UT and 8 UT on the 16th. This period was during the third Sea Soar observation period as we sailed out of the Gulf Stream, and then turned back into the Gulf Stream. During the transit over the cooler seas the reflectivity of the atmosphere (SNR in figure 12) dropped considerably as surface driven convection was suppressed. The reflectivity recovered when we returned to warmer waters around 8 UT.

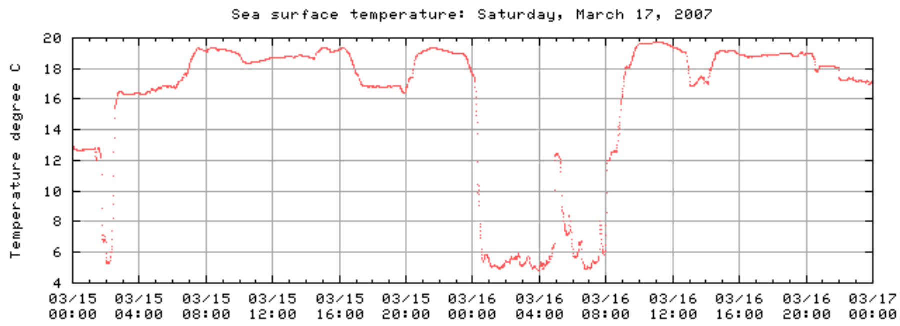


Figure 13. Imet sea surface temperature for the same period as figure 12.

RASS

The Radio Acoustic Sounding System (RASS) measures virtual temperature aloft by emitting a loud tone; the wind profiler radar can detect the sound wave as it travels vertically and uses the relationship between the speed of sound and virtual temperature to measure temperature. The RASS virtual temperature measurements were compared to the radiosonde observations and agreed to within about 1C. RASS measured up to 500 m around half of the time, and occasionally over 1000 m (for example when there was a tail wind advecting the acoustic signal along with the ship).

An example of RASS virtual temperature measurements is given in figure 14. This example is for the same time period as figures 12 and 13. Notice that when the sea surface temperature drops (0 UTC on March 16) the temperature measured by RASS also drops. As expected the air temperature recovers as the sea surface temperature warms; using RASS we can see that this recovery extends at least 500 meters up into the atmosphere.

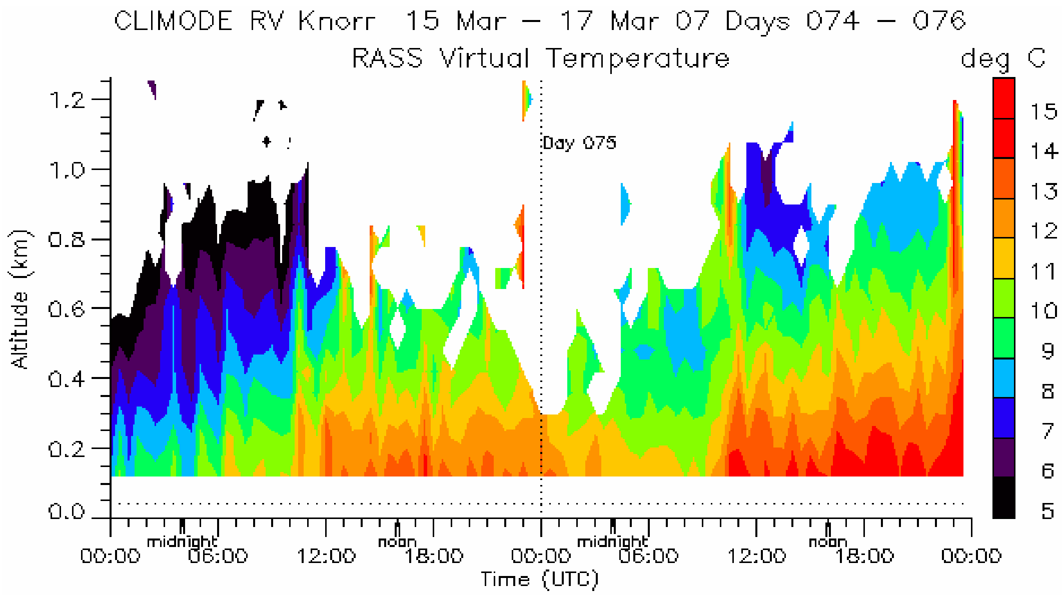


Figure 14. Wind profiler RASS virtual temperature for the same time period as figures 12 and 13.

Surface Drifters and Floats – B. Hodges and D. Fratantoni

Drifters

27 Global Drifter Program surface drifters were deployed during the second leg of the CLIMODE4 cruise (KN188-2). The drifters, equipped with holey sock drogues at a depth of 15 m, track surface currents and measure sea surface temperature. Data relay and drifter location observations are accomplished via Argos. The drifters were deployed three at a time, one trio at each of nine consecutive CTD stations in a hydrographic section crossing the Gulf Stream (see Fig. 15, which shows temperature and position for one drifter from each of the trios).

Drifters from the southern four stations (station numbers 32-35) were caught up in a cyclonic eddy. The trio deployed at CTD station 34 had completed a full loop in the eddy by March 18, 2007. Aside from an initial cooling of 3 degrees C measured by drifters from station 35 during the first 2 days of the deployment, and of 1 degree during the first day measured by those from station 34, the surface temperature reported by these 4 trios of drifters remained relatively constant, near 18.2 degrees C.

The four northernmost trios, released at CTD station numbers 37-40, moved swiftly eastward with the Gulf Stream. Those released at station 40, north of the core of the Gulf Stream in water several degrees cooler than the others, began diverging northward from the Gulf Stream on the ninth of March, and on the 12th turned sharply back toward the west. The three trios that remained in the Gulf Stream showed gradual cooling of surface water as they propagated eastward. On March 9, the drifters deployed at CTD station 37 recorded a rapid cooling event, from approximately 21.7 to 18.5 degrees C.

The drifters released at CTD station 36 were neither caught up in the eddy to the south, nor in the Gulf Stream to the north. They drifted slowly toward the southwest.

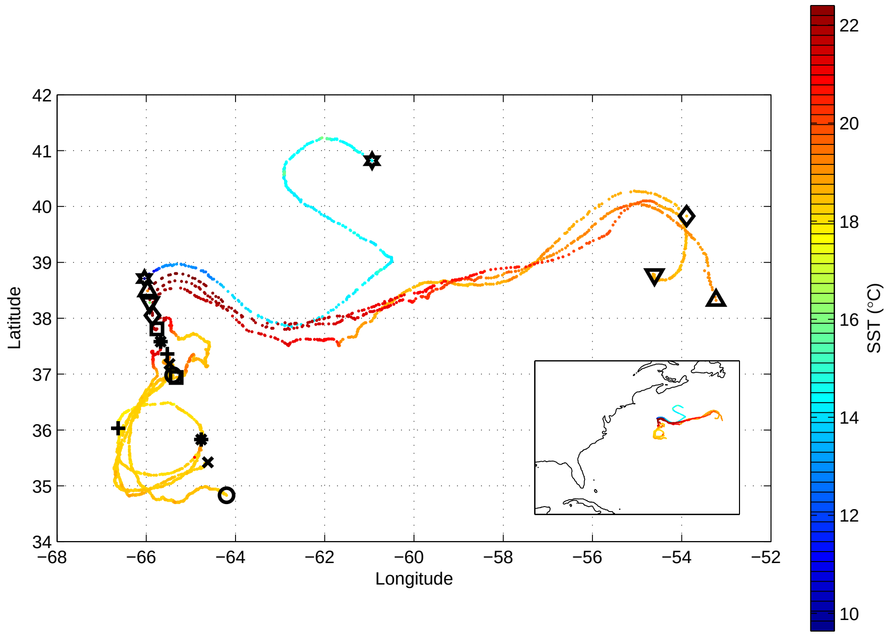


Fig. 15. Leg 2 drifter tracks, with SST shown as color. The drifters were deployed in trios, at the 9 southernmost stations of a hydrographic line across the Gulf Stream. The deployment sites and locations as of March 20, 2007 of one drifter from each trio are marked with matching black symbols.

Bobbers

Bobbers are Autonomous Profiling Expendable Floats (APEX floats) with TD-RAFOS instrumentation and a modified sampling program. Eight of these floats were deployed during the second leg (KN188-2) of the March 2007 CLIMODE Cruise. They are referred to here as Bobbers 7 through 14 to distinguish them from the six deployed during the first leg of the cruise (KN188-1).

Each bobber was equipped with a RAFOS hydrophone and a Sea Scan TD (temperature and pressure) sensor. Bobbers make temperature-depth profiles and are acoustically tracked underwater using the arrival time from several sound sources located on subsurface moorings deployed during the November 2005 CLIMODE cruise (OC419). The bobbers are programmed to seek the 18.5-degree isotherm, which is the nominal center of the mode water. They adjust their buoyancy to follow this isotherm. Each day the floats spend 120 minutes, starting at 00:00:00 GMT, listening for acoustic pings from the source moorings. Once every three days the floats bob between the 17-degree isotherm or the 700 dbar isobar, whichever is shallower, and the 20-degree isotherm or the surface in order to determine the thickness of the mode water. Every 30 days the floats are programmed to make a deeper profile from 1000 dbar to the surface. While at the surface, position and temperature profile data are transmitted via Argos.

As instructed in the APEX manual each float was reset before launch and completed the auto test. Each bobber was then deployed at a CTD station as the ship speed through the water approached 2 knots, immediately following the CTD cast. Bobbers were lowered gently into the water by slipping a line through the dampening ring as suggested by the manufacturer.

The deployment locations and dates are shown in Fig. 16. Bobber 7 was deployed at CTD station 31, in a cyclonic eddy. Bobbers 8-11 were deployed at alternating CTD stations (station numbers 32, 34, 36, and 38) along a hydrographic line. Stations in the core of the Gulf Stream and to the north were omitted. Bobbers 12 and 14 were deployed near subsurface moorings, at CTD stations 12 and 14 respectively, and Bobber 13 at the southernmost CTD station (49) of another hydrographic line across the Gulf Stream.

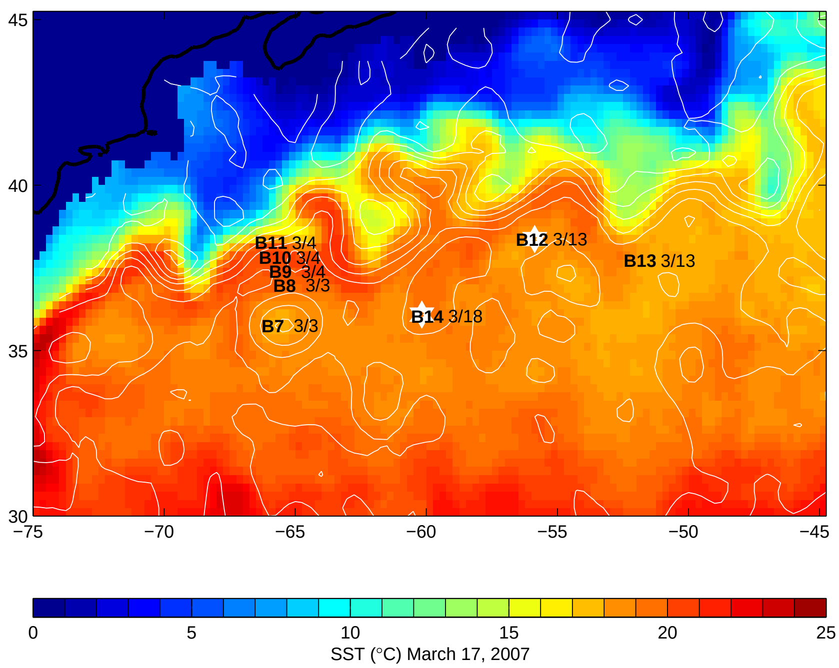


Figure. 16. Leg 2 bobber deployment locations (marked **B7** through **B14**) and dates. Also shown are satellite observations of SST (color) and sea surface height (white contours) on March 17, 2007, and the locations of subsurface hydrographic moorings (stars).

Students - Beatriz Pena-Molino, Katie Silverthorne, Otmar Olsina, Apurva Dave, Neven-Stjepan Fuckar

Beatriz, Katie, Otmar, and Neven joined the Knorr 188-2 in Bermuda on March 2nd and Apurva joined the cruise on March 6th. The goal of our participation on the CLIMODE4 cruise was to gain insight into oceanographic field studies, specifically measurements of the developing physical and chemical properties of the North Atlantic Subtropical Mode Water during its formation. We were involved with CTD casts and Seasoar surveys, as well Radiosonde launches and EM-Apex/ bobber float, and surface drifter deployments. We participated in several tasks associated with each instrument, including deployment and recovery operations on deck, water sampling, and console operations. Students gained appreciation for the difficulties that are inherent in field research, as well as developing a better understanding of the variable quality of observational data. One of the aspects that we did not anticipate was the required flexibility of the cruise plan. We learned how the decision making process has to be responsive to marine and atmospheric conditions, instrument performance, and shifting scientific goals. We observed collaborations between different scientific disciplines, including meteorological radiosonde deployments in coordination with CTD casts.

As a result of the combined work of the shipboard crew, and despite the uncertainties involved in the data acquisition, we were able to clearly observe evidence of upper ocean processes. These included shelf water intrusions much further south than anticipated, and the presence of deep mixed layers.

Table 1, Cruise Personnel

NAME (M/F)	INST/Responsibilty	EMAIL
Terry Joyce (M)	whoi/chief scientist	tjoyce@whoi.edu
Dave Fratantoni (M)	whoi/ bobbers/drifters	dfratantoni@whoi.edu
Frank Bahr (M)	whoi/ seasoar	fbahr@whoi.edu
John Toole (M)	whoi/ ASIS	jtoole@whoi.edu
George Tupper (M)	whoi/seasoar	gtupper@whoi.edu
Dave Wellwood(M)	whoi/seasoar	dwellwood@whoi.edu
Jane Dunworth-Baker (F)	whoi/watchstander/sat imagery	jdunworth@whoi.edu
Leif Thomas (M)	whoi/ watchleader	lthomas@whoi.edu
Jim Edson (M)	uconn/ASIS/shipmet,radiosondes	james.edson@uconn.edu
Jonathan Ware(M)	ASIS/FILIS	jware@whoi.edu
Neil McPhee (M)	whoi/ASIS	nmcphee@whoi.edu
Andreas Andersson (M)	DIC	aj@soest.hawaii.edu
Katie Silverthorne (F)	whoi/mit	ksilverthorne@whoi.edu
Beatriz Pena-Molino (F)	whoi/mit	bpena-molino@whoi.edu
Charles Bartlett (M)	uscg/watchstander/deck	cbartlett2@healy.uscg.mil
Christopher Schmidt	sio/ctd/hydro	cschmidt@gergx.gerg.tamu.edu
John Calderwood (M)	sio/ctd/oxygen	jkc@odf.ucsd.edu
Parisa Nahavandi (F)	sio/ctd/data/salinity	parisa@odf.ucsd.edu
Meghan Donohue (F)	sio/ctd	mkdonohue@ucsd.edu
Laura Tudor (F)	ucar/radiosondes	tudor@ucar.edu
Bill Brown (M)	ucar/radiosondes	wbrown@ucar.edu
Ben Hodges (M)	whoi/floats	bhodges@whoi.edu
Otmar Olsina (M)	fsu/watchstander	olsina@ocean.fsu.edu
Neven-Stjepan Fuckar (M)	princeson/watchstander	nevensf@princeton.edu
Rich Layman (M)	uscg/watchstander/deck	rlayman@healy.uscg.mil
Apurva Dave (m)	duke/nutrients	apurva.dave@duke.edu

Table 2, Kn188-2 Event Log

% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
%										
20070302	1300	34	19.64	-61	19.11	0	0	%	watch	depart Bermuda
20070303	0010	34	19.58	-65	14.53	2	1	%	bb/lt	radiosonde #1
20070303	0843	35	45.40	-65	51.43	3	7	%	df	bobber at 200nm limit
20070303	1200	36	00.00	-65	54.99	2	2	%	bb/lt	radiosonde #2
20070303	1230	35	59.98	-65	59.91	1	31	%	jt/tj	start ctd 31 sargasso h20 for chem/bio
20070303	1332	35	59.17	-65	59.89	0	0	%	tj	end ctd 31
20070303	1920	36	53.20	-65	28.30	0	0	%	je	climb bow mast to repair humidity sensor
20070303	1950	36	59.10	-65	24.90	2	3	%	bb/lt	radiosonde #3
20070303	2000	36	59.11	-65	24.84	1	32	%	watch	start ctd 32 sftwr issues start=2018
20070303	2155	36	58.59	-65	24.33	0	0	%	watch	end ctd 32
20070303	2202	36	58.50	-65	24.40	4	1	%	df/bh	drifters 72070,72062,72050
20070303	2202	36	58.5	-65	24.4	3	8	%	df/bh	bobber #8
20070303	2332	37	11.46	-65	29.58	1	33	%	watch	start ctd 33
20070304	0045	37	11.22	-65	28.97	0	0	%	watch	end ctd 33
20070304	0052	37	11.10	-65	28.90	4	2	%	bh/lt	drifters 72074,72073,72071
20070304	0200	37	20.40	-65	33.40	2	4	%	lt	fabulous radiosonde launch
20070304	0241	37	23.82	-65	55.01	1	34	%	watch	start ctd 34
20070304	0357	37	23.52	-65	34.40	0	0	%	watch	end ctd 34
20070304	0405	37	23.5	-65	34.9	4	3	%	df	drifters 72051,72052,72053
20070304	0405	37	23.50	-65	34.9	3	9	%	df	bobber #9
20070304	0705	37	34.9	-65	40.5	2	5	%	bb/lt	radiosonde, good launch
20070304	0552	37	36.14	-65	40.84	1	35	%	df	start ctd 35
20070304	0707	37	34.94	-65	40.83	0	0	%	df	end ctd 35
20070304	0714	37	34.76	-65	40.82	4	4	%	df	drifters 72061,72072,72054
20070304	0901	37	48.78	-65	46.10	1	36	%	df	start ctd 36
20070304	1009	37	48.95	-65	45.87	0	0	%	df	end ctd 36
20070304	1018	37	49.04	-65	46.04	4	5	%	df	drifters 72120,72121,72125

20070304	1048	37	49.04	-65	46.04	3	10	%	df	bobber #10
20070304	1136	38	01.31	-65	51.66	1	37	%	df	start ctd 37
20070304	1350	38	14.08	-65	57.15	0	0	%	df	end ctd 37
20070304	1205	38	01.7	-65	51.5	2	6	%	bb/lt	radiosonde, cloudy with showers
20070304	1300	38	01.7	-65	51.7	4	5	%	bh	drifters 72060,72063,72064
20070304	1350	38	14.19	-65	07.05	1	38	%	tj	start ctd 38
20070304	1616	38	26.51	-66	02.07	0	0	%	tj	end ctd 38
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070304	1425	38	15.06	-65	56.2	2	7	%	je/lt	radiosonde,nice weather, missing <600m profile
20070304	1500	38	15.92	-65	55.48	4	6	%	bh	drifters 72115,72116,72123
20070304	1500	38	15.92	-65	55.48	3	11	%	dh	bobber #11
20070304	1618	38	27.10	-66	01.99	1	39	%	tj	start ctd 39
20070304	1723	38	28.37	-65	59.51	0	0	%	tj	end ctd 39
20070304	1728	38	28.45	-65	59.37	4	7	%	bh	drifters 72114,72117,72119
20070304	1750	38	28.50	-65	59.40	2	8	%	lt/bb	radiosonde, good launch
20070304	1904	38	39.04	-66	07.35	1	40	%	tj	start ctd 40
20070304	2005	38	39.30	-66	06.28	0	0	%	th	end ctd 40
20070304	2010	38	39.10	-66	07.10	4	8	%	bh	drifters 72118,72122,72124
20070304	2138	38	51.13	-66	13.40	1	41	%	jt	start ctd 41
20070304	2216	38	50.6	-66	13.0	2	9	%	bb/lt	radiosonde, thanks chuck
20070304	2237	38	50.83	-66	12.96	0	0	%	jt	end ctd 41
20070305	0013	39	03.69	-66	19.06	1	42	%	jt	start ctd 42
20070305	0020	39	03.20	-66	19.0	2	10	%	lt/je	radiosonde, nice, thanks jim
20070305	0113	39	02.88	-66	19.12	0	0	%	jt	end ctd 42
20070305	0257	39	16.05	-66	24.76	1	43	%	jt	start ctd 43
20070305	0451	39	15.65	-66	25.34	0	0	%	jt	end ctd 43
20070305	1229	38	05.94	-65	56.45	9	2	%	jt	launch EM 1633
20070305	1229	38	05.94	-65	56.45	2	11	%	bb/lt	radiosonde, fab
20070305	1350	38	16.5	-66	08.0	2	12	%	lt/bb	radiosonde, nice, filmed
20070305	1545	38	27.6	-66	26.3	2	13	%	bb/je	radiosonde, filmed
20070305	2349	39	17.0	-67	36.5	2	14	%	bb/lt	radiosonde, good launch
20070306	0000	39	17.0	-67	36.5	0	0	%	watch	head to woods hole, injured mate

20070308	0945	38	55.5	-64	20.00	8	1	%	df	seasoar launched, grid 1
20070308	0951	38	55.5	-64	20.0	2	15	%	bb/lt	radiosonde , thanks jim
20070308	1254	40	41.8	-64	33.10	2	16	%	lt	radiosonde, thanks jim & john
20070308	1539	38	25.44	-64	46.20	2	17	%	lt	radiosonde, thanks jim & john
20070308	1806	38	08.0	-65	00.0	2	18	%	bb/je	radiosonde, thanks jim & chuck
20070308	2001	38	01.5	-64	47.1	2	19	%	bb	radionsonde, off starboard
20070308	2253	38	19.50	-64	32.6	2	20	%	lt/jw	radiosonde
20070309	0152	38	35.3	-64	20.0	2	21	%	lt/jw	radiosonde
20070309	0608	38	37.0	-64	00.2	2	22	%	bb/je	radionsonde
20070309	1258	37	53.5	-64	38.3	2	23	%	bb/lt	radiosonde
20070309	1540	37	56.60	-64	16.0	2	24	%	bb/lt	radiosonde
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070309	1954	37	51.1	-63	00.7	2	25	%	bb/jJ	radiosonde
2007039	2344	37	47.3	-61	48.3	2	26	%	lt/je	radiosonde
20070310	0031	37	47.33	-61	47.79	1	44	%	jt	start ctd 44
20070310	0133	37	47.93	-61	45.59	0	0	%	jt	end ctd 44
20070310	0242	37	57.28	-61	47.28	1	45	%	jt	start ctd 45
20070310	0245	37	57.3	-61	47.3	2	27	%	lt/je	radiosonde, very calm
20070310	0356	37	59.27	-61	43.34	0	0	%	jt	end ctd 45
20070210	0627	37	39.1	-61	48.0	1	46	%	df	start ctd 46
20070310	0741	37	37.43	-61	46.32	0	0	%	df	end ctd 46
20070310	0642	37	39.1	-61	42.5	2	28	%	lt/je	radiosonde, very calm
20070310	1233	37	48.6	-60	32.6	2	29	%	bb/jw	radiosonde
20070310	1640	37	58.9	-59	30.7	2	30	%	bb/jw	radiosonde, well done john
20070310	2103	38	06.5	-58	25.5	2	31	%	bb/jw	radiosonde
20070310	2134	38	07.55	-58	24.32	8	2	%	fb/tj	launch seasoar grid 2
20070310	2354	38	25.7	-58	21.9	2	32	%	bb/je	radiosonde
20070311	0245	38	49.2	-58	18.6	2	33	%	lt/le	radiosonde, sweet as pie
20070311	0541	39	12.8	-58	15.4	2	34	%	lt/je	radiosonde,fine as frog hair
20070311	0845	39	06.4	-57	57.0	2	35	%	lt	radiosonde
20070311	1154	38	46.1	-57	59.2	2	36	%	lt/bb	radiosonde, close one
20070311	1452	38	24.9	-58	01.6	2	37	%	bb/jj	radiosonde

20070311	1758	38	06.10	-57	55.6	2	38	%	bb/j2	radiosonde, a bit hairy
20070312	1056	39	21.7	-57	30.44	0	0	%	df	seasoar recovered
20070312	1122	39	22.08	-57	29.73	1	47	%	df/tj	start ctd 47
20070312	1152	39	22.1	-57	29.0	2	39	%	bb/jw	radiosonde
20070312	1226	39	22.21	-57	28.59	0	0	%	tj	end ctd 47
20070312	1515	39	17.7	-56	58.7	2	40	%	bb/j2	radiosonde
20070312	1655	39	19.62	-56	48.67	0	0	%	tj	em-apex 1633 recovered
20070312	1750	39	10.8	-56	39.1	2	41	%	bb/j2	radiosonde
20070312	2328	38	21.78	-55	57.28	1	48	%	jt	start ctd 48
20070313	0004	38	22.0	-55	57.7	2	42	%	je/b2/jw	radiosonde, lovely
20070313	0029	39	22.16	-55	58.12	0	0	%	jt	end ctd 48
20070313	0034	38	22.23	-55	58.26	3	12	%	bh	bobber
20070313	0600	38	14.2	-54	41.0	2	43	%	je/jw	radiosonde, a thing of beauty
20070313	1150	38	06.8	-53	17.5	2	44	%	lt/bb	radiosonde, lost gps
20070313	1747	37	46.4	-51	55.7	2	45	%	bb/lt	radiosonde
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070313	1833	37	43.52	-51	49.78	1	49	%	tj	start ctd 49
20070313	2008	37	43.61	-51	51.15	0	0	%	tj	end ctd 49
20070313	2014	37	43.67	-51	51.24	3	13	%	bh	bobber
20070313	2043	37	50.8	-51	52.2	2	46	%	lt	radiosonde
20070313	2139	37	57.80	-51	52.82	1	50	%	jt	start ctd 50
20070313	2232	37	57.95	-51	53.26	0	0	%	jt	end ctd 50
20070313	2351	38	00.9	-51	56.0	2	47	%	lt/je	radiosonde
20070313	2353	38	09.27	-51	56.00	1	51	%	jt	start ctd 51
20070314	0048	38	09.73	-51	56.18	0	0	%	jt	end ctd 51
20070314	0221	38	23.34	-51	59.01	1	52	%	jt	start ctd 52
20070314	0314	38	23.99	-51	58.58	0	0	%	jt	end ctd 52
20070314	0300	38	23.34	-51	59.01	2	48	%	lt.le	radiosonde
20070314	0451	38	38.04	-52	02.07	1	53	%	df/ap	start ctd 53
20070314	0608	38	39.5	-52	00.5	2	49	%	je/bb	radiosonde
20070314	0615	38	39.36	-52	00.52	0	0	%	df	end ctd 53
20070314	0800	38	52.15	-52	05.29	1	54	%	df	start ctd 54

20070314	0855	38	53.2	-52	03.1	2	50	%	jw	radiosonde
20070314	0916	38	53.51	-52	02.79	0	0	%	df	end ctd 54
20070314	1055	39	06.28	-52	08.77	1	55	%	df	start ctd 55
20070314	1155	39	06.6	-52	08.8	2	51	%	bb/jw	radiosonde
20070314	1158	39	06.67	-52	08.80	0	0	%	df	end ctd 55
20070314	1330	39	20.68	-52	12.00	1	56	%	tj	start ctd 56
20070314	1430	39	20.73	-52	11.95	0	0	%	tj	end ctd 56
20070314	1529	39	30.7	-52	14.8	2	52	%	je/jw	radiosonde
20070314	1610	39	35.03	-52	15.61	1	57	%	tj	start ctd 57
20070314	1712	39	35..38	-52	16.06	0	0	%	tj	end ctd 57
20070314	1744	39	40.5	-52	16.5	2	53	%	lt/je/bb	radiosonde
20070314	1851	39	49.39	-52	18.47	1	58	%	tj	start ctd 58
20070314	1954	39	49.88	-52	18.86	0	0	%	tj	end ctd 58
20070314	2045	39	57.5	-52	20.6	2	54	%	lt/je/bb	radiosonde, not shorts weather
20070314	2134	40	03.64	-52	21.92	1	59	%	jt	start ctd 59, end of line
20070314	2351	39	52.6	-52	32.6	2	55	%	bb/je	radiosonde
20070314	2302	40	03.92	-52	22.27	0	0	%	jt	end ctd 59
20070315	0303	39	41.0	-53	11.9	2	56	%	bb/je	radiosonde
20070315	0300	39	41.0	-53	13.0	0	0	%	fb	begin seasoar deployment
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070315	0401	39	40.68	-53	13.43	8	3	%	fb	seasoar deployed, grid 3
20070315	0546	39	28.7	-53	30.6	2	57	%	bb/je	radiosonde
20070315	0845	39	09.3	-53	58.2	2	58	%	lt	radiosonde, close one
20070315	1140	38	51.9	-54	14.1	2	59	%	lt/jw	radiosonde
20070315	1443	38	51.5	-53	53.4	2	60	%	lt/jw	radiosonde
20070315	1757	38	02.05	-53	37.04	2	61	%	bb/fb/je	radiosonde
20070315	2051	39	12.9	-53	21.9	2	62	%	bb/je	radiosonde
20070315	2358	39	23.0	-53	07.2	2	63	%	bb/je	radiosonde, still good relative
20070316	0253	39	24.7	-53	04.4	2	64	%	lt/je	radiosonde, with style
20070316	0545	39	21.2	-52	46.7	2	65	%	lt/je	radiosonde
20070316	0845	39	05.7	-53	05.0	2	66	%	lt/jw	radiosonde
20070316	1146	38	47.1	-53	31.9	2	67	%	lt/bb/jw	radiosonde

20070316	1452	38	27.9	-53	59.4	2	68	%	bb/j2	radiosonde
20070316	1630	38	22.94	-54	10.86	0	0	%	fb	start seasoar recovery
20070316	1750	38	24.88	-54	11.96	2	69	%	bb/j2	radiosonde
20070316	1755	38	24.67	-54	11.99	1	60	%	watch	start ctd 60
20070316	1853	38	24.11	-54	13.05	0	0	%	watch	end ctd 60
20070316	2357	38	28.7	-54	23.0	2	70	%	bb/je	radiosonde, tranquil
20070317	0138	37	13.27	-54	24.8	1	61	%	watch	start ctd 61
20070317	0236	37	14.12	-54	24.87	0	0	%	watch	end ctd 61
20070317	0550	38	45.4	-54	44.9	2	71	%	lt	radiosonde, straight up
20070317	1134	35	53.4	-55	24.7	2	72	%	lt/bb	radiosonde, straight up
20070317	1755	36	07.9	-56	01.9	2	73	%	bb.je	radiosonde
20070317	2226	36	48.80	-56	20.29	1	62	%	jt	start ctd 62
20070317	2319	36	48.49	-56	20.39	0	0	%	jt	end ctd 62
20070317	2350	36	47.0	-56	26.3	2	74	%	bb/je	radiosonde
20070318	0250	36	38.3	-57	05.75	2	75	%	lt/je	radiosonde
20070318	0555	36	31.3	-57	50.8	2	76	%	lt/le	radiosonde, Wx getting worse
20070318	0753	36	26.87	-58	13.46	1	63	%	df	start ctd 63
20070318	0845	36	26.83	-58	13.56	2	77	%	lt/jw	radiosonde
20070318	0900	36	26.83	-58	13.57	0	0	%	df	end ctd 63
20070318	1153	36	19.06	-58	51.91	2	78	%	lt/bb	radiosonde
20070318	1755	36	11.9	-59	51.6	2	79	%	bb/je	radiosonde
20070318	2050	36	00.1	-60	04.0	2	80	%	bb/jj	radiosonde
20070319	0005	36	44.1	-60	41.2	2	81	%	bb/je	radiosonde
20070318	1903	36	04.42	-59	58.22	1	64	%	tj/jt	start ctd 64
20070318	2008	36	03.32	-59	57.58	0	0	%	jt	end ctd 64
% 1=ctd	2=radiosond	3=bobber	4=drifter	5=asis	6=amp	7=float	8=seasoar	9=em-apex		
%	GMT	lat	latdeg	lon	londeg	event	incrment	comment	who	activity
20070318	2020	36	02.6	-59	58.1	3	14	%	df	bobber #14, last one
20070319	0203	35	35.46	-60	59.92	1	65	%	jt	start ctd 65
20070319	0257	35	35.68	-61	35.68	0	0	%	jt	end ctd 65
20070319	0542	35	22.3	-61	28.3	2	82	%	lt/je	radiosonde, very windy
20070319	0905	35	06.04	-62	00.98	1	66	%	df	start ctd 66
20070319	1024	35	05.81	-62	01.06	0	0	%	df	end ctd 66

20070319	1144	35	14.5	-62	10.4	2	83	%	bb/lt	radiosonde
20070319	1750	35	59.5	-62	50.8	2	84	%	bb/j2	radiosonde
20070319	1836	36	04.01	-62	55.28	1	67	%	bpm	start ctd 67
20070319	1944	36	03.85	-62	56.56	0	0	%	bpm	end ctd 67
20070319	2356	35	58.5	-63	49.1	2	85	%	bb/j2	radiosonde
20070320	0326	35	53.68	-64	34.21	1	68	%	df	start ctd 68
20070320	0451	35	53.59	-64	34.22	0	0	%	df	end ctd 68
20070320	0546	35	54.33	-64	46.30	2	86	%	lt/je	radiosonde
20070320	1145	35	42.2	-66	02.3	2	87	%	lt/bb/jw	radiosonde
20070320	1526	35	29.13	-66	46.18	1	69	%	tj	start ctd 69
20070320	1628	35	27.94	-66	45.69	0	0	%	tj	end ctd 69
20070320	1755	35	40.7	-66	53.8	2	88	%	bb/j2	radiosonde
20070320	2102	36	11.7	-67	13.1	2	89	%	je/bb	radiosonde
20070320	2337	36	32.80	-67	29.69	1	70	%	jt	start ctd 70
20070320	2350	36	32.9	-67	29.7	2	90	%	bb/j2	radiosonde
20070321	0031	36	33.72	-67	30.04	0	0	%	jt	end ctd 70
20070321	0253	36	55.3	-67	45.4	2	91	%	lt./je/cb	radiosonde
20070321	0550	37	25.7	-68	08.9	2	92	%	lt/je/rl	radiosonde
20070321	0845	37	50.84	-68	29.22	1	71	%	df	start ctd 71
20070321	0855	37	50.81	-68	29.93	2	93	%	lt/jw	radiosonde
20070321	1037	37	50.86	-68	30.17	0	0	%	df	end ctd 71
20070321	1146	38	00.94	-68	37.11	2	94	%	lt/bb/jw	radiosonde
20070321	1453	38	27.9	-68	54.9	2	95	%	bb/j2	radiosonde
20070321	1748	38	56.2	-69	15.5	2	96	%	bb/j2	radiosonde
20070321	2054	39	28.0	-69	36.6	2	97	%	bb.j2	radiosonde
20070321	2350	39	58.6	-70	00.00	2	98	%	bb/je	radiosonde, calm
20070322	0246	40	30.73	-70	23.63	2	99	%	lt/je/jw	radiosonde
20070322	1142	41	03.92	-70	47.7	2	100	%	lt/bb/je/jw	radiosonde, #100!!!
20070322	1700					0	0	%	jd	dock woods hole

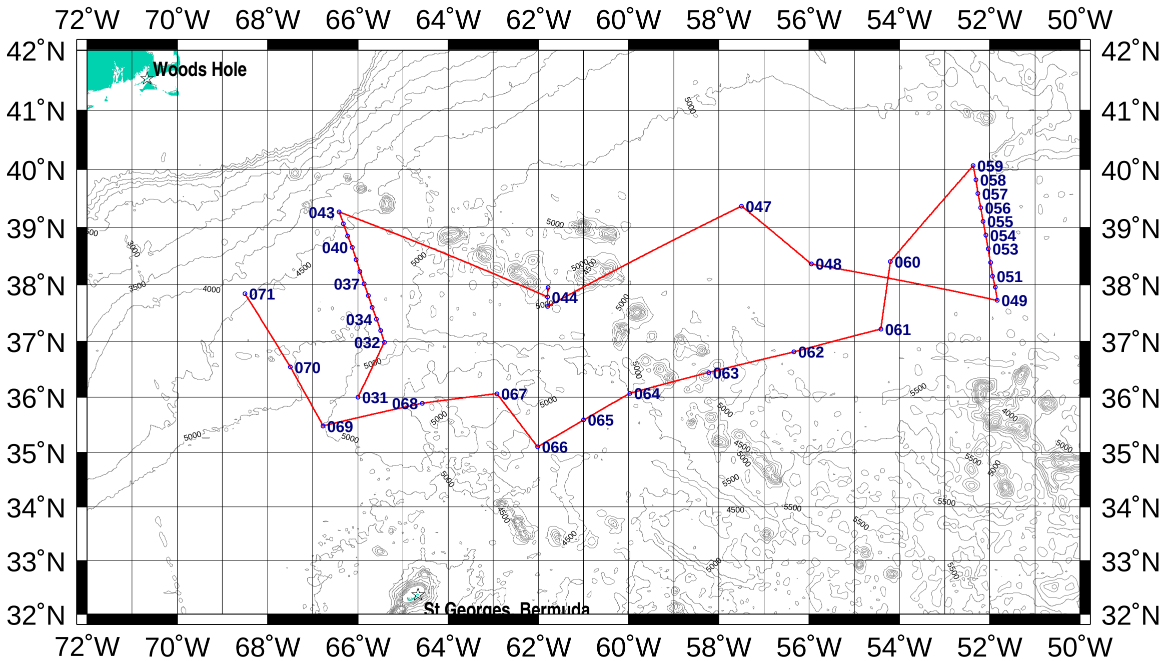
CLIMODE-4 Leg 2

R/V KNORR, KN188-2

02 March 2007 - 21 March 2007

St.Georges, Bermuda - Woods Hole, MA

Chief Scientist: Terrence M. Joyce, WHOI



CLIMODE4 Cruise Track 2007-03-23 14:17

Appendix 1, CTD/Hydro Data Report
22 March 2007

Data Submitted by:

Shipboard Technical Support

Oceanographic Data Facility / Shipboard Electronics Group

Susan M. Becker, Mary C. Johnson, Parisa Nahavandi / John K. Calderwood

Scripps Institution of Oceanography

La Jolla, Ca. 92093-0214

Summary

A hydrographic survey consisting of CTD/rosette sections across the Gulf Stream was carried out during February/March 2007. The R/V Knorr departed St.Georges, Bermuda on 02 March 2007. A total of 42 CTD/rosette stations were occupied. An ODF 24-bottle rosette was used successfully during the entire survey. CTD data plus water samples for oxygen, salinity, nutrient and DIC/Total Alkalinity analyses were collected on each cast to 1000 meters, or to 2000 meters for casts on either end of two lines of stations across the Gulf Stream. The cruise ended in Woods Hole, Massachusetts on 21 March 2007.

Description of CTD/Hydrographic Measurement Techniques (*SIO/STS/ODF+SEG*)

1. CTD/Hydrographic Measurements Program

The basic CTD/hydrographic measurements consisted of salinity, dissolved oxygen and nutrient measurements made from water samples taken on CTD/rosette casts, plus pressure, temperature, salinity, and dissolved oxygen from CTD profiles. Nutrients were frozen and stored for analysis ashore.

A total of 30 CTD/rosette casts were made: 26 casts to 1000m and 4 casts to 2000m depth. Samples were drawn from 603 bottles out of 688 attempted trips during the casts. The distribution of samples is illustrated in Figures 1.0-1.2.

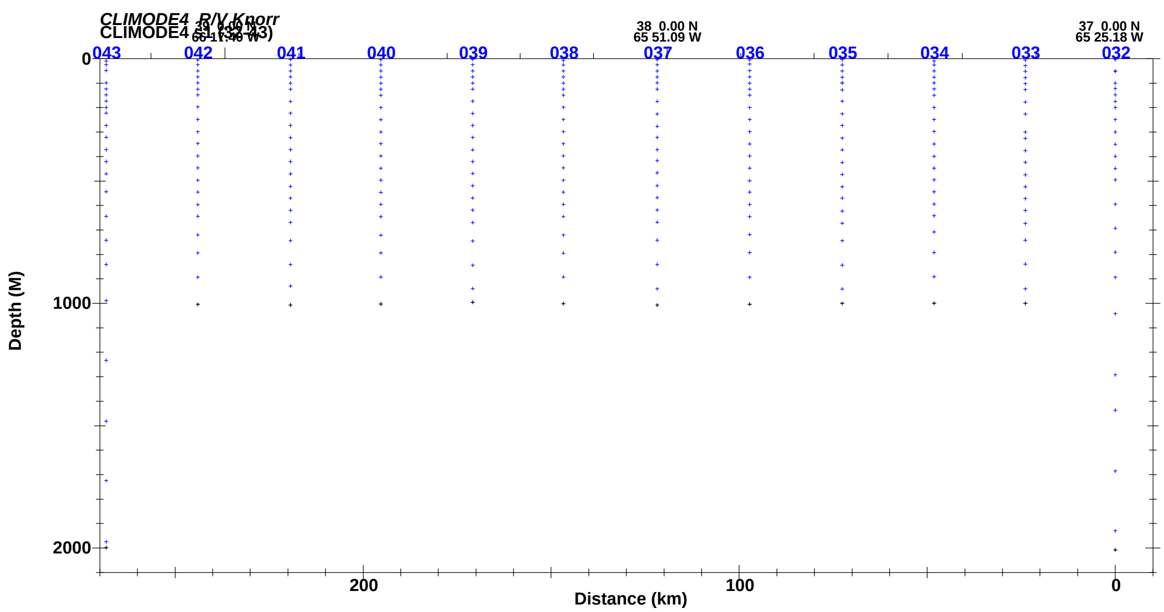


Figure 1.0 Sample distribution, Line 1, stations 32-43.

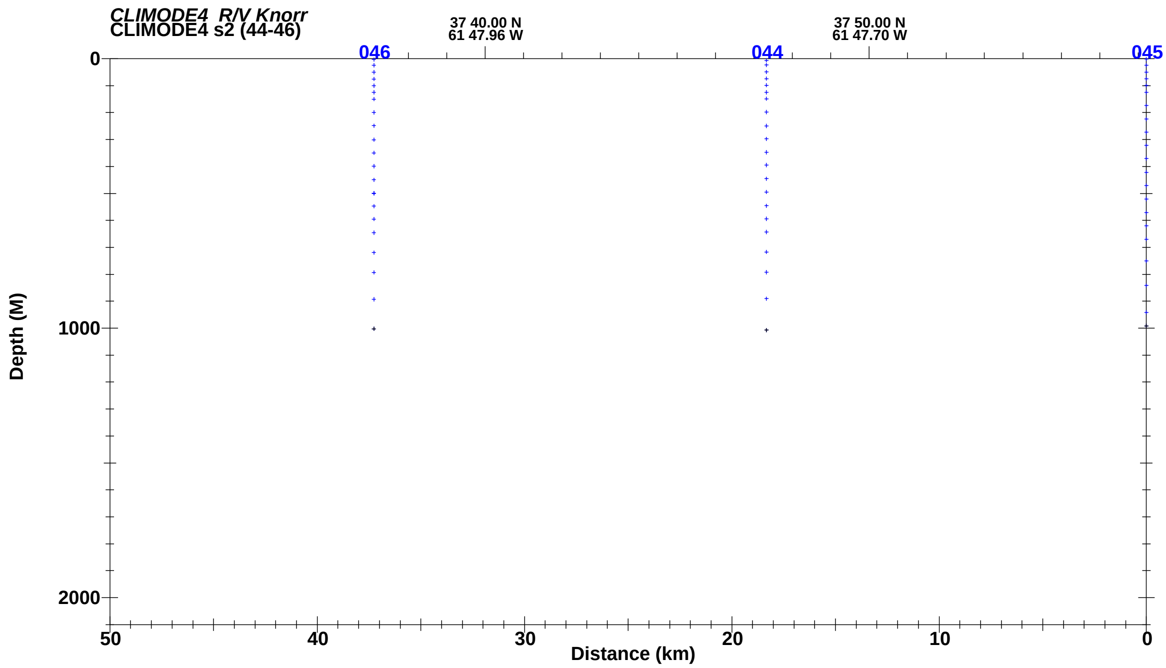


Figure 1.1 Sample distribution, Line 2, stations 44-46.

Figure 1.1 Sample distribution, Line 2, stations 49-59.

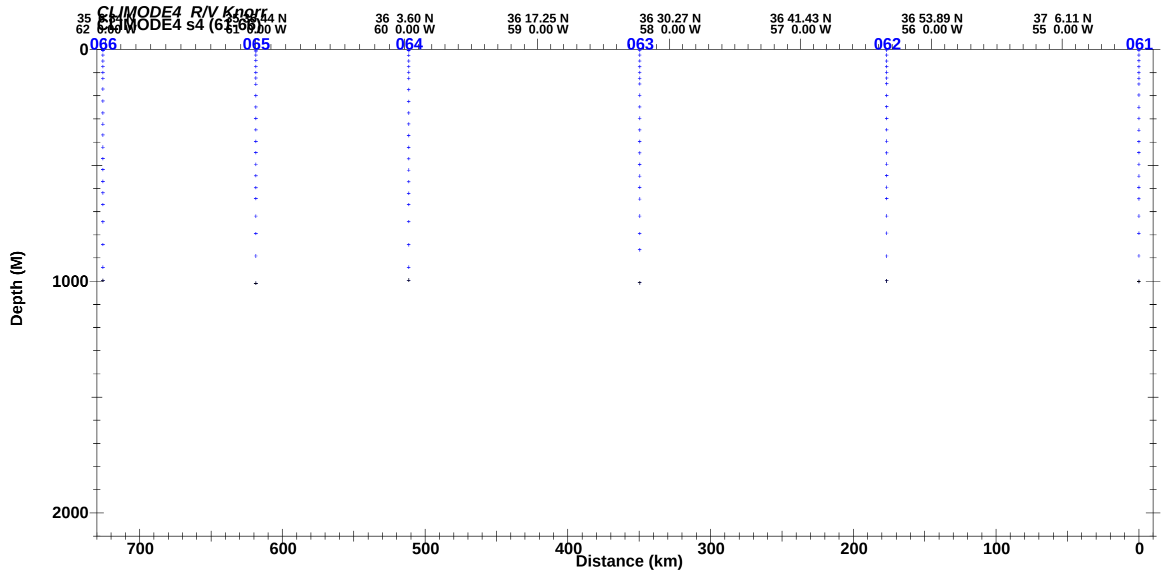


Figure 1.2 Sample distribution, stations 61-66.

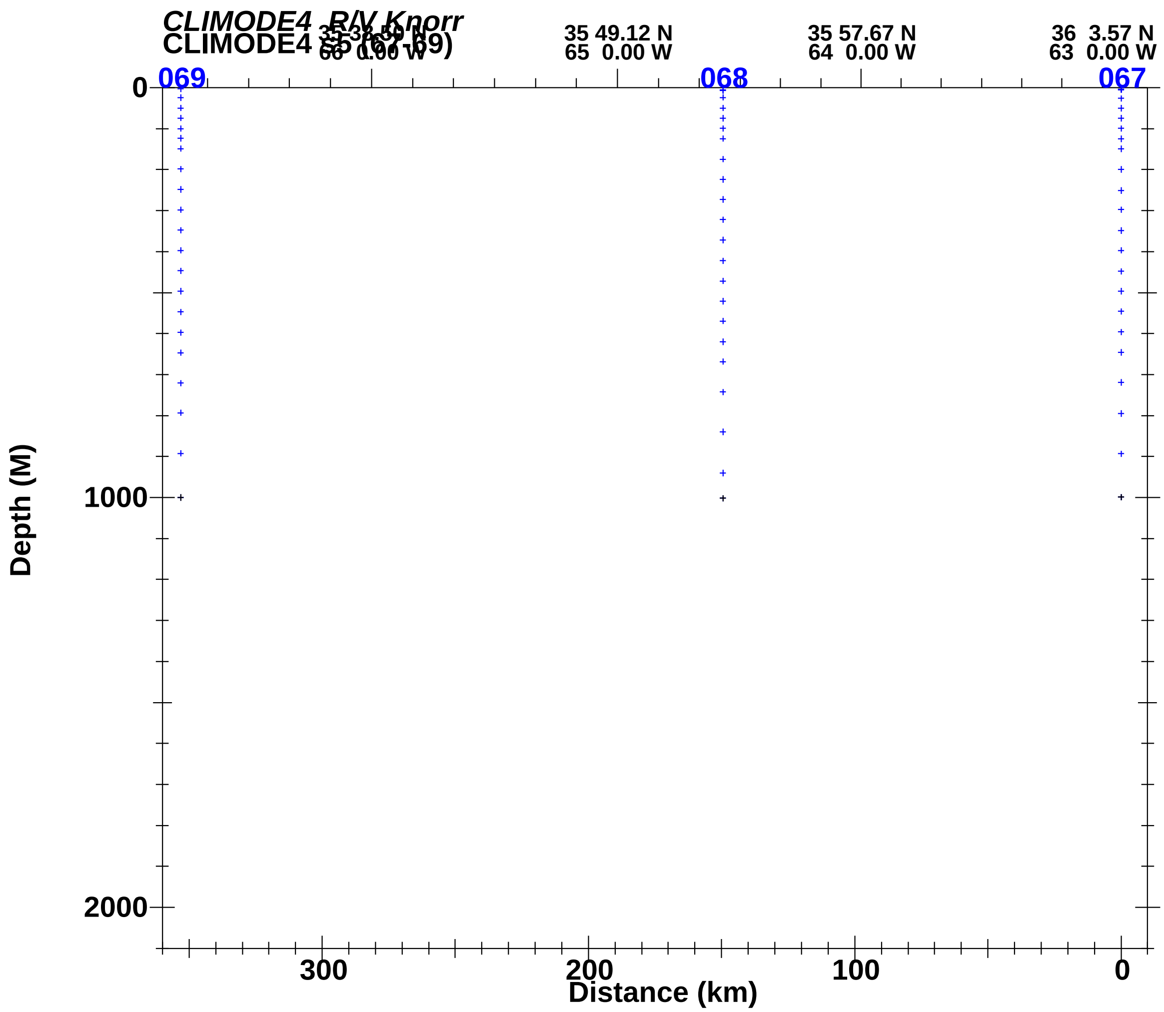


Figure 1.2 Sample distribution, Other stations 67-69.

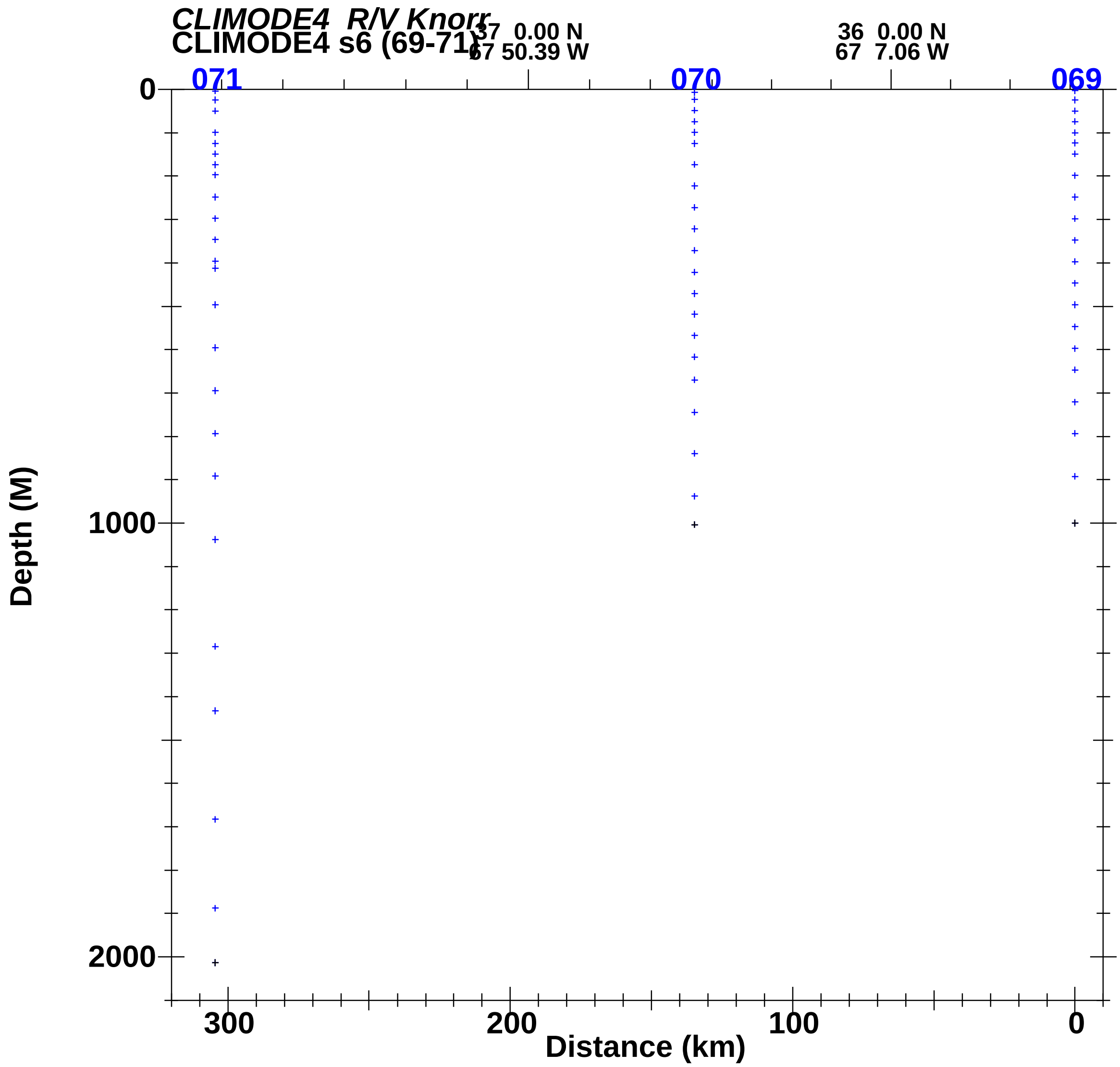


Figure 1.2 Sample distribution, Other stations 69-71.

1.1. Water Sampling Package

CTD/rosette casts were performed with a package consisting of a 24-bottle rosette frame (ODF), a 24-place pylon (SBE32) and 24 10-liter Bullister bottles (ODF). Underwater electronic components consisted of a Sea-Bird Electronics (SBE) 9*plus* CTD (ODF #878) with dual pumps, dual temperature (SBE3*plus*), dual conductivity (SBE4), dissolved oxygen (SBE43); an SBE35RT Digital Reversing Thermometer; a Seapoint Chlorophyll Fluorometer (SCF) and Simrad altimeter (807). An experimental "GCTD" (for Ray Schmitt) was also mounted in the rosette frame.

The CTD was mounted vertically in an SBE CTD frame attached to the bottom center of the rosette frame. The SBE4 conductivity and SBE3*plus* temperature sensors and their respective pumps were mounted vertically as recommended by SBE. Pump exhausts were attached to inside corners of the CTD cage and directed downward. The entire cage assembly was then mounted on the bottom ring of the rosette frame, offset from center to accommodate the pylon, and also secured to frame struts at the top. THE SBE35RT sensor was mounted vertically, between the CTD temperature sensors, at the same level. The fluorometer was mounted to the CTD, pointing vertically downward, approximately 5cm above the bottom plane of the package. The altimeter was mounted to the outside of the bottom frame ring.

The rosette system was suspended from a UNOLS-standard three-conductor 0.322" electro-mechanical sea cable. The R/V Knorr’s starboard-side Markey winch was used for all casts. Sea cable reterminations were made prior to casts 2/1 (at slip-rings and rosette) and 27/1 (at rosette only).

The deck watch prepared the rosette 10-20 minutes prior to each cast. The bottles were cocked and all valves, vents and lanyards were checked for proper orientation. Once stopped on station, the rosette was moved into position under the starboard-side squirt boom using an air-powered cart and tracks. The CTD was powered-up and the data acquisition system in the main lab started when directed by the deck watch leader. Tag lines were threaded through the rosette frame, syringes were removed from the CTD intake ports and the "GCTD" was powered on. The winch operator was directed by the deck watch leader to raise the package, the boom and rosette were extended outboard and the package quickly lowered into the water. The tag lines were removed and the package was lowered to 10 meters, by which time the sensor pumps had turned on. The winch operator was directed to bring the package back to the surface (0 winch wire-out) and to begin descent. Each rosette cast was lowered to 1000m (or 2000m at either end of the two transects).

The winch operator was directed to stop at each bottle trip depth on the up cast. The CTD console operator waited 10 seconds before tripping a bottle to insure the package wake had dissipated and the bottles were flushed, then an additional 10 seconds after receiving the trip confirmation to allow the SBE35RT temperature sensor time to make a measurement. Then the winch operator was directed to proceed to the next bottle stop. Four sets of standard sampling depths (two each for 1000m and 2000m casts) were used alternately throughout CLIMODE-4 LEG 2.

Recovering the package at the end of the deployment was essentially the reverse of launching, with the additional use of poles and snap-hooks to attach tag lines, and air-tuggers on the tag lines for added safety and stability. The rosette was moved into the forward hangar for sampling. The bottles and rosette were examined before samples were taken, and anything unusual noted on the sample log.

Each bottle on the rosette had a unique identifier number. This bottle identification was maintained independently of the bottle position on the rosette, which was used for sample identification.

Routine CTD maintenance included soaking the conductivity and DO sensors in fresh water between casts to maintain sensor stability. The sensors were stored dry before the first cast due to extremely cold temperatures, and occasionally stored with standard seawater instead of fresh water during the cruise as air temperatures warranted.

Rosette maintenance was performed on a regular basis. O-rings were changed as necessary and bottle maintenance was performed each day to insure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed. Occasionally the carousel "top hat" was removed to clean solenoid faces and latches or polish the action to deal with bottle triggering issues.

All of the O-rings on bottle 2 were changed before station 26 as a possible solution to abnormally high differences between CTD and bottle values for dissolved oxygen and salinity, observed on the 3 previous casts. The problem was more likely mis-tripping due to a carousel latch problem, since high differences or no trip at position 2 were noted on 3 of the next 4 casts.

The top ring of the rosette broke into 3 pieces (at welds) during initial deployment at station 11; no unusual forces were noted to cause this. The package was brought back aboard, the top rosette ring was removed (for the duration of the leg), and then re-deployed. Four top-ring scallops broke off at welds, and were re-fastened with hose clamps.

The cable between the altimeter and CTD was hooked during recovery at station 30, ultimately bending the connector on the altimeter. This is likely repairable, but the altimeter was removed after the cast in anticipation of more casts that were later canceled due to bad sea conditions.

1.2. Underwater Electronics Packages

CTD data were collected with a SBE9*plus* CTD. This instrument provided pressure, dual temperature (SBE3), dual conductivity (SBE4), dissolved oxygen (SBE43), fluorometer (Seapoint SCF) and altimeter (Simrad 807) channels. The CTD supplied a standard SBE-format data stream at a data rate of 24 Hz.

Sea-Bird SBE32 24-place Carousel Water Sampler	S/N 320
Sea-Bird SBE35RT Digital Reversing Thermometer	S/N 35-0011
Sea-Bird SBE9*plus* CTD	S/N 09P91878-0878
Paroscientifi c Digiquartz Pressure Sensor	S/N 67248
Sea-Bird SBE3*plus* Temperature Sensor	S/N 03P-2309 (Primary)
Sea-Bird SBE3*plus* Temperature Sensor	S/N 03P-2322 (Secondary)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2818 (Primary/C1A, 1/1-2/1)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2765 (Primary/C1B, 2/2-30/1)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2659 (Secondary)
Sea-Bird SBE43 Dissolved Oxygen Sensor	S/N 43-0275 (1/1-2/1)
Sea-Bird SBE43 Dissolved Oxygen Sensor	S/N 43-0875 (2/2-30/1)
Sea-Bird SBE5T Pump	S/N 05-4131 (Primary)
Sea-Bird SBE5T Pump	S/N 05-4132 (Secondary)
Seapoint Fluorometer	S/N SCF2748
Simrad 807 Altimeter	S/N 9711090
SBE11*plus*-v.2 Deck Unit	S/N 11P21561-0621 (Shipboard; 1/1-20/1)
SBE11*plus*-v.2 Deck Unit	S/N 11P21561-0726 (Shipboard; 21/1-30/1)

Table 1.2.0 CLIMODE-4 LEG 2 Rosette Underwater Electronics.

The CTD was outfi tted with dual pumps. Primary temperature, conductivity and dissolved oxygen were plumbed on one pump circuit and secondary temperature and conductivity on the other. The sensors were deployed vertically.

The SBE9*plus* CTD and SBE35RT temperature sensor were both connected to the SBE32 24-place pylon providing for single-conductor sea cable operation. The sea cable armor was used for ground (return). Power to the SBE9*plus* CTD was provide through the sea cable from an SBE11 deck unit in the main lab. All sensors, dual temperature and conductivity, oxygen, SBE32 carousel, SBE35RT, Seapoint fluorometer and Simrad altimeter, received power from the CTD.

1.3. Navigation and Bathymetry Data Acquisition

Navigation data were acquired at 1-second intervals from the ship's C-Nav GPS receiver by one of the Linux workstations beginning February 7. Data from the ship's Knudsen 320B/R Echosounder (12 KHz transducer) were acquired and merged with the navigation beginning February 9. The Knudsen bathymetry data were noisy and subject to washing out when the seas were choppy or the ship's bow thruster engaged.

1.4. CTD Data Acquisition and Rosette Operation

The CTD data acquisition system consisted of an SBE-11*plus* (V2) deck unit and three networked generic PC workstations running CentOS Linux. Each PC workstation was confi gured with a color graphics display, keyboard, trackball and DVD+RW drives. One of the three systems also had 8 additional RS-232 ports via a Comtrol Rocketport PCI serial controller. The systems were connected through a 100BaseTX ethernet switch, which was also connected to the ship's network. These systems were available for real-time operational and CTD data displays, and provided for CTD and hydrographic data management and backup.

One of the workstations was designated the CTD console and was connected to the CTD deck unit via RS-232. The CTD console provided an interface and operational displays for controlling and monitoring a CTD deployment and closing bottles on the rosette.

CTD deployments were initiated by the console watch after the ship had stopped on station. The watch maintained a console operations log containing a description of each deployment, a record of every attempt to close a bottle and any pertinent comments. The deployment and acquisition software presented a short dialog instructing the operator to turn on the deck unit, examine the on screen CTD data displays and to notify the deck watch that this was accomplished.

Once the deck watch had deployed the rosette, the winch operator began the descent. When permitted by sea conditions, the rosette was lowered to 10 meters, raised back to the surface then lowered for the descent. This procedure was adopted to allow the immersion-activated sensor pumps time to start and flush the sensors.

Profiling rates were frequently dictated by sea conditions, but never exceeded 60m/minute with the rosette package.

The progress of the deployment and CTD data quality were monitored through interactive graphics and operational displays. Bottle trip locations were decided and transcribed onto the console and sample logs. The sample log would later be used as an inventory of samples drawn from bottles.

A maximum depth of 1000m was attained on most casts, with a 2000m maximum for the 4 casts at the either end of 2 sections across the Gulf Stream.

Bottles were closed on the up cast by operating an on-screen control. The winch operator was given a target wire-out for the bottle stop, proceeded to that depth and stopped. Bottles were tripped at least 10 seconds after stopping to allow the rosette wake to dissipate and the bottles to flush. The winch operator was instructed to proceed to the next bottle stop at least 10 seconds after closing bottles to allow the SBE35RT calibration temperature sensor time to make a measurement.

After the last bottle was tripped, the console watch directed the deck watch to bring the rosette on deck. Once on deck, the console watch terminated the data acquisition, turned off the deck unit and assisted with rosette sampling.

1.5. CTD Data Processing

Shipboard CTD data acquisition was the first stage in shipboard processing. Raw CTD data were converted to engineering units, filtered, response-corrected, calibrated and decimated to a more manageable 0.5 second time-series. The laboratory calibrations for pressure, temperature and conductivity were applied at this time. The 0.5 second time-series data were used for real-time graphics during deployments, and were the source for CTD pressure, temperature and conductivity associated with each rosette bottle. Both the raw 24hz data and the 0.5 second time-series were stored for subsequent processing steps.

At the completion of a deployment, a series of processing steps were performed automatically. The 0.5 second time-series data were checked for consistency, clean sensor response and calibration shifts. A 2 decibar pressure-series was generated from the down cast data whenever possible, where the CTD sensors saw the water before the rosette disturbed it. Only two casts had surface data extrapolated more than 8 decibars due to sea conditions and not being able to yoyo back to the surface after sensors stabilized. Both the 2 decibar pressure-series and 0.5 second time-series data were made available for downloading, plotting and reporting on the shipboard cruise website.

CTD data were routinely examined for sensor problems, calibration shifts and deployment or operational problems. The primary and secondary temperature sensors (SBE3*plus*) were compared to each other and to the SBE35RT temperature sensor. CTD conductivity sensors (SBE4C) were compared with each other and with check-sample conductivity values to determine if any corrections were warranted. The CTD dissolved oxygen sensor (SBE43) data were calibrated to check-sample data. Additional deep theta-S and theta-O_2 comparisons were made between down and up casts as well as with adjacent deployments.

CTD data were collected successfully at all 30 stations occupied. Problems specific to the CTD signal, sensors or data are listed in Table 1.5.0.

Station/Cast	Problem/Comment	Solution
1/1	CTD signal cutouts/spikes/pumps off and on/missed trip confirmations from 735db up cast, increasing until no usable signal at 125db up; cast aborted 125db up, deck unit blew a fuse before cast terminated.	Recovered two 128db trips from raw data; short found at slip-rings/lab cable connection, wire reterminated at slip-rings and rosette after cast. Despiked noisy CTD data affecting bottle trips.
	No 10m yoyo at surface down cast due to rough seas.	Pressure-sequenced data after sensors somewhat stabilized, top 6 db extrapolated.
	CTD-C1 10mS/cm too high during cast.	Error in correction coefficients fixed, cast re-averaged.
	CTD sensors stored dry before first station due to sub-freezing Ts in hangar.	Despiked excessively noisy T/C data in top 70db.
	CTDOXY signal noisy, pegged out top 100+db, deeper data a bit better.	Try one more cast to see if signal improves.
	No upcast bottle o2 data above 127db.	Fit CTDOXY from 127db to bottom, quality code 4 for top 126db and 1014-1018db.
2/1	CTD-C1 cut out/both pumps off at 545db down; pumps back on at 280db upcast.	Noticed pumps off at 1280m down, ABORT cast. Replaced CTD-C1 sensor with spare after recovery.
	CTDOXY trace still looked bad until 100+db (almost 0 raw signal).	Replaced with spare CTDOXY sensor after cast.
2/2	CTDOXY looks fine. CTD-C1 cut out/both pumps off 487db down, back on 316db up, all signals good.	Abort cast at 487db. Replaced cables between CTD/CTD-C1 and CTD/CTD-T1 after cast.
9/1	CTD-T1 signal lost 696db down, back on 528db up cast. CTD-C1 jumped/temporarily unstable at same spots.	Replaced cable between CTD/CTD-T1 before next cast (with cable changed out after station 2/2). Used CTD-T2/CTD-C2 for primary sensors this cast.
16/1-17/1	Kinks in wire caused by rough seas increasing.	Mechanical termination shifted up 10m at rosette end after one of these casts.
18/1	No 10m yoyo at surface down cast due to rough seas.	Pressure-sequenced data after sensors stabilized, top 8 db extrapolated.
19/1	No 10m yoyo at surface down cast surface due to rough seas.	Pressure-sequenced data after sensors stabilized, top 10 db extrapolated.
21/1	Problem initiating acquisition, CTD signal/software could not communicate.	Booted acquisition computer, switched to spare Deck Unit, and talked to Deck Unit through SeaSave software; combination proved successful.
26/1	Major signal noise during up cast beginning 422db bottle stop.	Right-angle kink in wire: cut off ~30 ft. of wire and reterminated at rosette end after cast. Despiked noisy CTD data affecting bottle trips.
30/1	Altimeter cable snagged by taglines on recovery, bent connector on altimeter end.	Removed altimeter after cast, repair pending.

Table 1.5.0 CLIMODE-4 LEG 2 CTD Data Comments and Problems

1.6. CTD Sensor Laboratory Calibrations

Laboratory calibrations of the SBE pressure, temperature, conductivity, dissolved oxygen and digital Reversing Thermometer sensors were performed prior to CLIMODE-4 LEG 2. The calibration dates are listed in table 1.6.0.

Sensor	S/N	Calibration Date	Calibration Facility
Paroscientific Digiquartz Pressure	67248	19-Dec-2006	SIO/STS
Sea-Bird SBE3*plus* T1 Temperature	03P-2309	14-Dec-2006	SIO/STS
Sea-Bird SBE3*plus* T2 Temperature	03P-2322	14-Dec-2006	SIO/STS
Sea-Bird SBE4C C1A Conductivity	04-2818	05-Dec-2006	SBE
Sea-Bird SBE4C C1B Conductivity	04-2765	05-Dec-2006	SBE
Sea-Bird SBE4C C2 Conductivity	04-2659	05-Dec-2006	SBE
Sea-Bird SBE43 Dissolved Oxygen	43-0275	(13-Jan-2007-N/A)	SBE
Sea-Bird SBE43 Dissolved Oxygen	43-0875	(18-Jan-2007-N/A)	SBE
Sea-Bird SBE35RT Dig.Reversing Therm.	35-0011	29-Dec-2006	SBE

Table 1.6.0 CLIMODE-4 LEG 2 CTD sensor laboratory calibrations.

1.7. CTD Shipboard Calibration Procedures

CTD #878 was used for all CTD casts on Climode-4 Leg 2. The CTD was deployed with all sensors and pumps aligned vertically, as recommended by SBE. The primary temperature and conductivity sensors (T1 and C1B) were used for CTD data reported for all casts. The SBE35RT Digital Reversing Thermometer (S/N 35-0011) served as an independent calibration check for temperature. *In-situ* salinity and dissolved O_2 check samples collected during each cast were used to calibrate the conductivity and dissolved O_2 sensors.

1.7.1. CTD Pressure

The Paroscientific Digiquartz pressure transducer (CTD 878, Pressure S/N 67248) was calibrated in December 2006 at the SIO/STS Calibration Facility. Coefficients derived from the calibration were applied to convert raw pressure frequencies to corrected pressures during each cast. Residual pressure offsets (the CTD pressures just before submersion and just after coming out of the water) were examined to check for calibration shifts. Offsets varied between -0.4 to +0.3db; no adjustments to the calculated pressures were warranted during Leg 2.

1.7.2. CTD Temperature

The same SBE3*plus* primary and secondary temperature sensors (T1-S/N 03P-2309 and T2-S/N 03P-2322) served for all of Leg 2. Calibration coefficients derived from the pre-cruise calibrations in December 2006 were applied to raw primary and secondary temperature data during each cast.

The SBE35RT Digital Reversing Thermometer is an internally recording temperature sensor that operates independently of the CTD. It is triggered by the SBE32 pylon in response to a bottle trip. According to the Manufacturer's specifications the typical stability is 0.001° C/year. The SBE35RT used on CLIMODE-4 LEG 2 (S/N 35-0011) was calibrated in December 2006.

Two independent metrics of calibration accuracy were examined. T1 and T2 were compared, and the SBE35RT temperatures were compared to both T1 and T2 at each rosette trip.

Calibration accuracy was first examined by tabulating T1-T2, SBE35RT-T1 and SBE35RT-T2 differences over a range of pressures (at bottle trip locations) for stations 31-72. The differences showed no drift with station number (time). SBE35RT-T1 or -T2 differences indicated both T1 and T2 had a slight offset. A T1 and T2 offset were determined, based on SBE35RT-T1 differences outside of higher gradient areas (pressures less than 100db and deeper than 1000db) for all 42 stations. T1 was corrected by applying an offset of -0.000965° C for stations 31-72. T2 was corrected by applying an offset of 0.001898 eC for stations 31-72.

The residual differences for temperatures are summarized in fi gures 1.7.2.0 through 1.7.2.4. A 4,2 standard deviation rejection fi lter was applied to the differences before plotting, to eliminate larger values in higher-gradient regions.

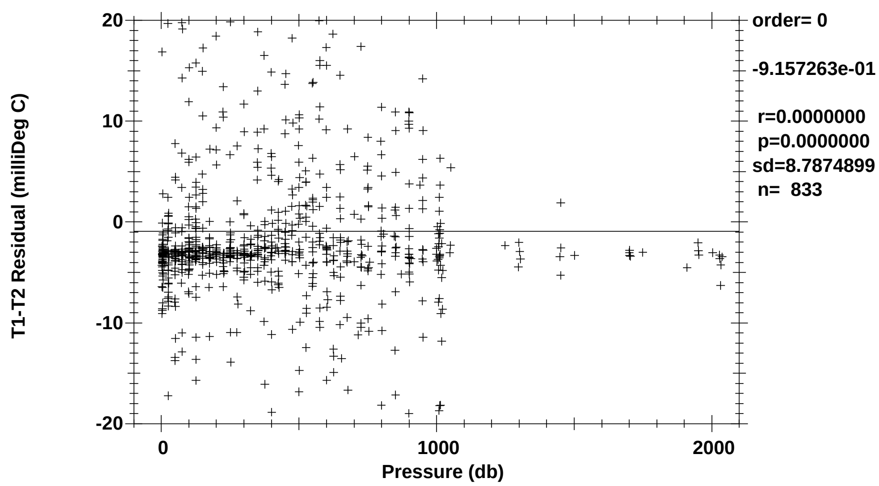


Figure 1.7.2.0 Climode-4 Leg 2 T1-T2 vs pressure, all pressures.

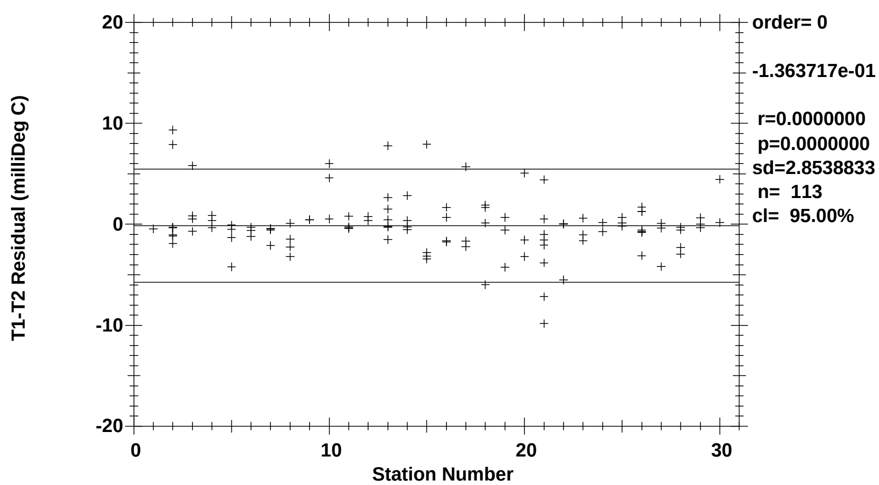


Figure 1.7.2.1 Climode-4 Leg 2 T1-T2 vs station, p<35db or p>980db.

Figure 1.7.2.2 Climode-4 Leg 2 SBE35RT-T1 vs pressure, all pressures.

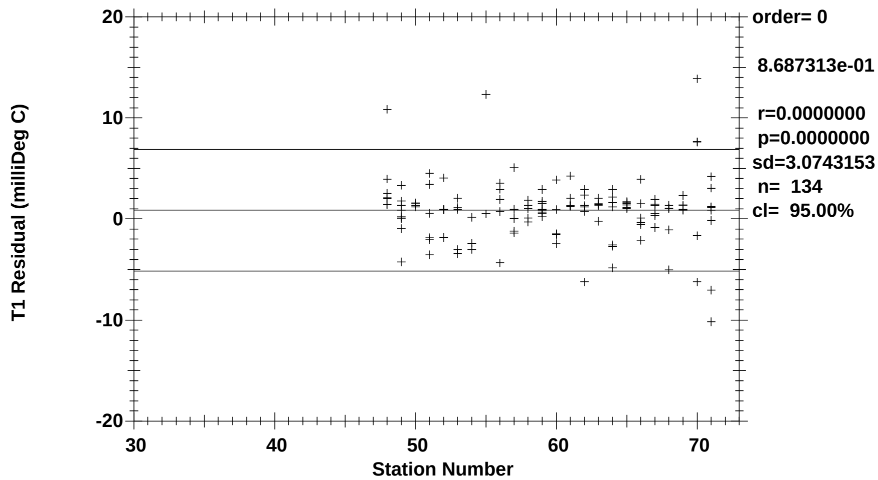


Figure 1.7.2.3 Climode-4 Leg 2 SBE35RT-T1 vs station, p<100db or p>1000db.

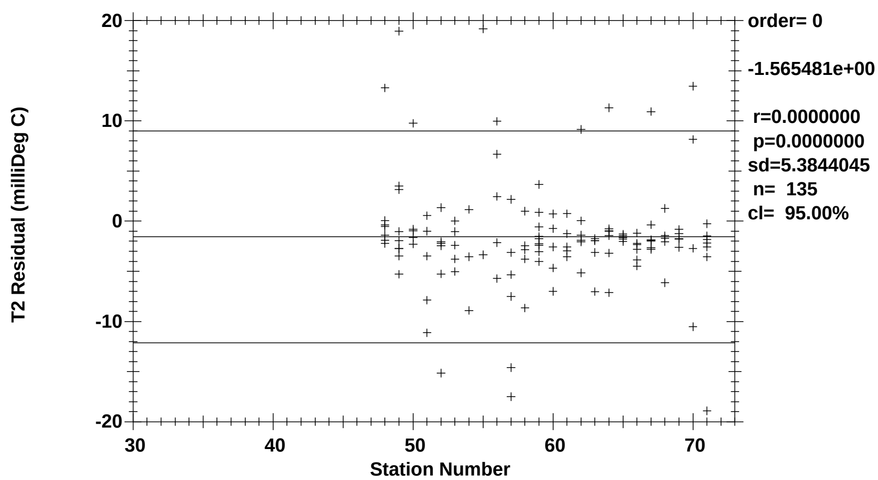


Figure 1.7.2.4 Climode-4 Leg 2 SBE35RT-T2 vs station, p<100db or p>1000db.

1.7.3. CTD Conductivity

One primary SBE4C conductivity sensor (C1-S/N 04-2765) and one secondary SBE4C conductivity sensor (C2-S/N 04-2659 for all casts) served for the entire cruise. Conductivity sensor calibration coeffi cients derived from the pre-cruise calibrations were applied to raw primary and secondary conductivities.

Comparisons between the primary and secondary sensors, and between each sensor vs check sample conductivities calculated from bottle salinities, were used to derive conductivity corrections.

The salinometer standard dial was stable for casts 30-42, then raised 10 units through station 48, dropped back 10 units through station 54, raised 5 units for stations 55/56, raised another 10 units for stations 57-66, and fi nally dropped 2 units for stations 67-72. The standard dial maintaied a 15-unit consistency throughout stations 31-72. As quality codes for no salt bottles updated into the database, only stations containing the least number of "flyers" 42-53 and 60-69 were used to calibrate the conductivity sensors.

In addition to a previous slope of -9.13936e-05, an offset of 0.00318765mS/cm was applied to C1. In addition to a previous slope of -0.000117275, an offset of 0.0085908 was applied to C2.

Lower-gradient conductivity differences, after applying shipboard corrections, are summarized in fi gures 1.7.3.0-1.7.3.3. Note that a 4,2 standard deviation rejection fi lter was applied to the differences before plotting, to eliminate a few higher-gradient values that fell within the specifi ed pressure ranges.

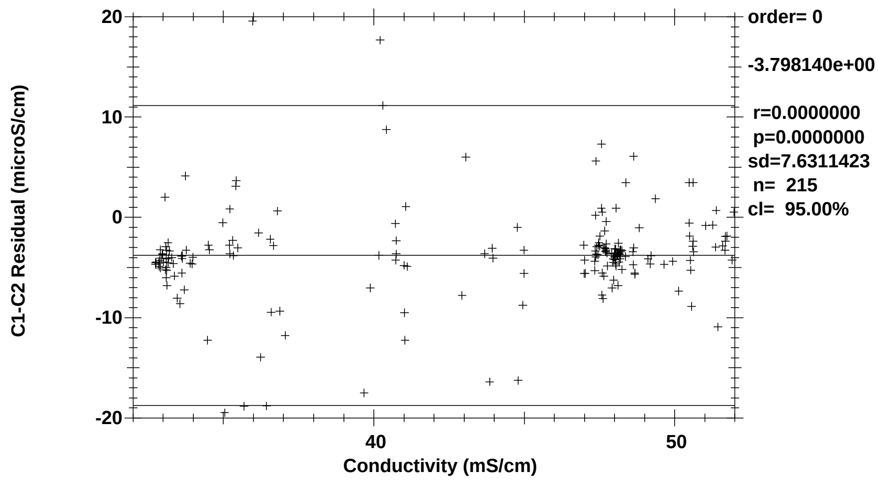


Figure 1.7.3.0 Climode-4 Leg 2 C1-C2 vs Conductivity

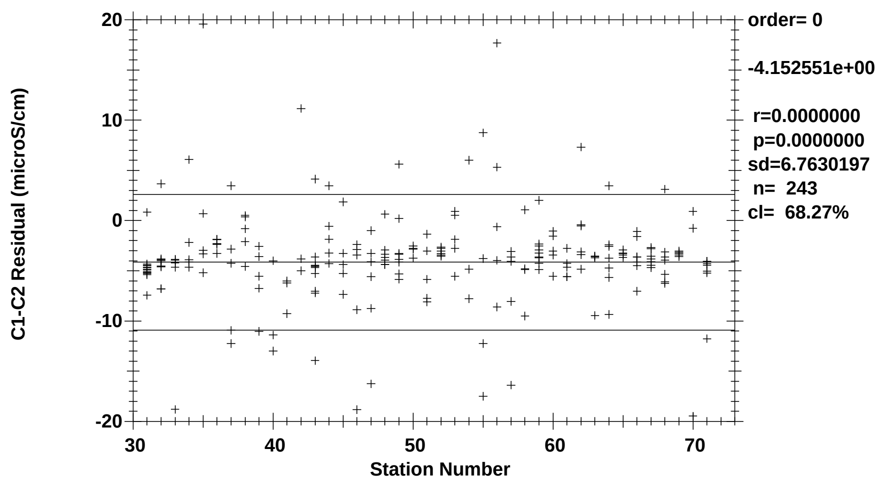


Figure 1.7.3.1 Climode-4 Leg 2 C1-C2 vs station

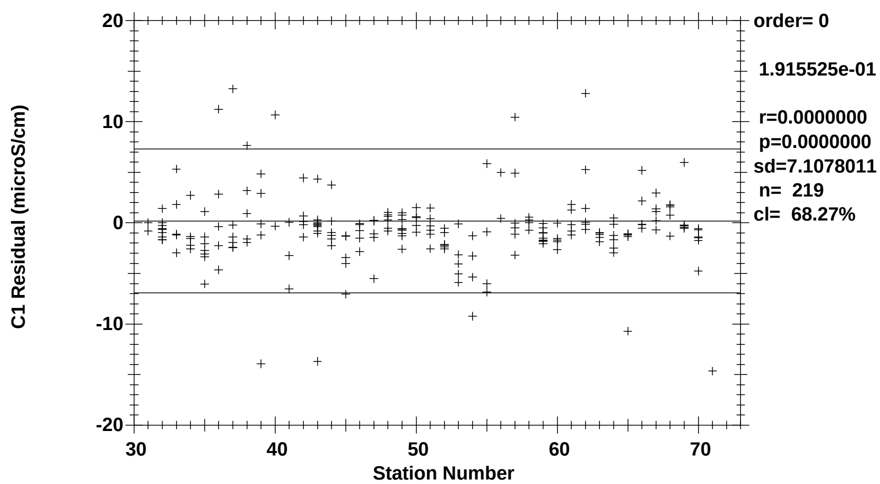


Figure 1.7.3.2 Climode-4 Leg 2 Bottle-C1 vs station

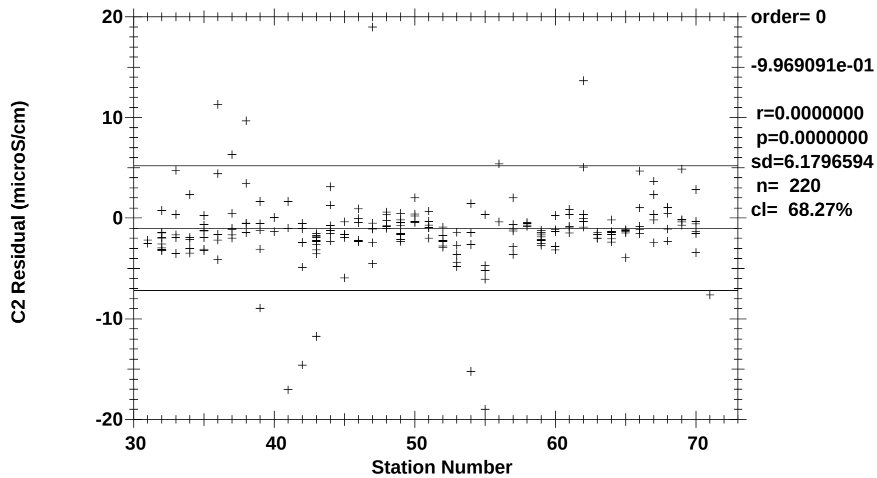


Figure 1.7.3.3 Climode-4 Leg 2 Bottle-C2 vs station

Sensor	Offset	Slope (as f(x))	x
Pressure	0	none	
T1	-0.00189862	none	
T2	0	none	
C1	0.00318765	-9.13936e-5	C1B
C2	0.0085908	-1.17275e-4	C2

Table 1.7.3.0 Climode-4 Leg 2 Summary of CTD T/C Corrections.

Bottle minus CTD salinity residuals, after applying shipboard T1/C1 and T2/C2 corrections, are summarized in figures 1.7.3.4 through 1.7.3.6.

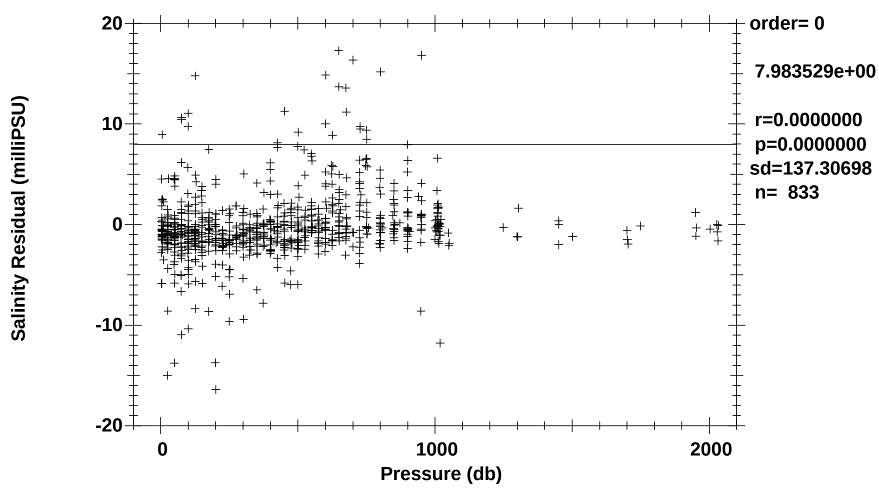


Figure 1.7.3.4 Climode-4 Leg 2 Salinity residuals vs pressure, all pressures.

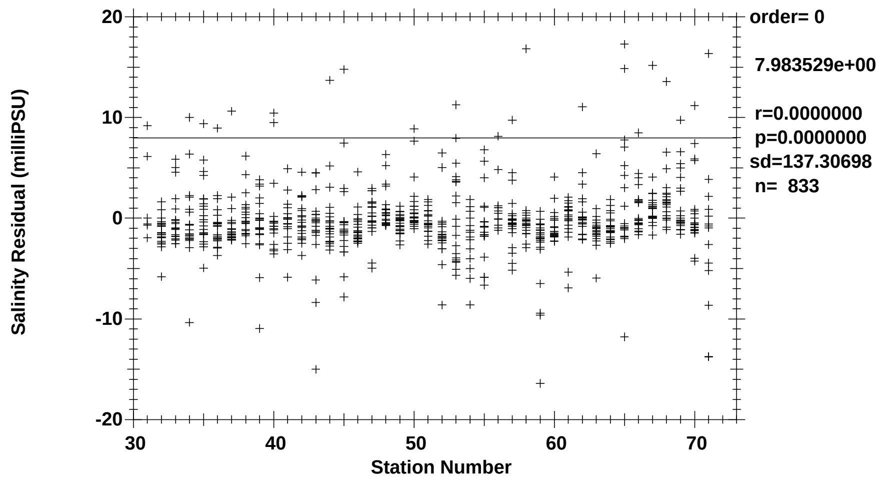


Figure 1.7.3.5 Climode-4 Leg 2 Salinity residuals vs station, all pressures.

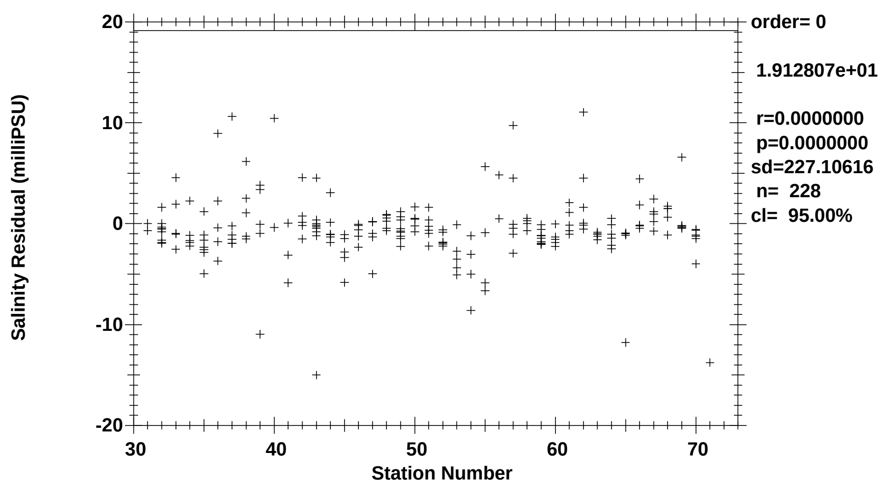


Figure 1.7.3.6 Climode-4 Leg 2 Salinity residuals vs station

Figure 1.7.3.6 represents an estimate of the salinity accuracy on Climode-4 Leg 2. The 95% confidence limit is ±0.0046 PSU relative to the lower-gradient bottle salts.

1.7.4. CTD Dissolved Oxygen

Two SBE43 dissolved O_2 sensors (S/N 43-0875, stations 2-30) were used during this leg. The DO sensor was plumbed into the primary T1/C1 pump circuit after C1. Down cast data were used for all casts.

The DO sensor calibration method used for this cruise matched down cast pressure-series CTD O_2 data to up cast bottle trips along isopycnal surfaces. Residual differences between the *in-situ* check sample values and CTD O_2 were minimized using a non-linear least-squares fitting procedure.

The fitting procedure determined the calibration coefficients for the sensor model conversion equation, and was accomplished in stages. The time constants for the exponential terms in the model were first determined for the sensor. These time constants are sensor-specific but applicable to an entire cruise. Next, casts were fit individually to check sample oxygen data. CTD data were refit if bottle oxygen data changed by 0.005ml/l or more after bottle data were recalculated with smoothed standards/blanks. Deep theta-O_2 overlays of nearby stations were compared to ensure data consistency. Down and up cast differences were also considered when bottle data in shallower areas disagreed. CTD O_2 data were converted from ml/l to umol/kg units after fitting.

Bottom bottle O_2 data were occasionally missing or coded "questionable" due to tripping, sampling or analytical problems. Deep theta-O_2 comparisons were used to estimate a bottom value for fitting where possible, typically helping to optimize the fi t through other deep bottles.

Figures 1.7.4.0-1.7.4.2 show the residual differences between bottle and calibrated CTD O_2 where both CTD and bottle oxygen data are coded "acceptable".

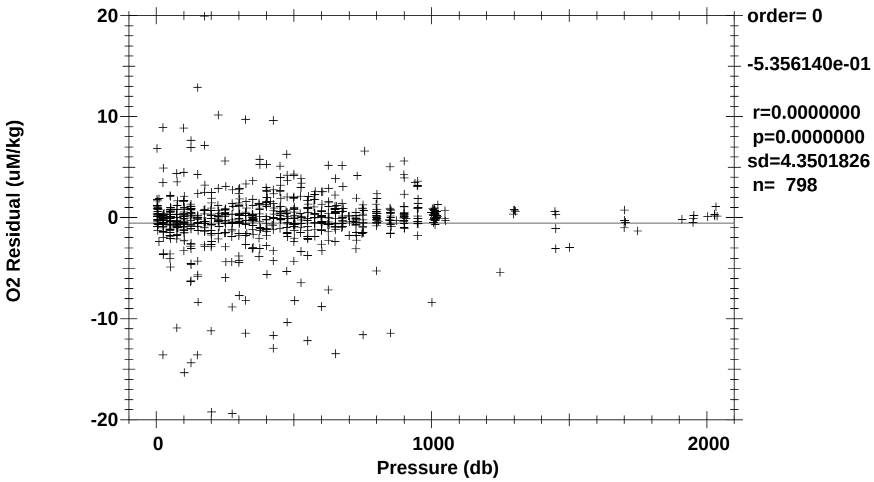


Figure 1.7.4.0 O_2 residuals vs pressure, all pressures.

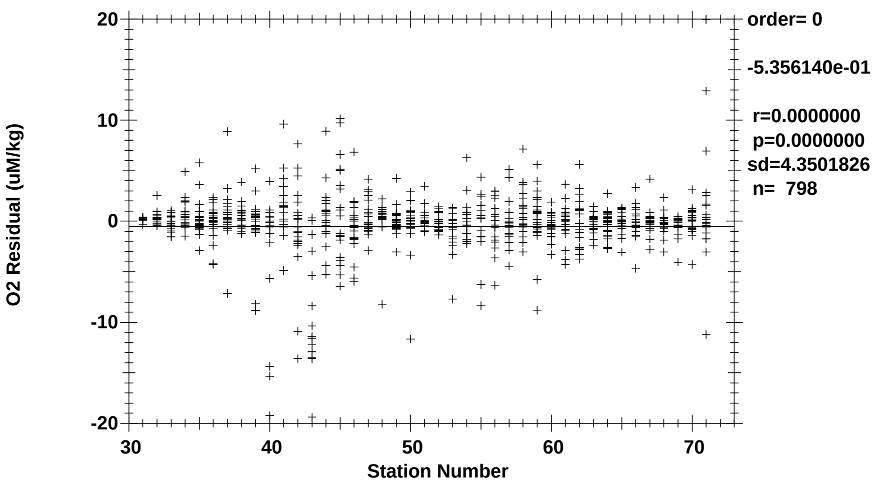


Figure 1.7.4.1 O_2 residuals vs station, all pressures.

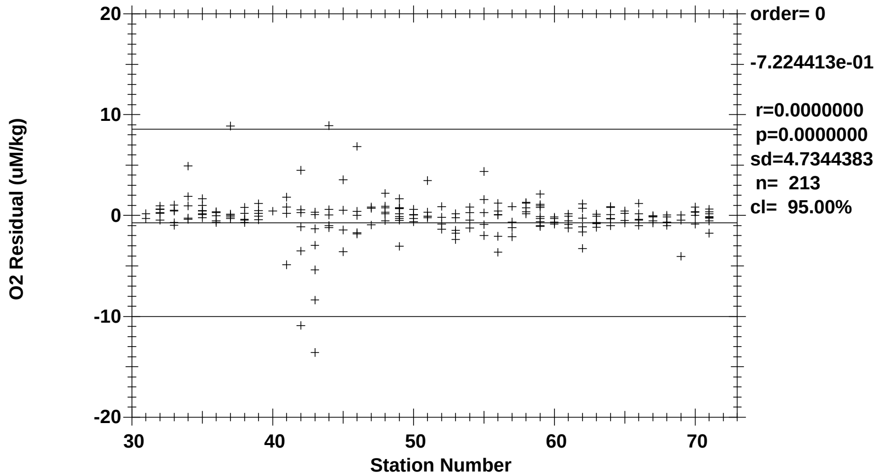


Figure 1.7.4.2 O_2 residuals vs station, p>500db .

The standard deviations of 2.107 umol/kg for all oxygens and 1.868 umol/kg for deep oxygens are only presented as general indicators of goodness of fit. STS makes no claims regarding the precision or accuracy of CTD dissolved O_2 data.

The general form of the STS O_2 conversion equation for Clark cells follows Brown and Morrison [Brow78] and Millard [Mill82], [Owen85]. STS models membrane and sensor temperatures with lagged CTD temperatures and a lagged thermal gradient. *In-situ* pressure and temperature are filtered to match the sensor response. Time-constants for the pressure response τ_p, two temperature responses τ_{Ts} and τ_{Tf}, and thermal gradient response τ_{dT} are fitting parameters. The thermal gradient term is derived by low-pass filtering the difference between the fast response (T_f) and slow response (T_s) temperatures. This term is SBE43-specific and corrects a non-linearity introduced by analog thermal compensation in the sensor. The O_c gradient, dO_c/dt, is approximated by low-pass filtering 1st-order O_c differences. This gradient term attempts to correct for reduction of species other than O_2 at the sensor cathode. The time-constant for this filter, τ_{og}, is a fitting parameter. Dissolved O_2 concentration is then calculated:

$$O_{2ml/l} = [c_1 O_c + c_2] \cdot f_{sat}(S,T,P) \cdot e^{(c_3 P_l + c_4 T_f + c_5 T_s + c_6 \frac{dO_c}{dt} + c_7 dT)} \qquad (1.7.4.0)$$

where:

$O_{2ml/l}$	= Dissolved O_2 concentration in ml/l;
O_c	= Sensor current (μamps);
$f_{sat}(S,T,P)$	= O_2 saturation concentration at S,T,P (ml/l);
S	= Salinity at O_2 response-time (PSUs);
T	= Temperature at O_2 response-time (° C);
P	= Pressure at O_2 response-time (decibars);
P_l	= Low-pass filtered pressure (decibars);
T_f	= Fast low-pass filtered temperature (° C);
T_s	= Slow low-pass filtered temperature (° C);
$\frac{dO_c}{dt}$	= Sensor current gradient (μamps/secs);
dT	= low-pass filtered thermal gradient (T_f - T_s).

The time-constants and coefficients used to correct Climode-4 Leg 2 CTD Oxygen data are listed in table 1.7.4.0.

Table 1.7.4.0 Summary of Climode-4 Leg 2 CTD Oxygen Time Constants
(time constants in seconds)

Temperature Fast(τ_{Tf})	Temperature Slow(τ_{Ts})	Pressure (τ_p)	O_2 Gradient (τ_{og})	dT Gradient (τdT)
12.00	120.00	0.04	2.00	400.00

Table 1.7.4.1 Climode-4 Leg 2: Conversion Equation Coefficients for CTD Oxygen
(refer to Equation 1.7.4.0)

Sta/ Cast	O_c Slope (c_1)	Offset (c_2)	P_l coeff (c_3)	T_f coeff (c_4)	T_s coeff (c_5)	$\frac{dO_c}{dt}$ coeff (c_6)	T_{dT} coeff (c_7)
1/1	-1.1745e-04	1.8789e-01	-2.4478e-01	3.1841e+00	-1.6955e-04	4.6538e-06	0.9486660
2/3	4.2377e-04	2.7125e-03	1.6958e-03	-2.2426e-01	1.6560e-04	1.8764e-06	-0.0174792
3/1	3.3531e-04	3.4165e-02	-2.2225e-02	-1.0919e-01	1.5367e-04	-3.5042e-07	-0.0473943
4/1	4.4102e-04	2.2693e-03	-2.9332e-04	-2.2462e-01	1.2516e-04	1.3666e-06	-0.0370380
5/1	3.4554e-04	2.8843e-02	-2.1163e-02	-6.8052e-02	1.0045e-04	1.3073e-06	-0.0330765
6/1	4.5159e-04	1.0685e-02	-9.1024e-03	-2.4223e-01	1.2452e-04	1.2018e-06	-0.0441379
7/1	3.7417e-04	1.4635e-02	-5.5953e-03	-1.7766e-01	1.1657e-04	-8.4304e-07	-0.0984374
8/1	5.1349e-04	-1.6027e-02	1.5143e-02	-3.4088e-01	-5.4805e-05	-7.2752e-07	-0.1165380
9/1	4.3027e-04	4.2560e-02	-4.7019e-02	-6.3587e-02	-1.7061e-06	2.1004e-06	-0.0103594
10/1	9.4176e-04	-1.1249e-03	-4.9617e-02	-3.2304e-01	-3.2808e-04	1.0163e-06	0.1472660
11/1	4.2961e-04	-2.8899e-03	5.0669e-03	-2.0493e-01	1.5426e-04	1.9635e-06	-0.0025820
12/1	5.4029e-04	-1.2035e-03	-2.4977e-02	-1.5175e-01	-2.2569e-05	1.4674e-06	0.0477859
13/1	4.1459e-04	1.2314e-02	-7.8674e-03	-1.8023e-01	1.4741e-04	7.8280e-08	-0.0253085
14/1	4.0192e-04	-7.3111e-03	1.3565e-02	-1.9876e-01	9.0990e-05	4.7372e-07	-0.0801280
15/1	4.6984e-04	-1.4137e-02	1.3317e-02	-2.4733e-01	1.4139e-04	1.4966e-06	0.0040428
16/1	3.1786e-04	2.5302e-02	-7.8618e-03	-1.3832e-01	1.3626e-04	6.0955e-07	-0.1384370
17/1	4.0644e-04	-1.4242e-02	2.2833e-02	-2.4178e-01	1.3926e-04	4.0118e-07	-0.0808534
18/1	4.2033e-04	9.0798e-04	3.5641e-03	-2.1500e-01	1.4961e-04	2.2036e-06	-0.0343997
19/1	2.9203e-04	2.8705e-02	-6.2151e-03	-1.3323e-01	1.3780e-04	1.7944e-06	-0.1986610
20/1	5.3206e-04	-2.4283e-02	1.7626e-02	-2.9449e-01	1.4123e-04	3.6798e-07	0.0612347
21/1	4.3254e-04	2.2475e-02	-2.1468e-02	-1.7719e-01	1.2675e-04	3.0747e-06	-0.0027363
22/1	4.4233e-04	-4.7456e-03	6.3378e-03	-2.1723e-01	1.3537e-04	1.4820e-06	-0.0185315
23/1	3.7889e-04	1.2667e-02	-4.6876e-03	-1.5754e-01	1.3482e-04	7.7545e-09	-0.0638025
24/1	3.5994e-04	3.1800e-02	-1.9940e-02	-1.5957e-01	1.1174e-04	1.8409e-06	-0.1331320
25/1	4.0678e-04	2.0064e-02	-1.5672e-02	-1.7018e-01	1.1066e-04	2.9220e-06	-0.0644904
26/1	4.2556e-04	3.8939e-03	-1.9449e-03	-1.7445e-01	1.3190e-04	7.6936e-07	-0.0027296
27/1	4.7761e-04	-1.7448e-02	1.3521e-02	-2.1239e-01	8.9855e-05	-1.4647e-07	0.0446175
28/1	4.0883e-04	2.0203e-02	-1.3147e-02	-2.1653e-01	1.4789e-04	6.4560e-07	-0.0971966
29/1	4.5233e-04	1.1257e-03	-7.0374e-04	-2.1861e-01	1.2700e-04	1.1765e-06	-0.0091114
30/1	3.7292e-04	1.6462e-02	-6.4803e-03	-1.6953e-01	1.2927e-04	-5.0913e-07	-0.0897090

1.8. Bottle Sampling

At the end of each rosette deployment water samples were drawn from the bottles in the following order:

- O_2
- DIC/Total Alkalinity
- Nutrients
- Salinity

The 24-place 10-liter rosette was used on all casts. Six carousel latches (3/7/11/15/19/23 - every 4th) that release lanyards and subsequently trip bottles malfunctioned early in the expedition, 4 of them beginning station 1. The problem was investigated after the first trans-sect and traced to bolts that fastened the carousel to its mounting ring: they were protruding ~1/8" into the space behind the faulty latches. The bolts were shortened and replaced. Bottle 9 also malfunctioned on stations 9-13; its repair involved cleaning of peeling parts. One other bottle latch with a broken plastic trigger release (position 2) was replaced with another from the WHOI backup carousel. The only tripping problem thereafter was bottle 2, which was apparently mis-tripping (or not tripping) on most casts from stations 23-30. A likely culprit is the replacement carousel trigger release in that position, which will be checked before Leg 2 begins.

The correspondence between individual sample containers and the rosette bottle position (1-24) from which the sample was drawn was recorded on the sample log for the cast. This log also included any comments or anomalous conditions noted about the rosette and bottles. One member of the sampling team was designated the *sample cop*, whose sole responsibility was to maintain this log and insure that sampling progressed in the proper drawing order.

Normal sampling practice included opening the drain valve and then closing it and opening the air vent on the bottle, indicating an air leak if water escaped. This observation together with other diagnostic comments (e.g., "lanyard caught in lid", "valve left open") that might later prove useful in determining sample integrity were routinely noted on the sample log. Drawing oxygen samples also involved taking the sample draw temperature from the bottle. The temperature was noted on the sample log and was sometimes useful in determining leaking or mis-tripped bottles.

Once individual samples had been drawn and properly prepared, they were distributed for analysis. Oxygen and salinity analyses were performed on computer-assisted (PC) analytical equipment networked to the data processing computer for centralized data management. Nutrient samples were frozen and stored for later analysis ashore. DIC/Total Alkalinity samples were poisoned and stored for post-cruise analysis.

1.9. Bottle Data Processing

Water samples collected and properties analyzed shipboard were managed centrally in a relational database (PostgreSQL-8.0.8-1) run on one of the Linux workstations. A web service (OpenAcs-5.2.3 and AOLServer-4.0.10-2) front-end provided ship-wide access to CTD and water sample data. Web-based facilities included on-demand arbitrary property-property plots and vertical sections as well as data uploads and downloads.

The Sample Log (and any diagnostic comments) was entered into the database once sampling was completed. Quality flags associated with sampled properties were set to indicate that the property had been sampled, and sample container identifications were noted where applicable (e.g., oxygen flask number).

Analytical results were provided on a regular basis by the analytical groups and incorporated into the database. These results included a quality code associated with each measured value and followed the coding scheme developed for the World Ocean Circulation Experiment (WOCE) Hydrographic Programme (WHP) [Joyc94].

Various consistency checks and detailed examination of the data continued throughout the cruise.

1.10. Salinity Analysis

Equipment and Techniques

A Guildline Autosal Model 8400A salinometer (S/N 48-266), located in the analytical lab, was used for all salinity measurements. The salinometer was modified by ODF to contain an interface for computer-aided measurement. The water bath temperature was set at 24° C for the entire cruise and lab temperature was maintained at a value near 24° C +/- 2° C.

The salinity analyses were performed after samples had equilibrated to laboratory temperature, usually within 8-54 hours after collection. The salinometers were standardized for each group of analyses (usually 1-2 casts, up to ~48 samples) using at least two fresh vials of standard seawater per group. Salinometer measurements were made by computer, where the analyst was prompted by software to change samples and flush.

Sampling and Data Processing

597 salinity measurements were made and approximately 40 vials of standard water (SSW) were used. Salinity data was used as an additional calibration check for the CTD.

Salinity samples were drawn into 200 ml Kimax high-alumina borosilicate bottles, which were rinsed three times with sample prior to filling. The bottles were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. Prior to sample collection, inserts were inspected for proper fit and loose inserts replaced to insure an airtight seal. The draw time and equilibration time were logged for all casts. Laboratory temperatures were logged at the beginning and end of each run.

PSS-78 salinity [UNES81] was calculated for each sample from the measured conductivity ratios. The difference (if any) between the initial vial of standard water and the next one run as an unknown was applied as a linear function of elapsed run time to the data. The corrected salinity data were then incorporated into the cruise database. Salinometer 48-266 had problems with the Standby/Read switch: the "Suppression" (first 2 digits of the Conductivity ratio) was not displaying the true setting, showing zeros instead.Operating the switch again would correct the problem. The estimated accuracy of bottle salinities run at sea is usually better than ±0.002 PSU relative to the particular standard seawater batch used.

The standard dial setting on the Autosal was changed by -29 units before the run for stations 23/24 samples, and back up +15 units for stations 25-30. There was about a -0.002 mS/cm dip in bottle-CTD conductivity differences noted at station 22. Stations 23-24 showed approx. -0.004 mS/cm shift, relative to the first 21 casts, which could be accounted for entirely by the difference in standby numbers between the two standard dial settings.

Laboratory Temperature

The temperature of the laboratory used for the analyses ranged from 22° C to 24° C. The air temperature during any particular run varied less than 1° C.

Standards

IAPSO Standard Seawater (SSW) Batch P-147 was used to standardize all stations.

1.11. Oxygen Analysis

Equipment and Techniques

Dissolved oxygen analyses were performed with an ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by PC LabView software. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. ODF used a whole-bottle modified-Winkler titration following the technique of Carpenter [Carp65] with modifications by Culberson *et al.* [Culb91], but with higher concentrations of potassium iodate standard (~0.012N) and thiosulfate solution (~55 gm/l). Pre-made liquid potassium iodate standards were run once a day approximately every 4 stations, unless changes were made to system or reagents. Reagent/distilled water blanks were determined every day or more often if a change in reagents required it to account for presence of oxidizing or reducing agents. The auto-titrator performed well.

Sampling and Data Processing

587 oxygen measurements were made. Samples were collected for dissolved oxygen analyses soon after the rosette was brought on board. Using a Tygon and silicone drawing tube, nominal 125ml volume-calibrated iodine flasks were rinsed 3 times with minimal agitation, then filled and allowed to overflow for at least 3 flask volumes. The sample drawing temperatures were measured with a small platinum resistance thermometer embedded in the drawing tube. These temperatures were used to calculate uM/kg concentrations, and as a diagnostic check of bottle integrity. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice (10-12 inversions) to assure thorough dispersion

of the precipitate, once immediately after drawing, and then again after about 20 minutes.

The samples were analyzed within 1-2 hours of collection, and the data incorporated into the cruise database.

Thiosulfate normalities were calculated from each standardization and corrected to 20° C. The 20° C normalities and the blanks were plotted versus time and were reviewed for possible problems.

The blanks and thiosulfate normalities for each batch of thiosulfate were smoothed (linear fits) and the oxygen values recalculated.

A noisy endpoint was occasionally acquired during the analyses, usually due to small water-bath contaminations. These endpoints were checked and recalculated using STS/ODF designed software.

Volumetric Calibration

Oxygen flask volumes were determined gravimetrically with degassed deionized water to determine flask volumes at STS/ODF's chemistry laboratory. This is done once before using flasks for the first time and periodically thereafter when a suspect volume is detected. The volumetric flasks used in preparing standards were volume-calibrated by the same method, as was the 10 ml Dosimat buret used to dispense standard iodate solution.

Standards

Liquid potassium iodate standards were prepared in 6 liter batches and bottled in sterile glass bottles at STS/ODF's chemistry laboratory prior to the expedition. The normality of the liquid standard was determined at ODF by calculation from weight. Two standard batches were used during climode4.2. Potassium iodate was obtained from Acros Chemical Co. and was reported by the supplier to be 98% pure. The second standard was supplied by Alfa Aesar and has a reported purity of 99.4-100.4%. Tests at ODF indicate no difference between these 2 batches. All other reagents were "reagent grade" and were tested for levels of oxidizing and reducing impurities prior to use.

1.12. Nutrient Analysis

Equipment and Techniques

Nutrient analyses (phosphate, silicate, nitrate, nitrite, and ammonia) will be performed ashore on an ODF-modified 5-channel Technicon AutoAnalyzer II.

The methods used are described by Gordon *et al.* [Gord92]. The analog outputs from each of the five colorimeter channels are digitized and logged automatically by computer (PC) at 2-second intervals.

Silicate is analyzed using the technique of Armstrong *et al.* [Arms67]. An acidic solution of ammonium molybdate is added to a seawater sample to produce silicomolybdic acid which then reduces to silicomolybdous acid (a blue compound) following the addition of stannous chloride. Tartaric acid is also added to impede PO_4 color development. The sample is passed through a 15mm flowcell and the absorbence are measured at 660nm.

A modification of the Armstrong *et al.* [Arms67] procedure is used for the analysis of nitrate and nitrite. For the nitrate analysis, the seawater sample is passed through a cadmium reduction column where nitrate is quantitatively reduced to nitrite. Sulfanilamide is introduced to the sample stream followed by N-(1-naphthyl)ethylenediamine dihydrochloride which couple to form a red azo dye. The stream is then passed through a 15mm flowcell and the absorbence measured at 540nm. The same technique is employed for nitrite analysis, except the cadmium column is bypassed, and a 50mm flowcell is used for measurement.

Phosphate is analyzed using a modification of the Bernhardt and Wilhelms [Bern67] technique. An acidic solution of ammonium molybdate is added to the sample to produce phosphomolybdic acid, then reduced to phosphomolybdous acid (a blue compound) following the addition of dihydrazine sulfate. The reaction product is heated to ~55° C to enhance color development, then passed through a 50mm flowcell and the absorbence measured at 820nm.

Ammonium is analyzed via the Berthelot reaction in which hypochlorous acid and phenol react with ammonium in an alkaline solution to form indophenol blue. The sample is passed through a 50 mm flowcell and measured at 640nm. This method is a modification of the procedure by Koroleff [Koro70].

Explicit corrections for *carryover* in nutrient analyses are not made. In a typical AutoAnalyzer system, sample to sample carryover is ~1-2% of the concentration difference between samples. This effect is minimized by running samples in order of increasing depth such that concentration differences between samples are minimized. The initial surface samples could be run twice or a low nutrient sea water sample run ahead of the surface sample since these samples generally follow standard peaks.

Sampling and Data Processing

Nutrient samples are drawn into 30 ml polypropylene, screw-capped tubes. The tubes come pre-sterilized from the factory and are rinsed 2-3 times before filling. The samples were frozen until analysis.

Standardizations are performed at the beginning and end of each group of analyses with an intermediate concentration mixed nutrient standard prepared prior to each run from a secondary standard in a low-nutrient seawater matrix. The secondary standards are prepared by dilution from primary standard solutions. Dry standards are pre-weighed at the laboratory at ODF. Sets of 7 different standard concentrations are analyzed periodically to determine any deviation from linearity as a function of absorbence for each nutrient analysis. A correction for non-linearity is applied to the final nutrient concentrations when necessary. A correction for the difference in refractive indices of pure distilled water and seawater is periodically determined and applied where necessary.

After each group of samples is analyzed, the raw data file is processed to produce another file of response factors, baseline values, and absorbences. Computer-produced absorbence readings are checked for accuracy against values taken from a strip chart recording. The data are then added to the cruise database.

Nutrients, reported in micromoles per kilogram, are converted from micromoles per liter by dividing by sample density calculated at 1 atm pressure (0 db), *in situ* salinity, and a per-analysis measured laboratory temperature.

Standards

Primary standards for silicate (Na_2SiF_6) and nitrite ($NaNO_2$) were obtained from Johnson Matthey Chemical Co.; the supplier reported purities of >98% and 97%, respectively. Primary standards for nitrate (KNO_3) and phosphate (KH_2PO_4) were obtained from Fisher Chemical Co.; the supplier reported purities of 99.999% and 99.999%, respectively. Ammonia primary standard ($(NH_4)_2SO_4$) is obtained from Fisher Scientific; the supplier reports purities of 99.99%.

1.13. Bottle Data Quality Code Summary and Comments

This section contains WOCE quality codes [Joyc94] used during this cruise, and remarks regarding bottle data.

Property	1	2	3	4	5	6	7	8	9	Total
Bottle	0	594	3	6	0	0	0	0	85	688
Salinity	0	577	20	0	3	0	0	0	0	600
O_2	0	571	6	10	4	0	0	0	0	591
SiO_3	437	0	0	0	0	0	0	0	0	437
NO_3	437	0	0	0	0	0	0	0	0	437
NO_2	437	0	0	0	0	0	0	0	0	437
PO_4	437	0	0	0	0	0	0	0	0	437
DIC	451	0	0	0	0	0	0	0	0	451
TAlk	451	0	0	0	0	0	0	0	0	451

Table 1.13.0 Climode-4 Leg 2 Water Sample Quality Code Summary

Comments from the Sample Logs and the results of STS/ODF's investigations are included in this report. Units stated in these comments are degrees Celsius for temperature, Practical Salinity Units for salinity, and unless otherwise noted and milliliters per liter for oxygen The sample number is the cast number times 100 plus the bottle number.

Table 1.13.1 Climode-4 Leg 2 Bottle Quality Codes and Comments

Station /Cast	Sample No.	Property	Quality Code	Comment
1/1	101	o2	5	overtitrate did not work, lost sample.
1/1	101	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.02 PSU. Code salt questionable.
1/1	102	reft	3	SBE35RT-CTDT1 or SBE35-CTDT2 differences are -0.035/-0.025 deg.C. Code SBE35RT questionable.
1/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.045 PSU. Code salt questionable.
1/1	103	bottle	9	Bottle did not close. No sample taken.
1/1	104	reft	3	SBE35RT-CTDT1 or SBE35-CTDT2 difference is -0.035 deg.C. Code SBE35RT questionable.
1/1	104	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.025 PSU. Code salt questionable.
1/1	107	bottle	9	Bottle did not close. No sample taken.
1/1	109	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.045 PSU. Code salt questionable.
1/1	110	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.025 PSU. Code salt questionable.
1/1	111	bottle	9	Bottle did not close. No sample taken.
1/1	111	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	111	ctds2	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	112	CTDT2	7	Spiking at CTD trip, CTDTEMP ok after despike.
1/1	112	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.185 PSU. Code salt questionable.
1/1	113	CTDPRS	7	Spiking at CTD trip, CTDPRESS ok after despike.
1/1	113	CTDS1	7	Spiking at CTD trip, CTDSALT ok after despiking CTDPRESS.
1/1	114	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	114	CTDT1	7	Spiking at CTD trip, CTDTEMP ok after despike.
1/1	115	bottle	9	Bottle did not close. No sample taken.
1/1	115	CTDPRS	7	Spiking at CTD trip, CTDPRESS ok after despike.
1/1	115	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	115	ctds2	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	116	CTDPRS	7	Spiking at CTD trip, CTDPRESS ok after despike.
1/1	116	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	116	ctds2	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
1/1	116	CTDT1	7	Spiking at CTD trip, CTDTEMP/CTDSALT ok after despike.
1/1	116	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.02 PSU. Code salt questionable.
1/1	117	CTDPRS	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	117	CTDS1	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	117	ctds2	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	117	CTDT1	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	117	CTDT2	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	118	CTDPRS	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	118	CTDS1	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	118	ctds2	3	Signal mostly noise at CTD trip, data pulled from unaveraged data; Bottle-CTDS2/CTDS1-CTDS2 differences -0.05 PSU, code questionable.
1/1	118	CTDT1	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
1/1	118	CTDT2	7	Signal mostly noise at CTD trip, data pulled from unaveraged data.
2/3	303	bottle	9	Bottle did not close. No sample taken.
2/3	304	salt	2	Wrong Autosal suppression range (1.9), changed to 2.0. Value acceptable.

Station /Cast	Sample No.	Property	Quality Code	Comment
2/3	305	salt	2	Wrong Autosal suppression range (1.9), changed to 2.0. Value acceptable.
2/3	308	o2	2	Overtitrate, value acceptable.
2/3	311	bottle	9	Bottle did not close. No sample taken.
2/3	315	bottle	9	Bottle did not close. No sample taken.
2/3	319	bottle	9	Bottle did not close. No sample taken.
2/3	323	bottle	9	Bottle did not close. No sample taken.
3/1	103	bottle	9	Bottle did not close. No sample taken.
3/1	111	bottle	9	Bottle did not close. No sample taken.
3/1	115	bottle	9	Bottle did not close. No sample taken.
3/1	117	o2	2	slower titration than normal, value acceptable.
3/1	118	o2	2	slower titration than normal, value acceptable.
3/1	119	bottle	9	Bottle did not close. No sample taken.
3/1	123	bottle	9	Bottle did not close. No sample taken.
4/1	101	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 difference is -0.04 deg.C in high gradient. Code CTDT2 questionable.
4/1	101	salt	2	Wrong Autosal suppression range (1.9), changed to 2.0. Value acceptable.
4/1	103	bottle	9	Bottle did not close. No sample taken.
4/1	107	bottle	9	Bottle did not close. No sample taken.
4/1	111	bottle	9	Bottle did not close. No sample taken.
4/1	115	bottle	9	Bottle did not close. No sample taken.
4/1	118	o2	4	Overtitration 2x (O2), bottle value +0.45 ml/l high, code bad.
4/1	119	bottle	9	Bottle did not close. No sample taken.
4/1	123	bottle	9	Bottle did not close. No sample taken.
5/1	103	bottle	9	Bottle did not close. No sample taken.
5/1	107	bottle	9	Bottle did not close. No sample taken.
5/1	111	bottle	9	Bottle did not close. No sample taken.
5/1	115	bottle	9	Bottle did not close. No sample taken.
5/1	119	bottle	9	Bottle did not close. No sample taken.
5/1	123	bottle	9	Bottle did not close. No sample taken.
6/1	101	o2	4	Overtitrated (2x). Value is high compared to nearby casts on theta-o2, Code bad.
6/1	102	o2	4	Overtitrated, "lost sample". Value is high compared to nearby casts on theta-o2, Code bad.
6/1	103	bottle	9	Bottle did not close. No sample taken.
6/1	107	bottle	9	Bottle did not close. No sample taken.
6/1	111	bottle	9	Bottle did not close. No sample taken.
6/1	112	salt	5	Bottle popped during analysis, lost sample.
6/1	115	bottle	9	Bottle did not close. No sample taken.
6/1	119	bottle	9	Bottle did not close. No sample taken.
6/1	123	bottle	9	Bottle did not close. No sample taken.
7/1	103	bottle	9	Bottle did not close. No sample taken.
7/1	104	o2	2	Overtitrate, original endpoint 0.0002 lower. Value acceptable.
7/1	106	o2	2	Analyst observed: endpoint could be 0.0002 lower. Value acceptable.
7/1	107	bottle	9	Bottle did not close. No sample taken.
7/1	108	o2	5	Abort overtitration, lost sample.
7/1	110	o2	2	Overtitrate. Value acceptable.
7/1	111	bottle	9	Bottle did not close. No sample taken.
7/1	115	bottle	9	Bottle did not close. No sample taken.
7/1	119	bottle	9	Bottle did not close. No sample taken.
7/1	123	bottle	9	Bottle did not close. No sample taken.
8/1	101	CTDOXY	3	Cast sat at bottom for 2 minutes, CTDOXY signal dropped off bottom few db.

Station /Cast	Sample No.	Property	Quality Code	Comment
8/1	102	o2	2	Overtitrate. Value acceptable.
8/1	103	bottle	9	Bottle did not close. No sample taken.
8/1	107	bottle	9	Bottle did not close. No sample taken.
8/1	111	bottle	9	Bottle did not close. No sample taken.
8/1	115	bottle	9	Bottle did not close. No sample taken.
8/1	119	bottle	9	Bottle did not close. No sample taken.
8/1	123	bottle	9	Bottle did not close. No sample taken.
9/1	101	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	101	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	102	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	102	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	103	bottle	9	Bottle did not close. No sample taken.
9/1	103	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	103	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	104	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	104	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	105	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	105	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	106	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	106	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	107	bottle	9	Bottle did not close. No sample taken.
9/1	107	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	107	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	108	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	108	CTDT1	5	CTD-T1 Sensor cut out until bottle 9 trip. Data lost.
9/1	109	bottle	9	Bottle did not close. No sample taken.
9/1	109	CTDS1	5	CTD-T1 Sensor cut out until bottle 9 trip, CTD-C1 offset when T1 off or back on. Data lost.
9/1	111	bottle	9	Bottle did not close. No sample taken.
9/1	113	o2	4	Overtitrate (O2), bottle value +0.6 ml/l high, code bad.
9/1	115	bottle	9	Bottle did not close. No sample taken.
9/1	119	bottle	9	Bottle did not close. No sample taken.
9/1	123	bottle	9	Bottle did not close. No sample taken.
10/1	101	o2	3	Overtitration (2x) questionable (O2). Value seems 0.25 ml/l high, based on theta-o2 comparison with station 9. Code questionable.
10/1	101	salt	5	Sample lost due to folder renaming.
10/1	102	salt	5	Sample lost due to folder renaming.
10/1	103	bottle	9	Bottle did not close. No sample taken.
10/1	107	bottle	9	Bottle did not close. No sample taken.
10/1	109	bottle	9	Bottle did not close. No sample taken.
10/1	111	bottle	9	Bottle did not close. No sample taken.
10/1	112	reft	5	Tripped too soon after btl 11 trip, SBE35 Temp for btl 24 lost.
10/1	115	bottle	9	Bottle did not close. No sample taken.

Station /Cast	Sample No.	Property	Quality Code	Comment
10/1	116	reft	5	Tripped too soon after btl 15 trip, SBE35 Temp for btl 24 lost.
10/1	119	bottle	9	Bottle did not close. No sample taken.
10/1	120	reft	5	Tripped too soon after btl 19 trip, SBE35 Temp for btl 24 lost.
10/1	122	CTDS1	3	Bottle-CTDS1 or CTDS2-CTDS1 difference is -0.015 PSU, CTDC1-CTDC2 is +0.09 mS/cm. Code CTDS1 questionable.
10/1	123	bottle	9	Bottle did not close. No sample taken.
10/1	124	reft	5	Tripped too soon after btl 23 trip, SBE35 Temp for btl 24 lost.
11/1	101	o2	2	Overtitrate (O2), Value acceptable.
11/1	103	bottle	9	Bottle did not close. No sample taken.
11/1	107	bottle	9	Bottle did not close. No sample taken.
11/1	108	o2	2	Overtitrate (O2), Value acceptable.
11/1	109	bottle	9	Bottle did not close. No sample taken.
11/1	111	bottle	9	Bottle did not close. No sample taken.
11/1	115	bottle	9	Bottle did not close. No sample taken.
11/1	118	o2	5	Sample lost.
11/1	119	bottle	9	Bottle did not close. No sample taken.
11/1	123	bottle	9	Bottle did not close. No sample taken.
12/1	103	bottle	9	Bottle did not close. No sample taken.
12/1	107	bottle	9	Bottle did not close. No sample taken.
12/1	109	bottle	9	Bottle did not close. No sample taken.
12/1	111	bottle	9	Bottle did not close. No sample taken.
12/1	115	bottle	9	Bottle did not close. No sample taken.
12/1	118	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.07/+0.035 PSU in high gradient. Code salt questionable.
12/1	119	bottle	9	Bottle did not close. No sample taken.
12/1	121	CTDS1	7	Spiking at CTD trip, CTDCOND/CTDSALT ok after despike.
12/1	121	CTDT1	7	Spiking at CTD trip, CTDTEMP ok after despike.
12/1	122	salt	3	Bottle-CTDS1 or -CTDS2 difference is -0.02 PSU. Code salt questionable.
12/1	123	bottle	9	Bottle did not close. No sample taken.
13/1	103	bottle	9	Bottle did not close. No sample taken.
13/1	107	bottle	9	Bottle did not close. No sample taken.
13/1	109	bottle	9	Bottle did not close. No sample taken.
13/1	111	bottle	9	Bottle did not close. No sample taken.
13/1	114	reft	3	SBE35RT-CTDT1 or -CTDT1 differences are +0.065/+0.095 deg.C. Code CTDT1 questionable.
13/1	115	bottle	9	Bottle did not close. No sample taken.
13/1	116	CTDT2	3	SBE35RT-CTDT2/CTDT1-CTDT2 differences are +0.12/+0.11 deg.C. Code CTDT1 questionable.
13/1	119	bottle	9	Bottle did not close. No sample taken.
13/1	120	ctds2	3	High gradient at CTD trip, Bottle-CTDS2 and CTDS1-CTDS2 are -0.19 PSU. Code CTDS2 questionable.
13/1	120	CTDT2	3	High gradient at CTD trip, SBE35-CTDT2 difference is -0.70 deg.C, CTDT1-CTDT2 is -0.67 deg.C. Code CTDT2 questionable.
13/1	121	reft	3	SBE35RT-CTDT1 or -CTDT1 difference is +0.09 deg.C. Code SBE35RT questionable.
13/1	123	bottle	9	Bottle did not close. No sample taken.
14/1	101	o2	5	Abort sample/OT, lost sample.
14/1	111	bottle	9	Bottle lanyard hooked during recovery, emptied bottle. No samples taken.
14/1	112	o2	4	Overtitration 2x (O2), bottle value +0.40 ml/l high, code bad.
14/1	124	bottle	3	Bottle leaking, top vent not closed. No samples taken.
15/1	108	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.025 PSU. Code salt questionable.

Station /Cast	Sample No.	Property	Quality Code	Comment
15/1	115	o2	2	Bottle oxygen low compared to downcast, but matches upcast. Acceptable.
15/1	116	o2	2	Bottle oxygen low compared to downcast, but matches upcast. Acceptable.
16/1	102	CTDT1	3	SBE35-CTDT1 or CTDT2-CTDT1 differences are -0.03/-0.05 deg.C. Code CTDT1 questionable.
16/1	103	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 differences are +0.045/+0.065 deg.C in high gradient. Code CTDT2 questionable.
16/1	104	ctds2	3	Bottle-CTDS2 or CTDS1-CTDS2 difference is +0.025 PSU. Code CTDS2 questionable.
16/1	104	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 difference is +0.065+ deg.C in high gradient. Code CTDT2 questionable.
16/1	104	o2	2	Overtitration. Value is acceptable.
16/1	107	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 differences are -0.025/-0.05 deg.C in high gradient. Code CTDT2 questionable.
16/1	113	o2	2	"endpoint ˜0.5427". Value within 0.003ml/l with either endpoint, acceptable.
16/1	115	o2	4	"lost sample." Value is +0.75 ml/l high compared to CTDOXY, Code bad.
16/1	116	o2	3	Value is +0.40 ml/l high compared to CTDOXY, Code questionable.
16/1	118	bottle	3	Bottle lanyard hooked during recovery, contaminated bottle. No gas samples taken.
16/1	121	o2	2	Overtitration. Value is acceptable.
18/1	101	o2	4	OT 0.5620 2 x ot still no good. Value is +0.50 ml/l high, code bad.
18/1	102	CTDT1	3	SBE35RT-CTDT1/CTDT2-CTDT1 differences are -0.065/-0.08 deg.C. Code CTDT1 questionable.
18/1	102	o2	2	OT 0.4064 ot end point looks good. Value is acceptable.
18/1	124	bottle	9	Purposely tripped two at same pressure. No samples taken.
19/1	104	bottle	9	Purposely tripped two at same pressure. No samples taken.
19/1	119	bottle	9	Purposely tripped two at same pressure. No samples taken.
19/1	124	bottle	9	Purposely tripped two at same pressure. No samples taken.
20/1	102	CTDT2	3	SBE35RT-CTDT2 or CTDT1-CTDT2 difference is +0.05 deg.C. Code CTDT2 questionable.
20/1	106	salt	2	Bottle-CTDS1 or -CTDS2 difference is +0.015/+0.02 PSU in high gradient. Salt acceptable.
20/1	108	ctds2	2	High gradient at CTD trip, Bottle-CTDS2 and CTDS1-CTDS2 difference is +0.01 to +0.015 deg.C, CTDS2 acceptable.
20/1	114	o2	2	Overtitration. Value is acceptable.
20/1	118	o2	2	Overtitration. Value is acceptable.
21/1	105	o2	2	"endpoint ˜0.59875", orig. value is acceptable.
21/1	109	o2	2	overtitration, value is acceptable.
21/1	111	CTDT1	3	SBE35-CTDT1 or CTDT2-CTDT1 differences are +0.06/+0.075 deg.C. Code CTDT1 questionable.
21/1	116	CTDT2	3	SBE35-CTDT2 or CTDT1-CTDT2 difference is -0.03 deg.C. Code CTDT2 questionable.
21/1	116	o2	4	overtitration, "too quick addition added 3 mls lost sample". Value is 1.1 ml/l high, code bad.
21/1	119	o2	4	overtitration, "lost sample". Value is 0.5 ml/l high, code bad.
22/1	101	o2	2	"ep ˜0.4725"; value is acceptable.
22/1	113	o2	2	"ep 0.4618"; value is acceptable.
22/1	114	o2	2	"Overtitration, volts low 1st ep suspect"; value is acceptable.
23/1	101	o2	2	"missed endpoint, correct 0.4415"; used corrected endpoint in data fi le.
23/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-29) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.

Station /Cast	Sample No.	Property	Quality Code	Comment
23/1	102	o2	3	"missed endpoint, correct 0.3708"; with either endpoint, value is 0.2 ml/l high, code questionable. Changed O-rings on bottle 2 prior to sta.26.
23/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.05 PSU. Code salt questionable. Changed O-rings on bottle 2 prior to sta.26.
23/1	114	o2	2	"Overtitrated 0.5164, 1st endpoint wild scatter"; used corrected endpoint in data fi le.
24/1	101	CTDT1	3	SBE35RT-CTDT1 or CTDT2-CTDT1 differences are -0.055/-0.06 deg.C. Code CTDT1 questionable.
24/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-29) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
24/1	102	o2	3	value is 0.2 ml/l high compared to CTDOXY, code questionable. Changed O-rings on bottle 2 prior to sta.26.
24/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.15 PSU. Code salt questionable. Changed O-rings on bottle 2 prior to sta.26.
24/1	105	o2	2	"Overtitrated, 0.3921"; value is acceptable.
24/1	106	o2	2	"Overtitrated, 0.4335"; value is acceptable.
24/1	119	o2	2	"wrong endpoint, correct is .5077", used corrected endpoint in data fi le.
25/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-30) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
25/1	102	o2	3	value is 0.3 ml/l high compared to CTDOXY, code questionable. Changed O-rings on bottle 2 prior to sta.26.
25/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.025 PSU. Code salt questionable. Changed O-rings on bottle 2 prior to sta.26.
25/1	106	o2	2	"Overtitrated, 0.4429"; value is acceptable.
25/1	115	o2	2	"Overtitrated, 0.5375"; value is acceptable.
25/1	121	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.02 PSU. Code salt questionable.
26/1	102	bottle	2	O-rings changed out prior to cast, high bottle oxys,salts this bottle for previous 3 casts.
26/1	109	CTDT1	3	SBE35RT-CTDT1 or CTDT2-CTDT1 differences are +0.125/+0.085 deg.C. Code CTDT1 questionable.
26/1	114	CTDS1	7	Spiking and missing data at CTD trip, due to kink in wire. CTDC1/CTDS1 ok after despike.
26/1	114	CTDT1	7	Spiking and missing data at CTD trip, due to kink in wire. CTDT1 ok after despike.
26/1	115	CTDS1	7	Spiking and missing data at CTD trip, due to kink in wire. CTDC1/CTDS1 ok after despike.
26/1	115	reft	3	SBE35RT-CTDT1 or -CTDT2 difference is -0.07-0.08 deg.C. Code SBE35RT questionable.
26/1	116	CTDS1	7	Spiking and missing data at CTD trip, due to kink in wire. CTDC1/CTDS1 ok after despike.
26/1	116	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.11-0.12 PSU. Code salt questionable.
26/1	119	bottle	9	Bottle did not close. No sample taken.
26/1	121	bottle	3	SSSG tech saw top of btl 21 open during recovery.
27/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-30) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
27/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.035 PSU. Code salt questionable.

Station /Cast	Sample No.	Property	Quality Code	Comment
27/1	107	CTDT2	3	SBE35RT-CTDT2 or CTDT1-CTDT2 differences are +0.05/+0.08 deg.C. Code CTDT2 questionable.
27/1	107	reft	3	SBE35RT-CTDT1 or SBE35RT-CTDT2 differences are +0.13/+0.05 deg.C. Code SBE35RT questionable.
27/1	113	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.02-0.04 PSU. Code salt questionable.
28/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-29) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
28/1	105	o2	2	Overtitration 0.3634. Value is acceptable.
28/1	113	o2	2	Overtitration 0.5132. Value is acceptable.
28/1	117	o2	4	"Overtitration 0.5863; 5mls of io3 added for OT not 1ml". Value +1.9 ml/l high vs nearby or CTDOXY, code bad.
29/1	102	bottle	4	frequently high Bottle-CTD salinity and o2 differences or no-trip (stas 23-25,27-29) indicate bottle not closing at planned depth. Latch was replaced after sta.13, apparently not working reliably beginning sta.23.
29/1	102	o2	3	Bottle o2 is +0.5 ml/l vs CTDOXY. Code bottle o2 questionable.
29/1	102	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.10 PSU. Code salt questionable.
29/1	110	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.035 PSU. Code salt questionable.
29/1	116	salt	3	Bottle-CTDS1 or -CTDS2 difference is +0.025 PSU. Code salt questionable.
32/1	101	o2	4	Bottle oxygen high. Footnote O2 bad.
32/1	106	o2	4	Bottle oxygen high. Footnote O2 bad.
32/1	107	o2	4	Bad titer. Footnote O2 bad.
32/1	108	o2	4	Bottle oxygen high. Footnote O2 bad.
32/1	110	bottle	9	Bottle leaking. No samples taken.
32/1	111	o2	4	Bad titer. Footnote O2 bad.
32/1	120	o2	3	Bottle oxygen high. Footnote O2 questionable.
32/1	121	o2	2	Bottle oxygen high. Footnote O2 questionable.
32/1	124	o2	4	Bad titer. Footnote O2 bad.
33/1	110	o2	4	Bad titer. Footnote oxygen bad.
33/1	116	o2	3	Bottle oxygen high. Footnote questionable.
33/1	117	bottle	4	Bottle did not trip.
34/1	115	o2	2	Over titrated, but acceptable.
34/1	117	bottle	4	Bottle o2 unusually cold, may have been a mistrip.
34/1	117	dic	2	Bottle o2 unusually cold, may have been a mistrip.
34/1	117	no2	2	Bottle o2 unusually cold, may have been a mistrip.
34/1	117	no3	2	Bottle o2 unusually cold, may have been a mistrip.
34/1	117	o2	3	Bottle o2 unusually cold, value high, footnote questionable.
34/1	120	o2	2	Over titrated, but acceptable.
34/1	120	salt	2	Bottle salt low for downcast but matches upcast. Footnote acceptable.
34/1	121	salt	2	Bottle salt low for downcast but matches upcast. Footnote acceptable.
37/1	111	dic	2	DIC sampled after salt and at the end of all draws.
37/1	118	o2	3	Bottle O2 low compared with ctdo and other bottles. Footnote sample questionable.
37/1	120	o2	2	Wasn’t over titrated....original end point 0.4082ml of thio. Footnote acceptable.
37/1	121	o2	2	Overtitrated, value acceptable.
38/1	114	bottle	4	Bottom lanyard not hooked; O2 draw temp low. Suspect mistrip.
38/1	114	dic	2	Bottom lanyard not hooked; O2 draw temp low.
38/1	114	no2	2	Bottom lanyard not hooked; O2 draw temp low.
38/1	114	no3	2	Bottom lanyard not hooked; O2 draw temp low.

Station /Cast	Sample No.	Property	Quality Code	Comment
38/1	114	o2	4	Bottom lanyard not hooked; O2 draw temp low, bottle value low. Footnote O2 bad.
38/1	114	salt	4	Bottom lanyard not hooked; O2 draw temp low, salinity low. Footnote bottle salt bad.
38/1	120	o2	2	Overtitrated, value acceptable.
39/1	102	salt	4	Bottle salt high compared to ctd and other bottles. Footnote sample bad.
40/1	109	o2	4	Bad titer. Footnote oxygen bad.
40/1	115	salt	3	Bottle salt high compared to ctd and other bottles. Footnote sample questionable.
40/1	116	salt	3	Bottle salt high compared to ctd and other bottles. Footnote sample questionable.
40/1	119	o2	4	Bottle oxygen low compared to ctd and other bottles. Footnote sample bad.
40/1	120	o2	5	System crashed, sample lost.
40/1	120	salt	4	Bottle salt low compared to ctd and other bottles. Footnote sample bad.
40/1	121	o2	5	System crashed, sample lost.
40/1	121	salt	4	Bottle salt low compared to ctd and other bottles. Footnote sample bad.
41/1	104	salt	2	Bottle salt high compared to ctd and other bottles. Footnote bad.
41/1	116	o2	3	Bottle O2 high compared to ctd and other bottles. Footnote questionable.
41/1	119	salt	3	Bottle salt high compared to ctd and other bottles. Footnote questionable.
41/1	120	o2	3	Bottle O2 high compared to ctd and other bottles. Footnote questionable.
41/1	120	salt	3	Bottle salt low compared to ctd and other bottles. Footnote questionable.
42/1	103	o2	2	Overtitrated, but acceptable.
42/1	113	bottle	3	Bottom O-ring leaky.
43/1	111	o2	2	Overtitrated, value acceptable.
43/1	113	o2	3	Bottle O2 low compared to ctd and other bottles. Footnote questionable.
43/1	124	CTDOXY	3	CTDO2 spiky at surface. Footnote questionable.
44/1	111	o2	5	O2 flask 990 dropped in lab after sampling. Sample lost.
44/1	121	CTDOXY	3	CTDO2 spiky at surface. Footnote questionable.
45/1	115	o2	3	Bottle O2 high compared to ctd and other bottles. Footnote questionable.
45/1	121	CTDOXY	3	CTDO2 spiky.
46/1	101	o2	2	Overtitrated, value acceptable.
46/1	109	bottle	9	Bottle mistripped by operator. No samples drawn.
46/1	113	o2	2	Overtitrated, value acceptable.
47/1	119	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
47/1	120	o2	3	Bottle O2 low compared to ctd and other bottles. Footnote questionable.
47/1	121	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
49/1	110	o2	3	Bottle O2 high compared to ctd and other bottles. Footnote questionable.
51/1	114	salt	3	Bottle salt high compared to ctd and other bottles. Footnote questionable.
51/1	121	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
52/1	106	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
52/1	112	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
52/1	116	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
52/1	118	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
52/1	119	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
53/1	110	o2	3	Bottle O2 high compared to ctd and other bottles. Footnote questionable.
53/1	112	salt	5	Sample lost due to computer failure.
53/1	114	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
53/1	115	o2	3	Bottle O2 high compared to ctd and other bottles. Footnote questionable.
53/1	117	o2	3	Bottle O2 high compared to ctd and other bottles. Footnote questionable.
54/1	101	salt	3	Bottle salinity high compared to ctd and other bottles. Footnote questionable.
54/1	102	salt	3	Bottle salinity high compared to ctd and other bottles. Footnote questionable.

Station /Cast	Sample No.	Property	Quality Code	Comment
54/1	103	salt	3	Bottle salinity high compared to ctd and other bottles. Footnote questionable.
54/1	104	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
54/1	104	salt	4	Bottle salinity high compared to ctd and other bottles. Footnote bad.
54/1	108	o2	3	Bottle O2 high compared to ctd and other bottles. Footnote questionable.
54/1	108	salt	3	Bottle salinity high compared to ctd and other bottles, but agrees with upcast. Footnote questionable.
54/1	114	salt	2	Bottle salinity high compared to ctd and other bottles, but agrees with upcast. Footnote acceptable.
54/1	118	salt	2	Bottle salinity high compared to ctd and other bottles, but agrees with upcast. Footnote acceptable.
54/1	119	o2	4	Bottle O2 high compared to ctd and other bottles. Footnote bad.
54/1	119	salt	2	Bottle salinity high compared to ctd and other bottles, but agrees with upcast. Footnote acceptable.
54/1	120	salt	2	Bottle salinity high compared to ctd and other bottles, but agrees with upcast. Footnote acceptable.
54/1	121	salt	2	Bottle salinity high compared to ctd and other bottles, but agrees with upcast. Footnote acceptable.
55/1	101	o2	3	Bottle O2 lower than ctdo and other bottles. Footnote questionable.
55/1	102	o2	3	Bottle O2 lower than ctdo and other bottles. Footnote questionable.
55/1	103	o2	3	Bottle O2 lower than ctdo and other bottles. Footnote questionable.
55/1	104	o2	3	Bottle O2 lower than ctdo and other bottles. Footnote questionable.
55/1	105	o2	3	Bottle O2 lower than ctdo and other bottles. Footnote questionable.
55/1	114	o2	2	Bottle O2 doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	114	salt	2	Bottle salt doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	115	o2	2	Bottle O2 doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	115	salt	2	Bottle salt doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	116	o2	2	Bottle O2 doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	116	salt	2	Bottle salt doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	117	o2	2	Bottle O2 doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	117	salt	2	Bottle salt doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	118	o2	2	Bottle O2 doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	118	salt	2	Bottle salt doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	119	salt	2	Bottle salt doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
55/1	120	salt	2	Bottle salt doesn’t match ctd and other bottles, but matches upcast; in a gradient. Footnote acceptable.
56/1	113	salt	3	Bottle salt lower than ctds and other bottles. Footnote questionable.
56/1	114	salt	3	Bottle salt lower than ctds and other bottles. Footnote questionable.
56/1	115	salt	3	Bottle salt higher than ctds and other bottles. Footnote bad.
56/1	116	o2	2	Bottle O2 high compared with ctd and other bottles. Footnote bad.
56/1	116	salt	4	Bottle salt higher than ctds and other bottles. Footnote bad.

Station /Cast	Sample No.	Property	Quality Code	Comment
56/1	117	o2	2	Bottle O2 high compared with ctd and other bottles. Footnote questionable.
56/1	117	salt	3	Bottle salt higher than ctds and other bottles. Footnote bad.
56/1	120	o2	2	Bottle oxygen lower than ctdo and other bottles, but fi ts upcast. Footnote acceptable.
56/1	120	salt	4	Bottle salt higher than ctds and other bottles, but fi ts upcast. Footnote acceptable.
56/1	121	o2	2	Bottle oxygen lower than ctdo and other bottles, but fi ts upcast. Footnote acceptable.
56/1	121	salt	4	Bottle salt higher than ctds and other bottles. Footnote bad.
57/1	101	o2	4	Bad titer. Footnote sample bad.
57/1	116	o2	4	Bottle O2 high compared with ctd and other bottles. Footnote bad.
57/1	117	o2	3	Bottle O2 high compared with ctd and other bottles. Footnote questionable.
57/1	118	salt	2	Bottle salt high compared with ctds downcast, but agrees with downcast. Footnote acceptable.
57/1	119	salt	2	Bottle salt high compared with ctds downcast, but agrees with downcast. Footnote acceptable.
57/1	120	salt	2	Bottle salt high compared with ctds downcast, but agrees with downcast. Footnote acceptable.
57/1	121	salt	2	Bottle salt high compared with ctds downcast, but agrees with downcast. Footnote acceptable.
58/1	101	ctds	3	CTDS lower than bottle salinity and rest of cast. Footnote questionable.
58/1	101	CTDS1	3	CTDS lower than bottle salinity and rest of cast. Footnote questionable.
58/1	115	salt	4	Bottle salt low compared with ctds and other bottles. Footnote bad.
58/1	116	salt	3	Bottle salt high compared with ctds and other bottles. Footnote questionable.
59/1	121	o2	3	Bottle O2 high compared with ctd and other bottles. Footnote questionable.
60/1	121	o2	4	Bottle O2 high compared with ctd and other bottles. Footnote bad.
61/1	101	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	102	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	103	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	104	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	105	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	106	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	107	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	108	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	109	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	110	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	111	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	112	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.

Station /Cast	Sample No.	Property	Quality Code	Comment
61/1	113	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	114	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	115	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	116	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	117	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	118	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	119	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	120	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
61/1	121	o2	2	Thermister broke during sampling; used in-situ temperatures for bottle oxygens.
62/1	111	o2	4	Bottle O2 high compared with ctd and other bottles. Footnote bad.
64/1	119	bottle	2	Spout halfway pushed in to begin with.
65/1	101	CTDOXY	3	CTDO2 drift at bottom.
67/1	109	o2	3	Bottle O2 high compared with ctd and other bottles. Footnote questionable.
67/1	113	o2	3	Bottle salinity high compared with ctd and other bottles. Footnote questionable.
68/1	114	o2	3	Bottle O2 high compared with ctd and other bottles. Footnote questionable.
68/1	115	o2	4	Bottle O2 high compared with ctd and other bottles. Footnote bad.
68/1	119	o2	3	Bottle O2 low compared with ctd and other bottles. Footnote questionable.
68/1	121	o2	2	Bottle O2 high compared with ctd and other bottles. Footnote questionable.
69/1	101	CTDOXY	3	CTD O2 spiky. Footnote questionable.
69/1	110	o2	4	Bottle O2 high compared with ctd and other bottles. Footnote bad.
69/1	119	o2	3	Bottle O2 low compared with ctd and other bottles. Footnote questionable.
69/1	121	CTDOXY	3	CTD O2 low compared with bottle value. Footnote questionable.
69/1	121	ctds	2	CTD O2 low compared with bottle value. Footnote questionable.
69/1	121	o2	2	Bottle O2 high compared with ctd and other bottles.
71/1	101	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	102	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	103	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	104	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	105	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	106	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	107	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	108	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.

Station /Cast	Sample No.	Property	Quality Code	Comment
71/1	109	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	110	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	111	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	112	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	113	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	114	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	115	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	116	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	117	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	118	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	119	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	120	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	121	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	122	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	123	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.
71/1	124	salt	2	Bottle salt high compared with ctds downcast, but agrees with upcast. Footnote acceptable.

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CCHDO Data Processing Notes

- **File Merge** **SEE**

  316N188_ctd.zip (download) #83503
  Date: 2016-09-12
  Current Status: merged

- **CTD exchange and netcdf formats online** **SEE**

  Date: 2016-09-12
  Data Type: CTD
  Action: Website Update
  Note:

```
    2007 316N20070207 processing - CTD/merge -
CTDPRS,CTDTMP,CTDSAL,CTDOXY,FLUOR,CTDNOBS

2016-09-12

SEE


Submission

filename        submitted by date       id
--------------- ------------ ---------- -----
316N188_ctd.zip Lynne Talley 2012-08-22 10415

Changes
-------

316N188_ctd.zip
        - converted WOCE CTD and SUM files to Exchange
        -     neither the WOCE CTD or SUM files are in the correct WOCE
format
        - TIME,DATE,LATITUDE,LONGITUDE taken from the "BO" entry of SUM file
        - changed FLUROM to FLUOR
        - did not put DEPTH in Exchange header because it is uncorrected in
          the WOCE ctd files.
        - renamed ctd files to exchange format file names
        - added units comments
        - added cruise information as commented header

Conversion
----------

file                     converted from       software
------------------------ -------------------- -----------------------
316N20070207_nc_ctd.zip 316N20070207_ct1.zip hydro 0.8.2-47-g3c55cd3
```

```
Updated Files Manifest
----------------------

file                     stamp
------------------------ -----------------
316N20070207_ct1.zip     20160912CCHSIOSEE
316N20070207_nc_ctd.zip 20160912CCHSIOSEE

:Updated parameters: CTDPRS,CTDTMP,CTDSAL,CTDOXY,FLUOR,CTDNOBS

opened in JOA with no apparent problems:
     316N20070207_ct1.zip
     316N20070207_nc_ctd.zip

opened in ODV with no apparent problems:
     316N20070207_ct1.zip
```

- **Exchange and neCDF not available Carolina Berys**

  Date: 2016-04-29
  Data Type: BTL
  Action: Website Update
  Note:

  ```
  Exchange and netCDf bottle files not available due to conversion errors
  ```

- **File Merge Carolina Berys**

  316N188_hy.txt (download) #ae757
  Date: 2016-04-27
  Current Status: merged

- **Bottle file processed** **Carolina Berys**

  Date: 2016-04-27
  Data Type: Bottle
  Action: Update
  Note:

```
CLMD4 2007 316N20070207 processing - BTL

2016-04-27

C Berys

Submission

filename        submitted by  date        id
----------------------------------------------------------------------
316N188_hy.txt  Lynne Talley  2012-08-22  6500

Changes

- 316N188_hy.txt renamed 316N20070207hy.txt

Conversion
----------

file                     converted from                         software
--------------------------------------------------------------------------------
----
316N20070207_hy1.csv     316N20070207hy.txt, 316N20070207su.txt  0.8.2-47-
g3c55cd3
316N20070207_nc_hyd.zip  316N20070207_hy1.zip hydro              0.8.2-47-
g3c55cd3

Updated Files Manifest
----------------------

file                     stamp
----------------------------------------------
316N20070207_hy1.csv     20160427SIOCCHCBG
316N20070207_nc_hyd.zip  20160427SIOCCHCBG
316N20070207hy.txt
```

- **File Update** **CCHDO System**

  316N20070207su.txt (download) #690d1
  Date: 2015-04-23
  Current Status: dataset
  Notes

```
There is not enough information to know where this file should go in the
timeline.
```

- **File Update CCHDO System**

  316N20070207hy.txt (download) #c47ae
  Date: 2015-04-23
  Current Status: dataset
  Notes

  ```
  There is not enough information to know where this file should go in the
  timeline.
  ```

- **File Update CCHDO System**

  316N20070207_ct1.zip (download) #23f7f
  Date: 2015-04-23
  Current Status: dataset
  Notes

  ```
  There is not enough information to know where this file should go in the
  timeline.
  ```

- **File Update CCHDO System**

  316N20070207_nc_ctd.zip (download) #2efa3
  Date: 2015-04-23
  Current Status: dataset
  Notes

  ```
  There is not enough information to know where this file should go in the
  timeline.
  ```

- **File Merge cchdo_admin**

  316N188_su.txt (download) #c5d18
  Date: 2014-08-27
  Current Status: merged
  Notes

  ```
  SUM
  ```

- **Put SUM file online** **Geetha Ratnam**

  Date: 2014-08-27
  Data Type: SUM
  Action: Website Update
  Note:

```
========================================
CLMD4 2007 316N20070207 processing - SUM
========================================

2014-08-27

G Ratnam

.. contents:: :depth: 2

Submission
==========

============== ============ ========== ========= ===
filename       submitted by date       data type id
============== ============ ========== ========= ===
316N188_su.txt Lynne Talley 2012-08-22 SUM       871
============== ============ ========== ========= ===


Process
=======

Changes
-------
-Put SUM file online.
316N188_su.txt
~~~~~~~~~~~~~~

.. _merge:

Merge
-----

316N188_su.txt
~~~~~~~~~~~~~~

Directories
===========
:working directory:
  /data/co2clivar/atlantic/clmd4_316N20070207/original/2014.08.27_SUM_GR
:cruise directory:
  /data/co2clivar/atlantic/clmd4_316N20070207

Updated Files Manifest
======================
================== =====
file               stamp
```

```
================= =====
316N20070207su.txt
================= =====
```

- **Available under 'Files as received'** **CCHDO Staff**

  Date: 2012-09-14
  Data Type: CrsRpt/SUM/CTD/WOCE BTL
  Action: Website Update
  Note:

  ```
  The following files are now available online under 'Files as received',
  unprocessed by the CCHDO.

  316N188_su.txt
  316N188_hy.txt
  Cruise Report_KN188-1_final.pdf
  KN188 Leg 2 Cruise Report_final.pdf
  316N188_ctd.zip
  ```

- **File Submission** **Lynne Talley**

  316N188_su.txt (download) #c5d18
  Date: 2012-08-22
  Current Status: merged
  Notes

  ```
  SUM file
  ```

- **File Submission** **Talley, Lynne**

  316N188_su.txt (download) #c5d18
  Date: 2012-08-22
  Current Status: merged
  Notes

  ```
  Expocode: 316N188
  Ship: Knorr
  Woce Line: none
  Note: CLIMODE cruise: 2 legs on Knorr, Feb-March 2007. No WOCE designator.
  Full bottle data and CTD files, 71 stations. Carbon data for stations 1-30
  only, remaining data will be sent when ready. 2 separate cruise reports cover
  legs 1 and 2.
  ```

- **File Submission** **Lynne Talley**

  316N188_hy.txt (download) #ae757
  Date: 2012-08-22
  Current Status: merged
  Notes

  ```
  WOCE bottle file
  ```

- **File Submission** **Talley, Lynne**

  316N188_hy.txt (download) #ae757
  Date: 2012-08-22
  Current Status: merged
  Notes

  ```
  Expocode: 316N188
  Ship: Knorr
  Woce Line: none
  Note: CLIMODE cruise: 2 legs on Knorr, Feb-March 2007. No WOCE designator.
  Full bottle data and CTD files, 71 stations. Carbon data for stations 1-30
  only, remaining data will be sent when ready. 2 separate cruise reports cover
  legs 1 and 2.
  ```

- **File Submission** **Lynne Talley**

  Cruise Report_KN188-1_final.pdf (download) #5fb3e
  Date: 2012-08-22
  Current Status: unprocessed
  Notes

  ```
  Cruise documentation
  ```

- **File Submission** **Talley, Lynne**

  Cruise Report_KN188-1_final.pdf (download) #5fb3e
  Date: 2012-08-22
  Current Status: unprocessed
  Notes

  ```
  Expocode: 316N188
  Ship: Knorr
  Woce Line: none
  Note: CLIMODE cruise: 2 legs on Knorr, Feb-March 2007. No WOCE designator.
  Full bottle data and CTD files, 71 stations. Carbon data for stations 1-30
  only, remaining data will be sent when ready. 2 separate cruise reports cover
  legs 1 and 2.
  ```

- **File Submission** **Lynne Talley**

  KN188 Leg 2 Cruise Report_final.pdf (download) #d34a6
  Date: 2012-08-22
  Current Status: unprocessed
  Notes

  ```
  Cruise documentation
  ```

- **File Submission** **Talley, Lynne**

  KN188 Leg 2 Cruise Report_final.pdf (download) #d34a6
  Date: 2012-08-22
  Current Status: unprocessed
  Notes

  ```
  Expocode: 316N188
  Ship: Knorr
  Woce Line: none
  Note: CLIMODE cruise: 2 legs on Knorr, Feb-March 2007. No WOCE designator.
  Full bottle data and CTD files, 71 stations. Carbon data for stations 1-30
  only, remaining data will be sent when ready. 2 separate cruise reports cover
  legs 1 and 2.
  ```

- **File Submission** **Lynne Talley**

  316N188_ctd.zip (download) #83503
  Date: 2012-08-22
  Current Status: merged
  Notes

  ```
  CTD
  ```

- **File Submission** **Talley, Lynne**

  316N188_ctd.zip (download) #83503
  Date: 2012-08-22
  Current Status: merged
  Notes

  ```
  Expocode: 316N188
  Ship: Knorr
  Woce Line: none
  Note: CLIMODE cruise: 2 legs on Knorr, Feb-March 2007. No WOCE designator.
  Full bottle data and CTD files, 71 stations. Carbon data for stations 1-30
  only, remaining data will be sent when ready. 2 separate cruise reports cover
  legs 1 and 2.
  ```

- **to go online** **Lynne Talley**

  Date: 2012-08-22
  Data Type: CTD/BTL/SUM/CrsRpt
  Action: Submitted
  Note:

  ```
  CLIMODE cruise: 2 legs on Knorr, Feb-March 2007. No WOCE designator. Full
  bottle data and CTD files, 71 stations. Carbon data for stations 1-30 only,
  remaining data will be sent when ready. 2 separate cruise reports cover legs
  1 and 2.
  ```