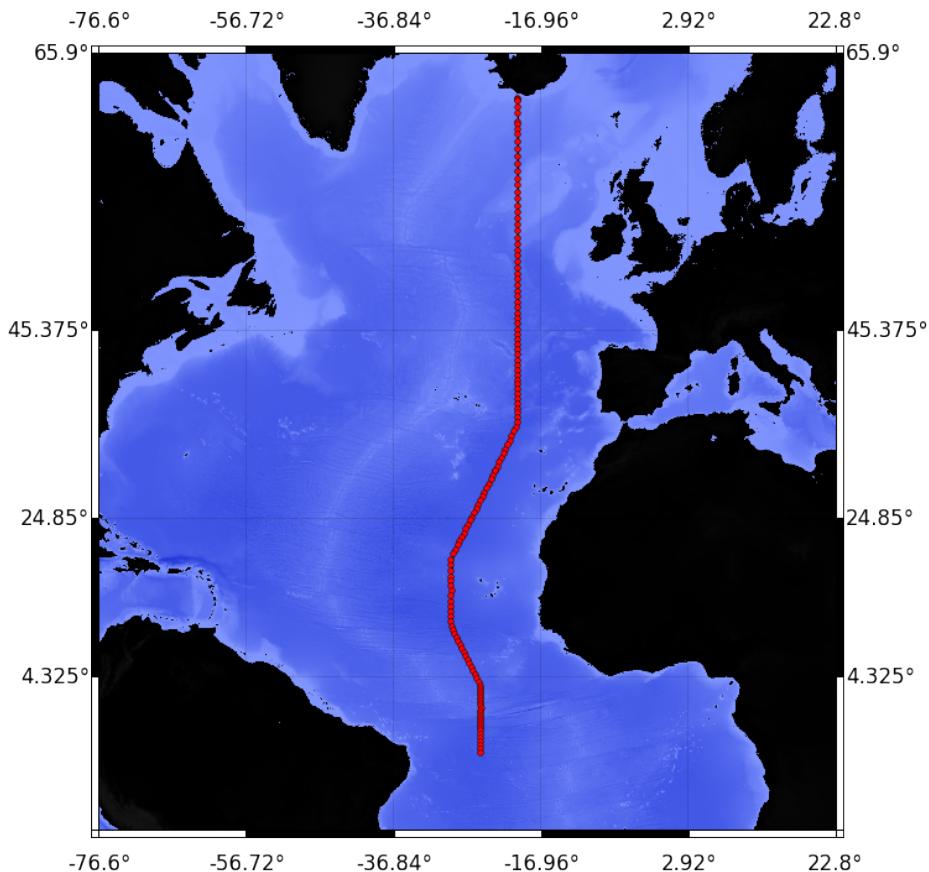


CRUISE REPORT: A16N

(Updated JUN 2014)



Highlights

Cruise Summary Information

Section Designation	A16N
Expedition designation (ExpoCodes)	33RO20130803
Chief Scientists	Molly O. Baringer / AOML John L. Bullister / PMEL
Dates	2013 AUG 03 - 2013 OCT 03
Ship	R/V RONALD H. BROWN
Ports of call	Reykjavik, Iceland - Funchal, Madeira - Natal, Brazil
Geographic Boundaries	29° W 63° 6.89' N 19° 59.97' W 5° 59.9' S
Stations	145
Floats and drifters deployed	16 Argo floats and 10 surface drifters deployed
Moorings deployed or recovered	0

Contact Information:

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Email: baringer@aoml.noaa.gov

NOAA/PMEL
Pacific Marine Environmental Laboratory
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Links To Select Topics

Shaded sections are not relevant to this cruise or were not available when this report was compiled.

Cruise Summary Information		Hydrographic Measurements
Description of Scientific Program		CTD Data:
Geographic Boundaries		Acquisition
Cruise Track (Figure): PI CCHDO		Processing
Description of Stations		Calibration
Description of Parameters Sampled		Temperature Pressure
Bottle Depth Distributions (Figure)		Salinities Oxygens
Floats and Drifters Deployed		Bottle Data
Moorings Deployed or Recovered		Salinity
		Oxygen
Principal Investigators		Nutrients
Cruise Participants		Carbon System Parameters
		CFCs
Problems and Goals Not Achieved		Helium / Tritium
Other Incidents of Note		Radiocarbon
Underway Data Information		References
Navigation		
Bathymetry		
Acoustic Doppler Current Profiler (ADCP)		
Thermosalinograph		
XBT and/or XCTD		
Meteorological Observations		Acknowledgments
Atmospheric Chemistry Data		
Data Processing Notes		

CLIVAR/GO-SHIP A16N_2013 Cruise Report

Leg 1

NOAA Ship Ronald H. Brown
03 August 2013 - 23 August 2013
Reykjavik, Iceland - Funchal, Madeira

Chief Scientist:
Dr. Molly O'Neil Baringer
National Oceanic and Atmospheric Administration, AOML

Co-Chief Scientist:
Dr. Denis L. Volkov
National Oceanic and Atmospheric Administration, AOML

Leg 2

NOAA Ship Ronald H. Brown
01 September 2013 - 03 October 2013
Funchal, Madeira - Natal, Brazil

Chief Scientist:
Dr. John L. Bullister
National Oceanic and Atmospheric Administration, PMEL

Co-Chief Scientist:
Dr. Rolf E. Sonnerup
University of Washington, JISAO

*CTD Data Submitted by:
Kristene E. McTaggart
Pacific Marine Environmental Laboratory (PMEL)
National Oceanic and Atmospheric Administration (NOAA)
Seattle, WA*

*Preliminary Bottle Data Submitted by:
Courtney M. Schatzman
Shipboard Technical Support/Oceanographic Data Facility
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(last edited 24 June 2014)

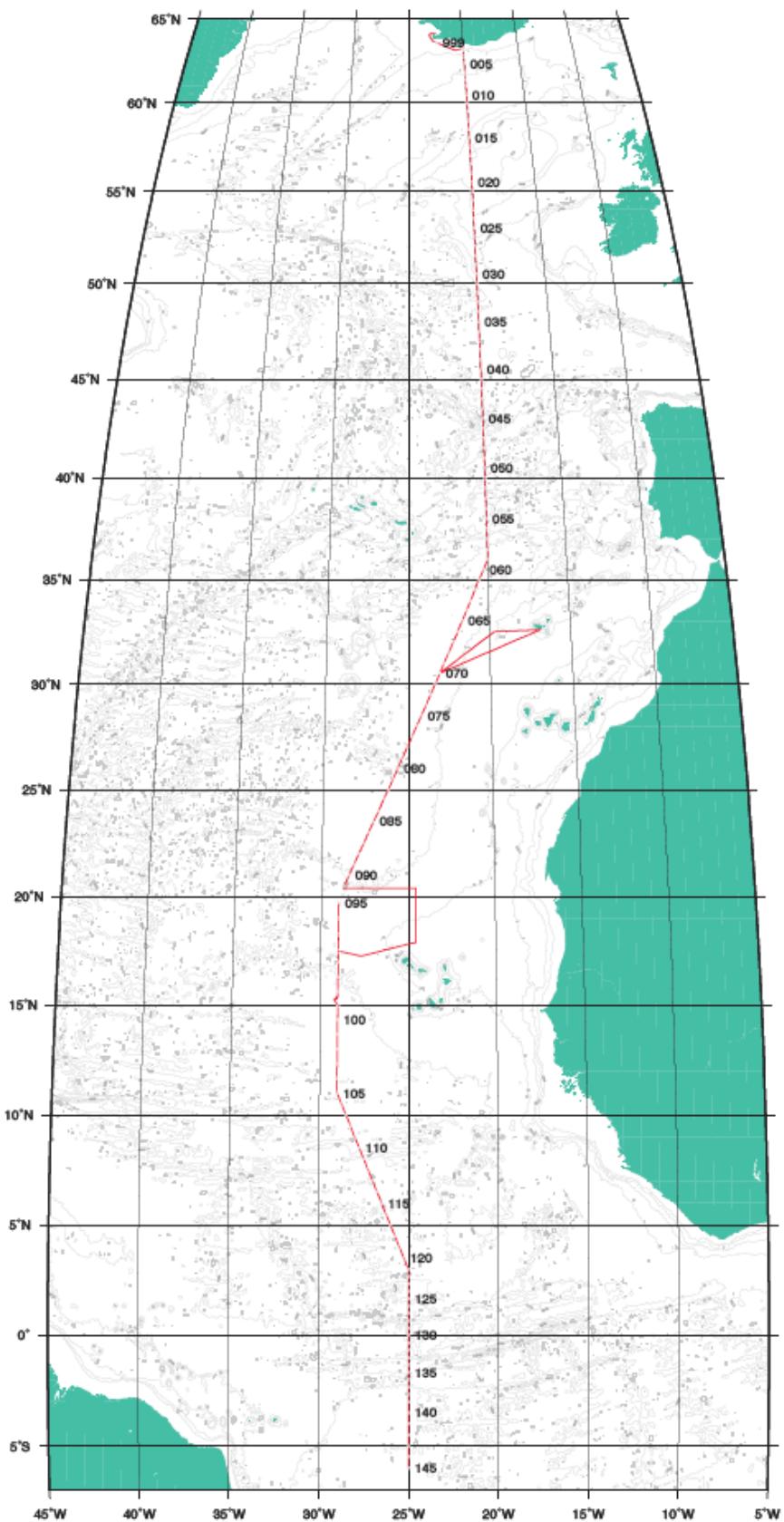


Fig. 1.1: A16N_2013 CRUISE TRACK

Introduction

CLIVAR/GO-SHIP cruise A16N_2013 in the North Atlantic on NOAA ship *Ronald H. Brown* was successfully completed over two legs: Leg 1: (3 August to 23 August 2013) and Leg 2: (1 September to 3 October 2013). This cruise is part of a decadal series of repeat hydrography sections jointly funded by NOAA-OCO and NSF-OCE as part of the CLIVAR/GO-SHIP/CO₂/Hydrography/Tracer program (<http://ushydro.ucsd.edu>). The goal of this effort is to occupy a set of hydrographic transects over the global ocean with full water column measurements to study physical, hydrographic and chemical changes over time. Leg 1 of the A16N_2013 cruise began in Reykjavik, Iceland and ended in Funchal, Portugal (island of Madeira). Leg 2 of the A16N_2013 cruise began in Funchal, Portugal and ended in Natal, Brazil. Various academic institutions and NOAA research laboratories participated in the cruise. The A16N_2013 cruise ran from approximately 66°N to 6°S, repeating the section previously occupied by the US in 1988 and 2003. A total of 145 full water column CTD/0₂/LADCP/rosette casts were completed along the A16N_2013 section at ~30 nautical mile (nm) spacing, with closer spacing near boundaries and between 3°N and 3°S. A 24 position rosette was used for the hydrocasts. Approximately 3400 bottle samples were collected on these casts to be analyzed of a variety of parameters including salinity, dissolved oxygen, nutrients, chlorofluorocarbons (CFCs), nitrous oxide (N₂O), sulfur hexafluoride (SF₆), trifluoromethyl sulfur pentafluoride (CF₃SF₅), dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), alkalinity, pH, carbon isotopes (¹⁴C of DIC and of DOC), ¹⁵N and ¹⁸O of N₂O, ¹⁸O/¹⁶O of H₂O, helium, tritium, chromophoric dissolved organic matter (CDOM) and particulate organic carbon (POC).

Separate casts for trace metal analysis were occupied at approximately 60 nm spacing, using a specially designed 12 position trace metal clean winch and rosette system.

Data from the cruise are available from the CLIVAR and carbon hydrographic data office (CCHDO) at:
<http://cchdo.ucsd.edu/cruise/33RO20130803>

Underway data collection included meteorological parameters, upper ocean current measurements from the shipboard ADCP, surface oceanographic (temperature, salinity, pCO₂) from the ship's underway clean seawater intake, bathymetric data, and measurements of atmospheric CO₂, CFCs, SF₆ and ozone.

Acknowledgments

The successful completion of the cruise relied on the dedicated assistance from many individuals on shore and on the NOAA ship *Ronald H. Brown*. Funded investigators in the project and members of the CLIVAR Repeat Hydrography/CO₂ program were instrumental in the successful planning and executing of the cruise. All of the participants showed dedication and camaraderie during their 21 days at sea on Leg 1 and 33 days at sea on Leg 2. Officers and crew of the *Ronald H. Brown* exhibited a high degree of professionalism and assistance in accomplishing the mission and made us feel at home during the voyage. Survey Technicians Darcy Elizabeth, Jonathan Shannahoff and Electronic Technicians Clay Norfleet and Jeff Hill contributed to the success of this cruise through their able deck handling, stewardship of shipboard scientific gear and troubleshooting experience.

The US Repeat Hydrography / CO₂ Program is sponsored by NOAA's Office of Climate Observations and the National Science Foundation. In particular, we wish to thank program managers David Legler (NOAA) and Eric Itsweire (NSF/OCE) for their support.

Clearance was requested and granted from the sovereign nations of Iceland and Portugal for research conducted in their territorial waters. Their collaboration in the research effort is greatly appreciated.

Thanks to science participants Monica Mejia, Josh Levy and Rachel Shelley for their informal 'blogs' that recount cruise/port highlights. They can be found at: http://teachers.dadeschools.net/mmejia/ERFS_AgroEcology>Hello.html, <http://4869milevoyage.blogspot.com/> and <http://eoas-fsu-clivar.blogspot.com/>

Background

The CLIVAR Repeat Hydrography Program focuses on the need to monitor inventories of CO₂, tracers, heat, and freshwater and their transports in the ocean. Earlier programs under WOCE and JGOFS provided a baseline observational field for these parameters. The new measurements reveal much about the changing patterns on decadal scales. The program serves as a backbone to assess changes in the ocean's biogeochemical cycle in response to natural and/or man-induced activity. Global changes in the ocean's transport of heat and freshwater, which can have a significant impact on climate, can

be followed through these long-term measurements. The CLIVAR Repeat Hydrography Program provides a robust observational framework to monitor these long-term trends. These measurements are in support of:

- Model calibration and testing
- Carbon system studies
- Heat and freshwater storage and flux studies
- Deep and shallow water mass and ventilation studies
- Calibration of autonomous sensors

This program follows the invasion of anthropogenic CO₂ and transient tracers into the oceans on decadal timescales, and determines the variability of the inorganic carbon system and its relationship to biological and physical processes. More details on the program can be found at the website: <http://ushydro.ucsd.edu>. Specific information about this cruise can be found at: <http://www.aoml.noaa.gov/ocd/gcc/A16N/>

CLIVAR/Carbon A16N_2013 Participating Institutions

Abbreviation	Institution
AOML	Atlantic Oceanographic and Meteorological Laboratory - NOAA
CPO	Climate Program Office - NOAA
FSU	Florida State University
LDEO	Lamont-Doherty Earth Observatory/Columbia University
NASA	National Aeronautics and Space Administration
PMEL	Pacific Marine Environmental Laboratory - NOAA
PU	Princeton University
RSMAS	Rosenstiel School of Marine and Atmospheric Science/University of Miami
SIO	Scripps Institution of Oceanography/University of California at San Diego
TAMU	Texas A&M University
UCSB	University of California, Santa Barbara
UCI	University of California, Irvine
UH	University of Hawaii at Manoa
WHOI	Woods Hole Oceanographic Institution
UW	University of Washington

Principal Programs of CLIVAR/Carbon A16N_2013

Analysis	Email	Institution	Principal Investigator
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¹⁴ C-DIC and ¹³ C-DIC	amcnichol@whoi.edu	WHOI	Ann McNichol
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Drifter Deployment	Shaun.Dolk@noaa.gov	NOAA/AOML	Shaun Dolk
Underway surface ocean, meteorological and bathymetry data		NOAA	Ship personnel

Scientific Personnel CLIVAR/Carbon A16N_2013 Leg I

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CTD Watch	Martine Stueben	RSMAS	mstueben@gmail.com
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Dissolved O ₂	Laura Stoltberg	RSMAS	l.stolti@yahoo.com
Nutrients	Eric Wisegarver	PMEL	eric.wisegarver@noaa.gov
Nutrients	Charles Fischer	AOML	charles.fischer@noaa.gov
Total CO ₂ (DIC)	Robert Castle	AOML	robert.castle@noaa.gov
Total CO ₂ (DIC)	Charles Featherstone	AOML	charles.featherstone@noaa.gov
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CDOM	Eli Aghassi	UCSB	eaghassiaeri.ucsb.edu

Measurement Program Summary

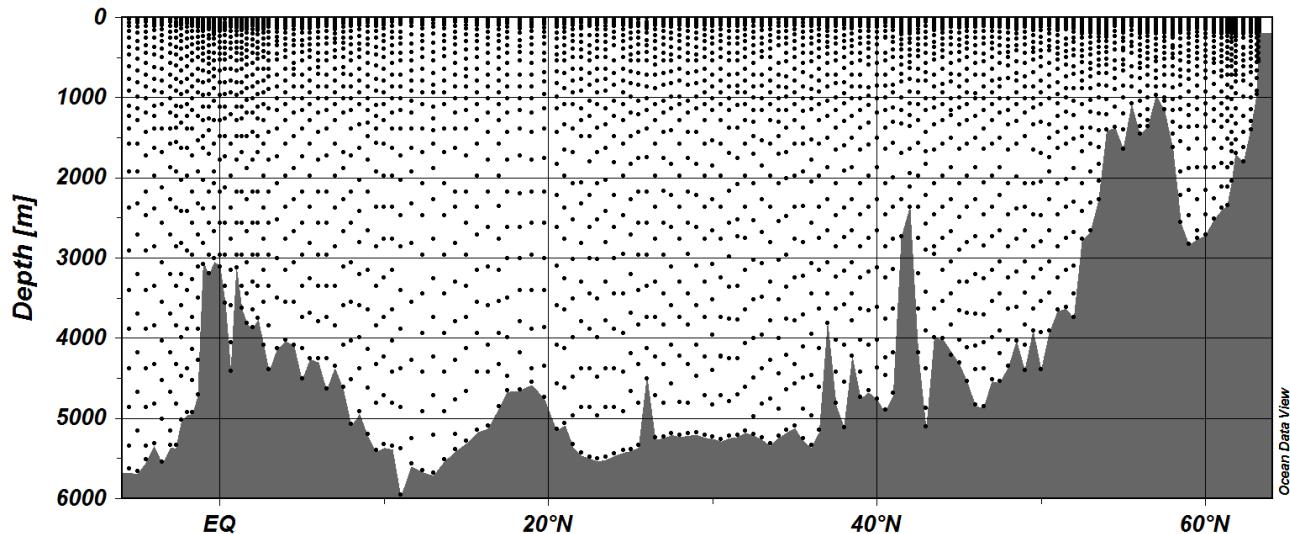


Fig. 1.2: A16N Bottle Sample distribution

This cruise was a reoccupation of a meridional section nominally along 20°W (WOCE Section A16N, occupied in 1988 and 2003). Operations included CTDO/LADCP/rosette casts nominally at half-degree spacing. Underway data collected included upper-ocean currents from the shipboard ADCP, surface oceanographic and meteorological parameters from the ship's underway systems, and bathymetric data. Ancillary operations included surface drifter deployments and Argo float deployments.

NOAA Ship Ronald H. Brown departed Reykjavik, Iceland, after a 2-day delay on August 3, 2013 at 0800 local time. A successful test cast to 213 meters was completed that afternoon, and stations started in earnest that evening at 2200 local time. Leg 1 ended in Funchal, Madeira on August 23. Leg 2 began on September 1 at 2300 local time after an additional 4-day delay to repair the air conditioning system. A successful full water column test cast was completed the next morning and the last station of Leg 1 (Sta. 70 at about 30°30'N) was reoccupied the following morning (as Sta. 71). Following station 91 (20° 30'N) operations were suspended for 67 hours owing to Hurricane Humberto. During this period, the ship steamed southeastward to avoid the path of the hurricane. After the hurricane passed, the ship steamed northward along the section (from 17° 30'N to 19°45'N) to occupy stations (92-95) missed by the detour. Station spacing along this segment was increased from 30 nm to 45 nm. Following a 15-hour steam south, station spacing was then set to 40 nm from 17°N to 10°N to make up for some of the time lost to the hurricane. At 10°N, station spacing was returned to 30 nm for the rest of the leg, except between 3°N-3°S where it was 20 nm. The cruise ended in Natal, Brazil on October 3, 2013.

A total of 145 stations were occupied during A16N_2013. 148 CTDO/LADCP/rosette casts were collected, including 2 test casts and 1 reoccupation at station 96. Sixteen Argo floats and ten surface drifters were deployed. CTDO data, LADCP data, and water samples were collected on most casts, in most cases to within 10 meters of the sea floor (Fig. 1.2).

Salinity, dissolved oxygen, and nutrient samples were analyzed from each station of the principal CTDO/LADCP/rosette program. Water samples were also measured for CFCs, pCO₂, Total CO₂ (DIC), Total Alkalinity, and pH. Additional samples were collected for ³He, Tritium, ¹⁴C/ ¹³C, DOC, DON, and POC.

Winch problems and loss of Rosette Package

During A16N_2013 Leg 2, significant level-wind difficulties developed with the ship's aft winch, which required stops on casts, slow winch speeds and manual adjustments of the winch's level wind mechanism to try to improve spooling of the CTD cable on the winch drum. Because of the poor spooling, it was often necessary to re-lower the CTD-rosette package to deeper depths during up-casts, even after sample bottles were closed, a process which over long vertical distances in regions of significant gradients, could potentially compromise the integrity of the water samples (see following discussion). Once

these problems developed and intensified, a number of discussions between ship's officers, survey, engineers, deck crew and scientists were held. During this period the ship's survey, deck, and engineering crews worked on a number of labor-intensive efforts which involved manually adjusting the level-winding using a variety of techniques. The level-winding did not improve and eventually at an on-board meeting it was decided to switch over to the forward winch at Sta. 96. Although it was thought that the cable on the forward winch was in good condition (and the outer layers of the cable on the forward winch appeared to be in excellent condition) the cable was badly corroded on the lower layers on the winch drum. This resulted in the loss of the CTD-rosette on the first cast using the forward winch (at Sta. 96)- a significant expense and the core equipment needed for our mission. Fortunately, a full backup CTD-rosette package and spares was on board and was rapidly put into service.

The aft winch was used for the next several stations, with continued level-wind problems, which appeared to be severe enough to risk loss of the backup CTD-rosette package. Based on limited options and the observation that a sheave on the level-wind mechanism on the aft winch appeared to have more lateral play than the corresponding one on the forward winch (possibly due to worn bushings), the decision was made to swap the entire level-winding mechanisms between the forward and aft winches. Unfortunately, after completing the swap, level-winding on the aft winch during a test cast was still poor, possibly because of poor spooling on the lower layers already on the drum. A meeting of officers, department heads and chief scientists considered possible ways to proceed, including aborting the expedition to seek repairs at a U.S. port. Rather than abandon the mission altogether, a decision was made at the meeting to attempt to pay out and carefully respool almost the entire length of the aft winch cable (-8700 m) at sea. After the re-spool, the top - 1800 m of wire appeared to have damaged sections (possibly due to contact with the seafloor during the re-spooling operation) and was discarded. This left about 6900 m of cable on the aft winch drum, which was adequate to allow us to complete the deepest stations (-6000 m) on the A16N section, barring further problems or losses.

After these re-spooling procedures and upon reattachment of the backup CTD-rosette package, the spooling of the cable on the aft winch was much improved and the aft winch worked well for their remainder of the cruise (46 additional stations), allowing us to complete the A16N section at 6°S.

First CTD Underwater Package (stations 1-96/2)

Sea-Bird instrumentation was mounted in a green 24-position aluminum rosette frame with 24 10-liter PVC water sample bottles and a 24-position carousel s/n 3261831-0824 provided by AOML. The PVC rosette water sample bottles ('Bullister bottles') used were designed at PMEL. 'Bullister' bottles differ from standard Niskin bottles in that they have a modified end-cap to minimize the contact of the water sample with the end-cap O-rings after closing and utilize stainless steel springs covered with a nylon powder coat instead of internal elastic tubing for closing the bottles. These PMEL-designed bottles are also referred to as 'rosette water sample bottles' or 'Niskin bottles' in this report. Sea-Bird sensors on the first frame included AOML's 9plus CTD s/n 09P61828-1035 and TCO sensors: primary TCO s/n 03P-5403, 04C-3338, 43-1666 with 05T-5946 (stations 1-25) or 05T-3956 (stations 26-96/2); and secondary TCO s/n 03P-2958 (stations 1-45) or 03P-5239 (stations 26-96/2), 04C-3647, 43-1329 with 05T-1027 (stations 1-25) or 05T-5946 (stations 26-96/2). Equal distance between the temperature sensors was PMEL's SBE 35RT internally recording reference temperature sensor s/n 54996-0064. Also mounted on the underwater package was Eric Firing's RDI Workhorse 150 kHz downward looking LACDP and battery pack (not all casts), AOML's Simrad altimeter, PMEL's Metrox load cell s/n 8756, Norm Nelson's Wetlabs fluorometer s/n FLCDRTD-428, and Wilf Gardner's Wetlabs C-Star transmissometer s/n 507DR.

Second CTD Underwater Package (stations 96/4-150)

Sea-Bird instrumentation was mounted in a white 24-position aluminum frame with 20 10-liter 'Bullister' bottles provided by AOML and 4 11-liter 'Bullister' bottles provided by PMEL. The 24-position carousels employed were AOML's s/n 328531-0032 (stations 96/4-98), PMEL's s/n 3210881-0053 (stations 99-103), and the trigger release mechanism of PMEL's s/n 3232696-0471 (stations 104-145). Sea-Bird sensors on the second frame included AOML's 9plus CTD s/n 0957 and PMEL's TCO sensors: primary TCO s/n 03-02/F-1370, 04C-2882, 43-0312 (stations 96/4-100) or 43-2083 (stations 101-145) with 05T-5855; and secondary TCO s/n 03-02-1710, 04C-3068, 43-1835 with 05T-0819. Equal distance between the temperature sensors was PMEL's SBE 35RT internally recording reference temperature sensor s/n 54996-0072. Also mounted on the underwater package was AOML's RDI Workhorse 300 kHz downward looking LACDP and battery pack (not all casts), PMEL's Kongsberg altimeter s/n 1108078 and battery pack, and AOML's Wetlabs fluorometer s/n FLRTD-2088.

CTD Processing and Data Acquisition

Principal Investigator: Gregory Johnson

Analytical Personnel: Kristy McTaggart

Institution: Pacific Marine Environmental Laboratory - NOAA

The CTD data acquisition system consisted of the ship's SBE-IIplus (V2) deck unit s/n 11P98520367 and a networked Dell Optiplex 755 PC workstation running Windows XP Professional. SBE Seasave v.7.21d software (c.2011) was used for data acquisition and to close bottles on the rosette. Real-time digital data were backed up by the data manager, and raw data files were archived immediately after each cast on a thumb drive as well as on Survey and PMEL networked PCs. No real-time data were lost during this cruise.

CTD deployments were initiated by Survey after the Bridge advised that the ship was on station. The computer console operator maintained a CTD Cast log recording position and depth information at the surface, depth, and end of each cast; a record of every attempt to close a bottle, and any pertinent comments.

After the underwater package entered the water, the winch operator would lower it to 15-30 meters and stop. The CTD pumps are configured with a 60-second startup delay, and were usually on by this time. The console operator checked the CTD data for reasonable values, waited an additional three minutes for sensors to stabilize, instructed the winch operator to bring the package to the surface, paused for 10 seconds, and descended to a target depth. The profiling rate was nominally 30 m/min to 50 m, 45 m/min to 200 m, and 60 m/min deeper than 200 m. These rates could vary depending on sea cable tension and the sea state.

The console operator monitored the progress of the deployment and quality of the CTD data through interactive graphics and operational displays. The Chief or co-Chief created a sample log for the cast that would be used to record the water samples taken from each rosette sample bottle. The altimeter channel, CTD depth, wire-out, and EM122 bathymetric depth were all monitored to determine the distance of the package from the bottom allowing a safe approach to within 10 meters. The pinger was on and off the frame during the first half of leg 1 in order to troubleshoot possible magnetic interference with the LADCP. It was on the frame at station 45 to troubleshoot the Bathy 2010. The results were marginal at best. Apparently the Knudsen can track the bottom but not the pinger so the pinger was permanently removed.

Rosette sample bottles were closed on the upcast through the software, and were tripped 30 seconds after stopping at a bottle depth to allow the rosette wake to dissipate and the bottles to flush. The winch operator was instructed to proceed to the next bottle stop 15 seconds after closing bottles to ensure that stable CTD and reference temperature data were associated with the trip.

Near the surface, Survey directed the winch to stop the rosette just beneath the surface. After the surface bottle was closed, the package was recovered. Once on deck, the console operator terminated data acquisition, turned off the deck unit, and assisted with rosette sampling.

At the end of each cast, primary and secondary CTDO sensors were flushed with a solution of dilute Triton-X in de-ionized water using syringes fitted with tubing. The syringes were left attached to the temperature ducts between casts, with the temperature and conductivity sensors immersed in the solution to guard against airborne contaminants.

Acquisition Problems

The CTD was terminated on the aft 0.322 three-conductor winch cable. The electrical termination method used hot glue and heat shrink, and no armor to ground. Test cast 999 to a depth of 213 meters was fully successful.

The transmissometer went to near zero values during the majority of each profile starting with station 2. Over the next several casts, connections were cleaned and reseated and the y-cable was replaced. At station 6 we realized that the previous profiles were actually reasonable data. Values greater than 5V were being reported as near zero values, e.g. 5.012V was being acquired as 0.012V, likely owing to a calibration error in the sensor itself. Wilf Gardner was confident that the data could be corrected post-cruise.

After station 26, the primary pump s/n 5946 (instead of the secondary pump s/n 1027) was inadvertently replaced with pump s/n 3956. So the secondary pump s/n 1027 was removed as intended and replaced with the primary pump s/n 5946. Prior to station 33, the secondary pump s/n 5946 was replaced with pump s/n 5416.

In order to further troubleshoot the transmissometer as requested by Wetlabs, the transmissometer was swapped with the fluorometer on the y-cable during station 42 (V7 to V6). Prior to station 43 the opticals y-cable at the CTD was swapped with the load cell (A/D 4 to A/D 3). Neither of these changes affected the measured values.

Prior to station 46, the secondary temperature sensor s/n 2958 was replaced with s/n 5239 because it was drifting with station number.

The underwater package was stored for 12 days between station 70 and 71 during the in port in Madeira, and for about three days between stations 91 and 92 while detouring around Hurricane Humberto.

Prior to arrival at station 96, the underwater package was attached to the forward winch to evaluate its performance for A16S. At 2957 dbar on the downcast (2872 meters wire out) the cable parted and the package was lost owing to excessive corrosion on the deeper layers of cable. A second package was quickly built and station 96 was reoccupied using the aft winch before continuing south.

Following station 97, the fluorometer cable was replaced and data quality was improved.

Following station 98, the trigger release mechanism on carousel s/n 328531-0032 was replaced with the trigger release mechanism on carousel s/n 3210881-0053 because the latch at position five was not releasing properly.

Between stations 98 and 99 (2.6 days), the level wind mechanisms of the forward and aft winches were swapped in an attempt to improve cable layers on the drum. 1000 meters of CTD cable were cut off the aft winch in order to view the deeper layers on the drum without towing the cable. Success came after the full length of cable on the aft winch drum (8714 meters) was spooled out under tow into less than 5500 meters of water with an 80 lb weight. The last 1740 meters of cable were cut off because of damage likely incurred from contact with the bottom. About 6900 meters of cable remained on the aft winch drum to continue CTD operations.

Following station 100, primary oxygen s/n 312 was replaced with s/n 2083 after drifting low by more than 40 umol/kg below 2000 dbar.

Following station 103, the trigger release mechanism on carousel s/n 3210881-0053 was replaced with the trigger release mechanism on carousel s/n 3232696-0471 because the latch at position 17 was not releasing properly.

Prior to station 118, AOML's LADCP was mounted on the frame. For station 118 and subsequent stations, the altimeter profiles were very noisy in spite of replacing the altimeter, the battery pack, and both cables. Only the adapter cable at the CTD could not be replaced because the spare was lost with the first underwater package. The fluorometer was removed after station 126 because it was echoing the altimeter noise (voltage 4) in the fluorometer profile (voltage 6). Then the altimeter was moved to voltage 6. None of these changes, implemented singly cast by cast, improved the altimeter signal displayed on the computer. However, the trace was such that a trend could be followed and the package stopped at a safe distance from the sea floor. Prior to station 139, the 300 kHz LADCP was removed from the frame and the 200 kHz altimeter trace was completely clean. When the LADCP was put back on the frame, the altimeter trace was noisy again.

CTD Data Processing

The reduction of profile data began with a standard suite of processing modules using Sea-Bird Data Processing Version 7.21d software (Version 7.23.1 post-cruise) in the following order:

DATCNV converts raw data into engineering units and creates a .ROS bottle file. Both down and up casts were processed for scan, elapsed time(s), pressure, tO, tl, cO, cl, oxvol, oxvo2, oxl and ox2. Optical sensor data were converted to voltages and also carried through the processing stream. MARKSCAN was used to skip over scans acquired on deck and while priming the system under water.

ALIGNCTD aligns temperature, conductivity, and oxygen measurements in time relative to pressure to ensure that derived parameters are made using measurements from the same parcel of water. Primary and secondary conductivity were automatically advanced in the V2 deck unit by 0.073 seconds. No further alignment was warranted. It was not necessary to align temperature or oxygen.

BOTTLESUM averages burst data over an 8-second interval (+1- 4 seconds of the confirm bit) and derives both primary and secondary salinity, potential temperature (0), and potential density anomaly (0). Primary and secondary oxygen (in umol/kg) were derived in DATCNV and averaged in BOTTLESUM, as recommended recently by Sea-Bird.

FILTER applies a low pass filter to pressure with a time constant of 0.15 seconds. In order to produce zero phase (no time shift) the filter is first run forward through the file and then run backwards through the file.

CELLTM uses a recursive filter to remove conductivity cell thermal mass effects from measured conductivity. In areas with steep temperature gradients the thermal mass correction is on the order of 0.005 PSS-78. In other areas the correction is negligible. Nominal values of 0.03 and 7.0 s were used for the thermal anomaly amplitude (α) and the thermal anomaly time constant (β^{-1}), respectively, as suggested by Sea-Bird.

LOOPEDIT removes scans associated with pressure slowdowns and reversals. If the CTD velocity is less than 0.25 m s⁻¹ or the pressure is not greater than the previous maximum scan, the scan is omitted.

DERIVE uses 1-dbar averaged pressure, temperature, and conductivity to compute primary and secondary salinity, as well as more accurate oxygen values.

BINAVG averages the data into 1-dbar bins. Each bin is centered on an integer pressure value, e.g. the 1-dbar bin averages scans where pressure is between 0.5 dbar and 1.5 dbar. There is no surface bin. The number of points averaged in each bin is included in the data file.

STRIP removes oxygen that was derived in DATCNV.

TRANS converts the binary data file to ASCII format.

Package slowdowns and reversals owing to ship roll can move mixed water in tow to in front of the CTD sensors and create artificial density inversions and other artifacts. In addition to Seasoft module LOOPEDIT, MATLAB program deloop.m computes values of density locally referenced between every 1 dbar of pressure to compute the square of the buoyancy frequency, N², and linearly interpolates temperature, conductivity, and oxygen voltage over those records where N² is less than or equal to -1 x 10⁻⁵ s⁻². Some profiles failed the criteria in the top 9 dbars. These data were retained by program deloop_post.m and will be flagged as questionable in the final WOCE formatted files.

Program calctd.m reads the delooped data files and applies preliminary calibrations to temperature, conductivity, and oxygen; and computes calibrated salinity.

Pressure Calibration

Pre-cruise pressure calibrations did not account for the 1.7 dbar mean offset that existed with CTD s/n 09P61828-1035 used for casts 0011-0962, or the 2.4 dbar mean offset that existed with CTD s/n 0957 used for casts 0964-1451. These offsets were not applied during the cruise but were subtracted prior to preliminary salinity and oxygen calibrations and to the preliminary data set at the end of the cruise.

On-deck pressure readings prior to each cast were examined at sea and their offsets remained within 1 dbar throughout the cruise. Differences between first and last submerged pressures for each cast were also examined and the residual pressure offsets were also less than 1 dbar.

Post-cruise, the ship's barometric pressure record was used to correct the CTD pressure sensor by -1.6814 dbar for CTD s/n 09P61828-1035 and -2.4505 dbar for CTD s/n 0957. This uniform correction was based on comparing in-air pressure values from the CTD to the ship's barometer and setting the pressure to 0 dbar at standard atmospheric pressure (1013.25 millibar), which is the TEOS-10 definition.

Pressure calibrations were applied to profile data using program calctd.m and to burst data using calclo.m.

Temperature Calibration

A viscous heating correction of -0.0006 °C was applied at sea (as recommended by Sea-Bird) prior to preliminary temperature, conductivity, and oxygen calibrations; and to the preliminary data set at the end of the cruise.

Post-cruise, SBE 35 reference temperature sensor data were used to correct SBE 3 temperature sensor data. For each SBE 3 sensor, residuals between its data and that from the SBE 35 were minimized to determine an offset, slope, and pressure correction term to be applied to temperatures below a determined pressure. For primary temperature sensor s/n 5403 (stations 1-95), these values were 4.2794e-04, 9.0016e-06, -2.4709e-07, and 3415 dbar, respectively. For secondary temperature sensor s/n 1710 (stations 96-145), these values were 7.7731e-04, 2.5514e-8, -3.1140e-7, and 1450 dbar, respectively.

Temperature corrections were applied to profile data using program calctd.m and to burst data using calclo.m.

Conductivity Calibration

Seasoft module BOTTLESUM creates a sample file for each cast. These files were appended using program sbecal.f. Program addsal.f matched sample salinities to CTD salinities by station/sample number.

For primary conductivity sensor s/n 3338, a single conductivity bias, a single pressure correction (pressure times measured conductivity), and a 5th order station-dependent slope were determined using program calcop5.m to produce the best fit to sample data for stations 1-95:

number of points used	1812
total number of points	2184
% of points used in fit	82.97
fit standard deviation	0.001384
fit bias	0.0032037547
fit co pressure correction	-2.5641484e-007
min fit slope	0.99987196
max fit slope	0.9999434

For secondary conductivity sensor s/n 3068, a single conductivity bias and a linear station-dependent slope were determined using program calcos1.m to produce the best fit to sample data for stations 96-145:

number of points used	969
total number of points	1180
% of points used in fit	82.12
fit standard deviation	0.001305
fit bias	-0.0022319781
min fit slope	1.0000634
max fit slope	1.0001293

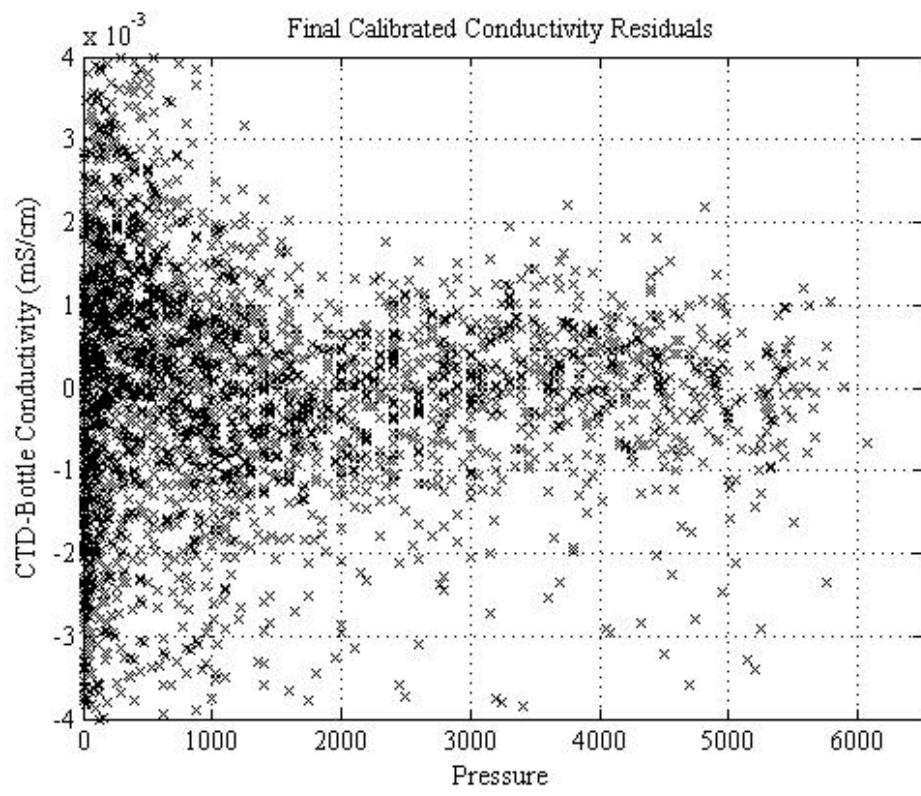
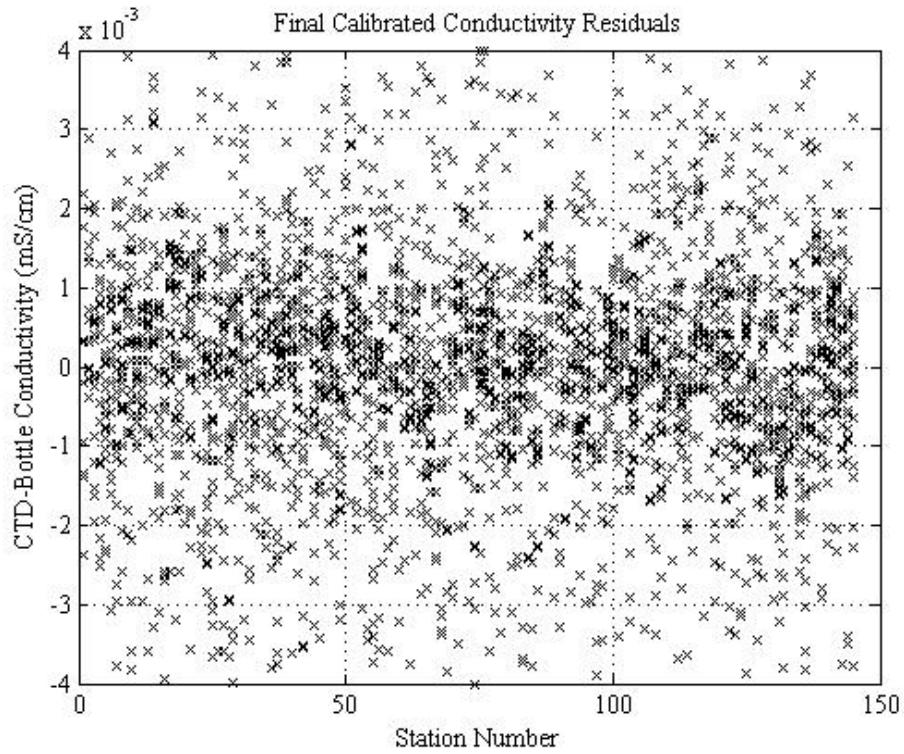


Fig. 1.3 Conductivity calibrations were applied to profile data using program `caletd.m` and to burst data using `calclo.m`. CTD-bottle conductivity differences plotted against station number (top figure) and pressure (bottom figure) allow a visual assessment of the success of the fits.

Oxygen Calibration

A hybrid of the Owens-Millard (1985) and Murphy-Larson (revised 2010) oxygen sensor modeling equations was used to calibrate the SBE-43 oxygen sensor data from this cruise. The equation has the form

$$Ox = Soc * (V + Voff + Tau * \exp(DI * P + D2 * T) * dVdt) * Os * \exp(Tcor * T) * \exp(Pcor * P / (273.15 + T));$$

Where Ox is the CTD oxygen (in umol/kg), V is the measured oxygen voltage (in volts), dVdt is the temporal gradient of the oxygen voltage (in volts/s estimated by running linear fits made over 5 seconds), P is the CTD pressure (in dbar), T is the CTD temperature (in °C), and Os is the oxygen saturation computed from the CTD data following Garcia & Gordon (1992). Oxygen sensor hysteresis was improved by matching upcast bottle oxygen data to downcast CTD data by potential density anomalies referenced to the closest 1000-dbar interval using program match_sgn.m. We used the values provided by SBE for each sensor for the constants D1 (1.9263e4) and D2 (-4.6480e-2) to model the pressure and temperature dependence of the response time for the sensor. For each group of stations fit we determined values of Soc (sometimes station dependent), Voff, Tau, Tcor, and Pcor by minimizing the residuals between the bottle oxygen and CTD oxygen. W represents fitting switches. If the switches are set to 0,0 the fit is a regular L2 (least squares) norm for the entire group. If the switches are set to 1,0 the fit is a regular L2 norm for the entire group but with a slope that is a linear function of station number. If the switches are set to 2,0 the program first fits the entire group, then goes back and fits a slope and bias to individual stations, keeping the other parameters at the group values. If the switches are set to 0,1 the fit is a regular L2 norm for the entire group but it is weighted by the nominal oxygen bottle spacing, thus fitting the deep portion of the water column better.

Program addsal.f matched bottle sample oxygen values to CTD oxygen values by station/sample number. Program run_oxygen_cal_ml.m was used to determine calibration coefficients for five station groupings for s/n 1666 determined by visual inspection:

Stns	Soc Range	Voff	Tau	Tcor	Pcor	Points	Used	StdDev	W
1-21	0.5666-0.5707	-0.4847	5.6445	-0.0020	0.0393	445	86.3%	0.9426	1,1
21-49	0.5754-0.5725	-0.4942	6.6770	-0.0022	0.0396	683	88.4%	1.1352	1,1
49-51	0.5709-0.5729	-0.4943	6.5008	-0.0020	0.0397	71	90.1%	0.8622	1,1
52-76	0.5758-0.5767	-0.4976	4.5274	-0.0020	0.0398	599	91.4%	0.9656	1,1
77-95	0.5762-0.5789	-0.4976	6.6706	-0.0021	0.0397	453	87.9%	0.8445	1,1

Calibration coefficients for the first station grouping for s/n 1835 were used for stations 96-100, and then four groupings for s/n 2083 were used for stations 101-145 determined by visual inspection:

Stns	Soc Start	Voff	Tau	Tcor	Pcor	Points	Used	StdDev	W
96-112	0.3675	-0.6714	6.7454	-0.0006	0.0383	24 ea	87.5%	1.3179	2,0
101-108	0.5729	-0.4969	4.0391	-0.0011	0.0391	184	90.2%	1.0709	0,0
109-117	0.5768	-0.4999	4.3067	-0.0013	0.0392	214	89.2%	0.7842	1,1
118-138	0.5795	-0.5083	5.5426	-0.0010	0.0397	502	89.4%	0.8343	0,1
139-145	0.5818	-0.5081	5.9109	-0.0011	0.0396	168	91.7%	0.6427	0,0

Oxygen calibration coefficients were applied to profile data using program calctd.m, and to burst data using calclo.m.

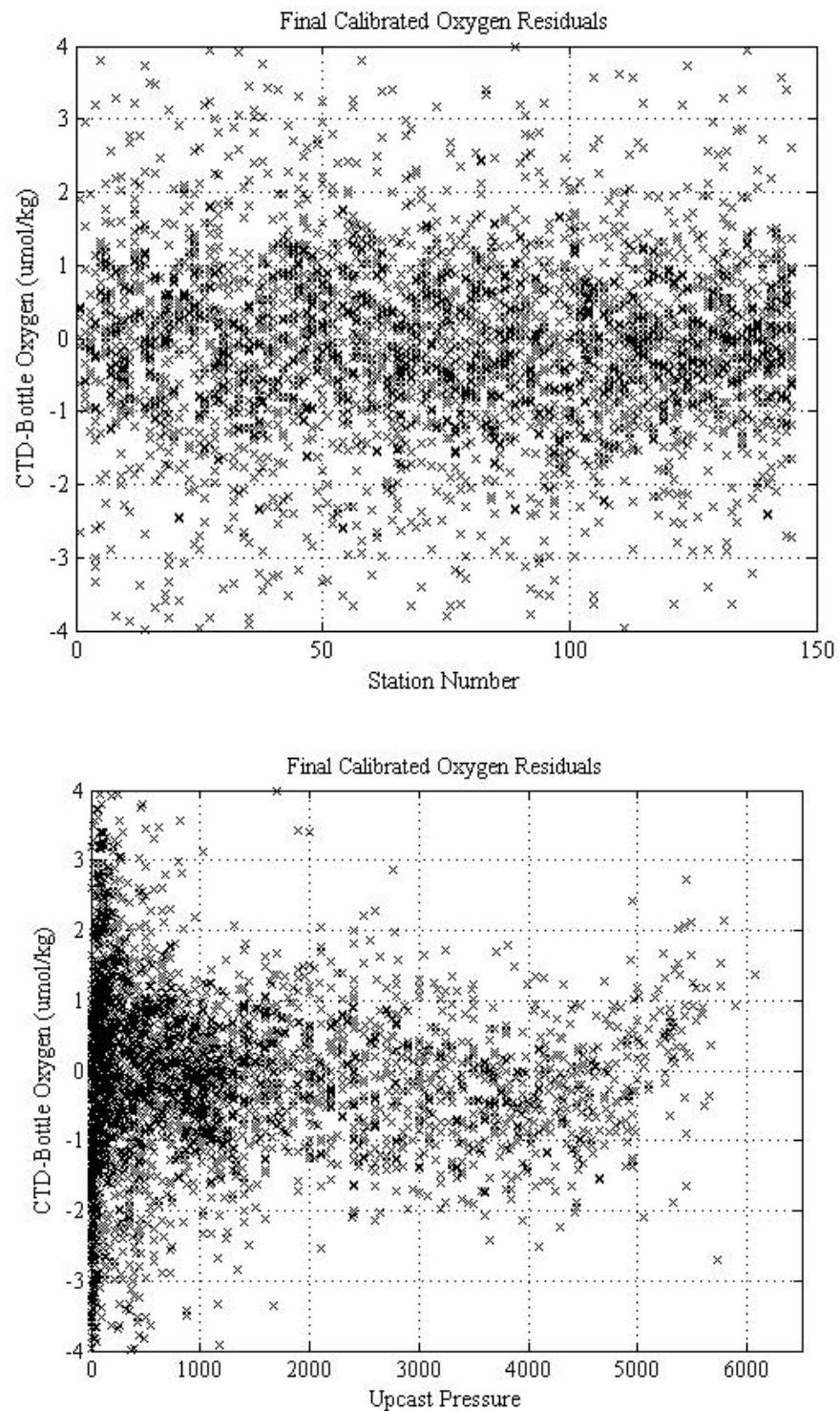


Fig. 1.4 Calibrated CTD - bottle oxygen differences plotted against station number (top figure) and pressure (bottom figure) allow a visual assessment of the success of the fits.

Despiking

Station 96 oxygen profile was despiked between 2635 and 2658 dbar. Oxygen values were interpolated over this pressure range using program `select_interp_ranges.m` and `apply_interp_sal_ox.m`. Interpolated records are indicated with WOCE quality flags of 6.

Bottle Sampling

The NOAA Ship Ronald H. Brown has two Markey DESH-5 winches. The aft winch was used for all 145 occupied stations. One incomplete cast was used on the forward winch that resulted in the loss of the primary package.

Most rosette casts were lowered to within 8-50 meters of the bottom, using an altimeter to determine distance above bottom. Details of these bottom approaches can be found in the Appendix.

A sample plan was utilized to stagger sample depths for all stations throughout A16N_2013. Staggering sample depths was to avoid spatial aliasing with in this sample data set (see Fig. 1.2).

The 24-place SBE32 carousel had few bottle lanyard or mis-tripped bottle problems. Rosette maintenance was performed on a regular basis. O-rings were changed and lanyards repaired as necessary. Rosette bottle maintenance was performed each day to insure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed. Periodic leaks were noted on sample logs. Log notes were cross-referenced with sample data values and quality coded. Log notes, mis-trips, bottle lanyard issues and associated quality codes can be found in the Appendix.

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

- Chlorofluorocarbons (CFCs) and SF₆
- ³He
- O₂
- Disscrete pCO₂
- Dissolved Inorganic Carbon (DIC)
- N₂O Isotopes
- pH
- Total Alkalinity (TALK)
- ¹⁴C of Black Carbon
- ¹⁴C DIC
- Dissolved Organic Carbon (DOC)
- ¹⁵N / ¹⁸O
- ¹⁸O/¹⁶O
- Tritium
- Nutrients
- Density
- Salinity
- Chromophoric Dissolved Organic Matter (CDOM)
- Particulate Organic Carbon (POC)

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 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 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. On-board analysis were performed on computer-assisted (PC) analytical equipment networked to the data processing computer for centralized data management.

Bottle Data Processing

Principal Investigator: Jim Swift

Analytical Personnel: Courtney Schatzman Institution: Scripps Institution of Oceanography/University of California at San Diego

Shipboard CTDO data were re-processed automatically at the end of each deployment using SIO/ODF CTD processing software v.5.2.0. The raw CTDO data and bottle trips acquired by SBE SeaSave on the Windows XP workstation were copied onto the Linux database and web server system. Pre-cruise calibration data were applied to CTD Pressure, Temperature and Conductivity sensor data, then the data were processed to a 0.5-second time series. A 1-decibar down-cast pressure series was created from the time series; CTDO data from down-casts were matched along isopycnals to up-cast trips and extracted, then fit to bottle O₂ data at trips. The pressure series data were used by the web service for interactive plots, sections and on-board CTDO data distribution; the 0.5 second time series data were also available for distribution through the web service.

CTDO data at bottle trips were extracted and added to the bottle database to use for CTD Pressure, Temperature and Salinity data in the preliminary bottle files. Downcast CTDO data, matched to up-cast bottle trips along isopycnals, were used for preliminary bottle file CTDO data. When final CTDO data were submitted, the NOAA/PMEL final PTSO data replaced the preliminary SIO/ODF CTD data in the bottle files.

Water samples collected and properties analyzed shipboard were managed centrally in a relational database (PostgreSQL-8.1.23-6.e15_8) run on a CentOS-5.9 Linux system. A web service (OpenACS5.3.2-3 and AOLServer-4.5.1-1) 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 information (and any diagnostic comments) were 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 various 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. A summary of Bottle Data Quality Codes and sampling comments are included in the Appendix.

Analytical Problems

CTD cast and sample collection logs were used to note bottle malfunctions, rosette anomalies, missed or accidental trips, bottle contamination, winch problems, cast irregularities and loss of data. Bottle data and analytical issues are detailed in the quality code and comments [table](#) portion of the [Appendix](#).

Few recorded mis-trips occurred on either leg of A16N_2013. Station-cast 4/1, oxygen draw temperature had a high reading on bottle 16; further study of nutrients, oxygen and salinity data indicated a mis-trip. Station-cast 132/1, oxygen draw temperature had a high reading on bottle 12; nutrient, oxygen and salinity samples indicated a mis-trip.

The digital reversing thermometer (SBE35RT) bottle-trip data was over written due to limited memory space resulting in loss of data; those stations-casts are 13/1 bottles 12-24, 16/1 bottles 18-20, 77/1 bottles 12-24, 78/1 bottles 1-24, 125/1 bottles 12-24 and 139/1 bottles 12-24.

Potential for contamination to samples drawn near the surface were noted on the CTD cast log sheet was noted on station 56 after a small boat deployment took place at the beginning of this cast as well as a phosphoric acid-wash on outer hull at the end of the same cast.

During stations 80-99 of the second Leg of A16N_2013, there were wire spooling problems with the aft winch. On many of these stations, winch difficulties altered the timing (velocity) of the CTD up-cast. In severe cases (stations listed below), difficulties spooling the wire (on the up-cast) required an interruption to let wire back out to re-spool troublesome sections.

Increased pressure on bottle samples collected thus far could be compromised. The reason is that water can be forced back in to the sample bottle as it is lowered back down in the water column to greater pressures. Although these 'closed bottle' descents were usually on the order of 5 meters, in some instances they were as large as 30-50 meters. A worst-case estimate of the extent to which an individual bottle samples may have been contaminated can be derived from in-situ density changes encountered during the descent.

For an extreme example, we consider rosette sample bottle 1 from cast 80. This bottle was closed at 4586 meters, raised to 1338 meters, lowered to 1361 meters, then raised to the surface.

Assuming the waters pressed back in were from - 1338m (worst case scenario -wcs) and no elasticity in the sample bottle or seals, then:

Leaked in S= 35.3, T=6.64, O₂= 241.2, and from the CTD profile we have:

$$\begin{aligned}\sigma \text{ at } 1338 \text{ m} &= 32.269, \rho_{1338} = 1032.269 \\ \sigma \text{ at } 1362 \text{ m} &= 32.281, \rho_{1362} = 1032.281\end{aligned}$$

From which these relative change in specific volume (the volumetric change due to compression) of the sample can be computed.

$$(\rho_{1362} - \rho_{1338})/\rho_{1338} = 1.16 \times 10^{-5}$$

Presuming that this relative amount from 1338 m (again, wcs) was pushed back into the deepest (wcs) bottle, we can estimate the impacts on that sample's T, S and salinity as follows:

$$\begin{aligned}S_{4586} = 34.9, S_{1338} = 35.3, \text{ calculated anomaly} &= (35.3 - 34.9) \times 1.16 \times 10^{-5} = 4.6 \times 10^{-6} \\ T_{4586} = 2.40, T_{1338} = 6.64, \text{ calculated anomaly} &= (6.64 - 2.40) \times 1.16 \times 10^{-5} = 4.9 \times 10^{-5} \text{ }^{\circ}\text{C} \\ O_2,4586, O_2,1338 = 241.2, \text{ calculated anomaly} &= (241.2 - 180) \times 1.16 \times 10^{-5} = 7.1 \times 10^{-4} \mu\text{mol/kg}\end{aligned}$$

In this worst case scenario calculation, all of these anomalies are far smaller than the measurement precisions for S, T and O₂ of $\pm 2 \times 10^{-3}$, $\pm 2 \times 10^{-3}$ °C, and $\pm 1 \mu\text{mol/kg}$, respectively. As a consequence, the rosette bottles which were re-lowered to deeper depths after closing (see Table 1 below) were not assigned quality flags of '3' (questionable) or '4' (bad) because of this process.

Table 1: A16N_2013 List of stations where sample bottles closed during CTD up-cast were later re-lowered to re-spool the aft winch cable.

Station	Decent Range of CTD (m)	Bottle Affected
80	1338-1362	1-9
	623-638	1-13
83	1267-1282	1-10
	2203-2209	1-7
	2031-2038	1-7
	1676-1677	1-8
	1278-1290	1-10
	149-164	1-18
88	1325-1347	1-9
89	1329-1333	1-10
	2100-2120	1-8
90	2669-2670	1-6
91	1264-1288	1-9
92	1326-1376	1-8
	1364-1371	1-8
	646-655	1-13
	634-664	1-13
	2723-2730	1-5
93	2728-2730	1-5
	2708-2710	1-5
	2706-2719	1-5
95	754-766	1-12
	2718-2710	1-5

Salinity

Principal Investigator: Molly Baringer

Analytical Personnel: Andrew Stefanick & James Hooper

Institution: Atlantic Oceanographic and Meteorological Laboratory - NOAA

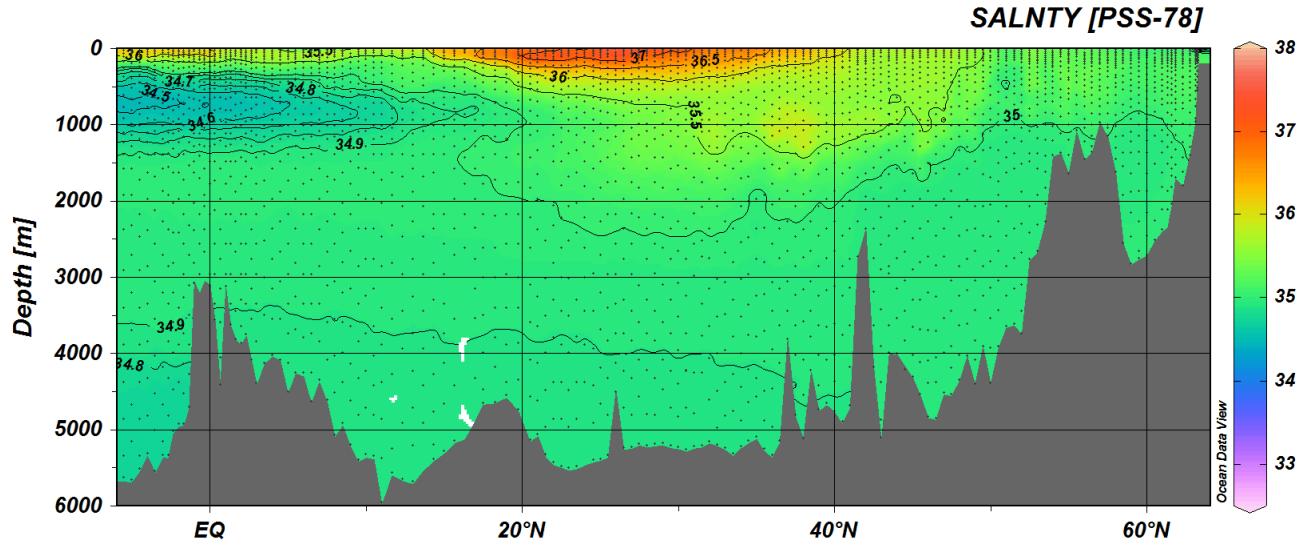


Figure 2.1: A 16N bottle Salinity

Equipment and Techniques

A Guildline Autosal, model 8400B salinometer, located in salinity analysis room, was used for all salinity measurements. The salinometer readings were logged on a computer using Ocean Scientific International's logging hardware and software. The Autosal's water bath temperature was set to 24°C, which the Autosal is designed to automatically maintain. To help further stabilize reading values and improve accuracy, the laboratory's temperature was also set and maintained to just below 24°C. As an additional safeguard, the Autosal was powered using the ship's clean power to minimize electrical noise.

Salinity analyses were performed after samples had equilibrated to laboratory temperature, usually over 24 hours after collection. The salinometer was standardized for each group of samples analyzed (usually 2 casts and up to 50 samples) using two bottles of standard seawater: one at the beginning and at the end of each set of measurements. The salinometer output was logged to a computer file. The software prompted the analyst to flush the instrument's cell and change samples when appropriate. For each sample, the salinometer cell was initially flushed at least 3 times before a set of conductivity ratio readings were taken.

Standards

IAPSO Standard Seawater Batch P-155 was used to standardize all casts.

Sampling and Data Processing

The salinity samples were collected in 200 ml Kimax high-alumina borosilicate bottles that had been rinsed at least three times with sample water 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. Laboratory temperature was also

monitored electronically throughout the cruise. PSS-78 salinity [UNES81] was calculated for each sample from the measured conductivity ratios. The offset between the initial standard seawater value and its reference value was applied to each sample. Then the difference (if any) between the initial and final vials of standard seawater was applied to each sample as a linear function of elapsed run time. The corrected salinity data was then incorporated into the cruise database. When duplicate measurements were deemed to have been collected and run properly, they were averaged and submitted with a quality flag of 6.

On A16N 2013, approximately 4117 salinity measurements were reported and approximately 148 vials of standard seawater (SSW) were used. A duplicate sample was drawn from each cast to determine total analytical precision.

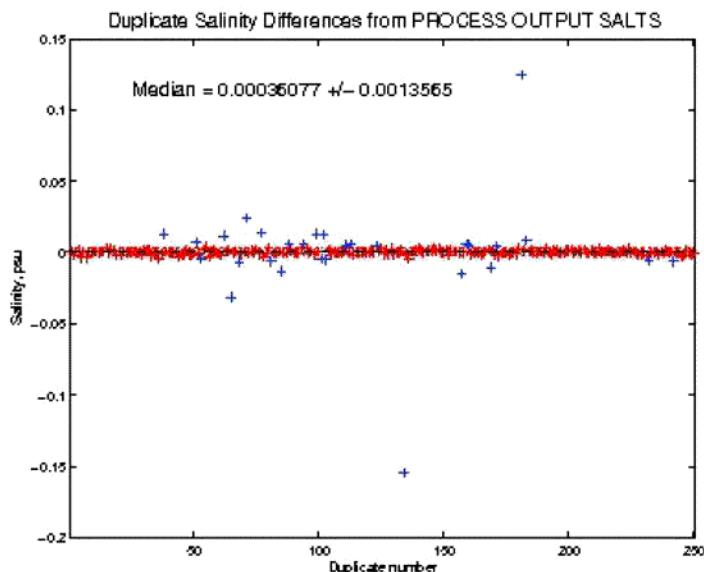


Fig. 2.1: A16N Salinity Duplicates

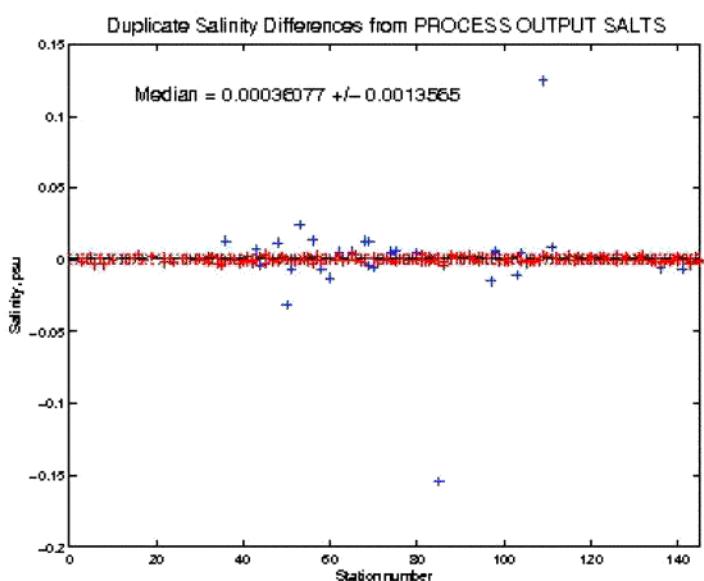


Fig. 2.2: AI6N Salinity Station Duplicates

Analytical Problems

For the sample analysis a newly calibrated Guildline Autosal 8400B serial number: 60843 was used. The calibration date is July 20, 2013 and this was the first analysis done on the machine since calibration. It was setup up in the aft hydrolab's climate controlled room which is set at 24°C. Also setup in that room as a backup was Guildline Autosal 8400b serial number 61664 with a calibration date of June 11, 2012. The unit had been setup in the analysis room already and used on previous trips. A small squealing sound was heard and after inspection found that the cooling fan on the 61644 was seized. The fan was replaced with a spare. After allowing time to acclimate, it was observed that the heater lamps in the water bath of the 61644 were not cycling. The Heater lamps were tested and replaced and found to work properly but still not cycling. After measuring the temperature of the water bath it was found to be at 27.5°C when the machine was set to maintain 24°C. It is possible that the thermal cooling unit may have stopped working on that unit. The backup Autosal was replaced by serial number 61688 with a calibration date of June 11, 2012. It was the first time the unit had been setup since coming back from calibration. During normal analysis runs a substandard of standard seawater was used before the initial beginning calibration. It was run as a sample with multiple flushes to ensure there was no drift in measurement readings upon the start-up of a sample run.

At the initial sample run on Autosal 60843 of the second leg of A16N_2013 (repeat of station 071), it was observed that the sample flow rate through the conductivity cell was slow. All air and water tubes were checked and it was found that the end tubing on the drain side of the cell inside the water bath had become dislodged. The autosal was momentarily turned off for repairs. The cabinet was opened, and the cell was removed to gain access to replace the tubing that had fallen off. After the unit was repaired and powered on, it was allowed to sit for the bath to acclimate as a precaution before running samples.

During the sample run for stations 73 and 74 the drain function was inoperable for the last two samples. Upon inspection it was found that the Cell tube fill had become disconnected causing an air bleed.

Oxygen Analysis

Principal Investigator: Chris Langdon

Analytical Personnel: Laura Stoltenberg

Institution: Rosenstiel School of Marine and Atmospheric Science/University of Miami

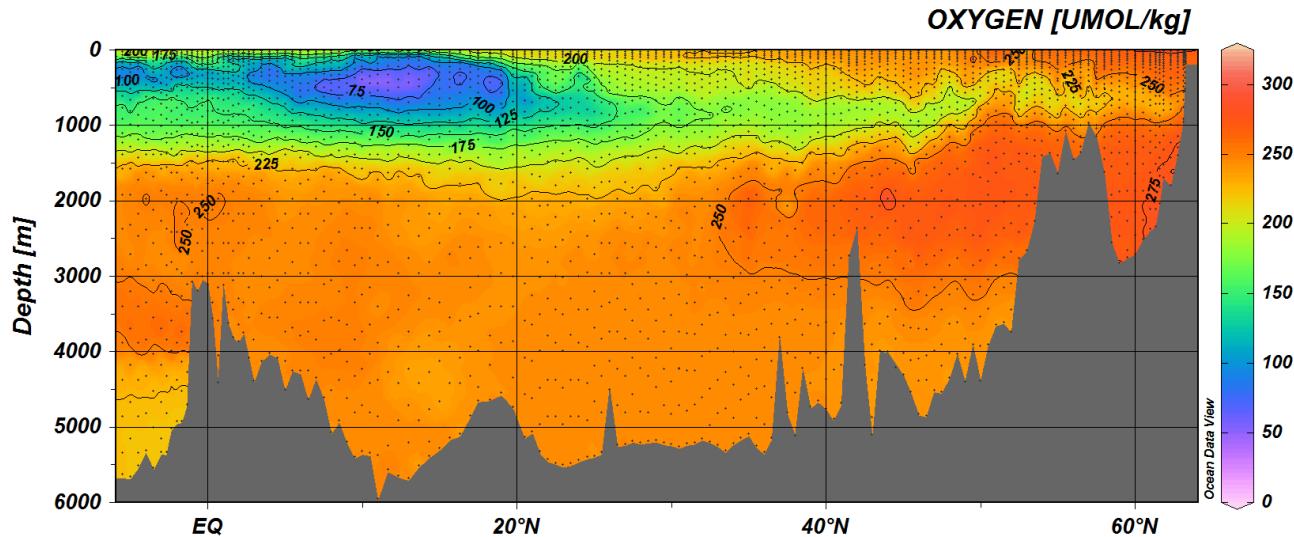


Fig. 3.1: A16N bottle oxygen

Equipment and Techniques

Dissolved oxygen analysis were performed with an automated titrator using amperometric endpoint detection [Lang10]. Sample titration, data logging, and graphical display were performed with a PC running a LabView program written by Ulises Rivero of AOML. Lab temperature was maintained at 19.5-25.4°C. The temperature corrected molarity of the thiosulfate titrant was determined as given by [DOE94]. Thiosulfate was dispensed by a 2 ml Gilment syringe driven with a stepper motor controlled by the titrator. Tests in the lab were performed to confirm that the precision and accuracy of the volume dispensed were comparable or superior to the Dosimat 665. The whole-bottle titration technique of Carpenter [Carp65], with modifications by Culberson et al. [Culb91], was used. Three to four replicate 10 ml iodate standards were run every 3-4 days ($SD < 1 \mu\text{L}$). Standards prepared with KIO₃ solution were made at AOML prior to departure and were compared with standards prepared using K103 certified reference material obtained from Guildline Instruments. The KIO₃ solutions from Guildline were certified to be 1.667 millimolar (0.0100 N).

A total of six standards were prepared using AOML (0.0100 N) KIO₃ solutions and six using the Guildline OSIL certified iodate solution (bottles 26017 and 26020). The differences between the means of six replicate titrations using the AOML or the OSIL KIO₃ were not significantly different (2sided T-test, $t=-0.84$, $df=11$, $p=0.41$, difference between means = -0.41 μL , NS). The reagent blank determined as the difference between V₁ and V₂, the volumes of thiosulfate required to titrate 1-ml aliquots of the iodate standard, was determined at the beginning, middle and end of the cruise.

Sampling and Data Processing

Dissolved oxygen samples were drawn from sample bottles into calibrated 125-150 ml iodine titration flasks using silicon tubing to avoid contamination of DOC and CDOM samples. Samples were drawn by counting while the flask was allowed to fill at full flow from the rosette sample bottles. This count was then doubled and repeated thereby allowing the flask to be overflowed by two flask volumes. At this point the silicone tubing was pinched to reduce the flow to a trickle. This was continued until a stable draw temperature was obtained on the Oakton meter. These temperatures were used to calculate mol/kg concentrations, and provide a diagnostic check of sample bottle integrity. 1 ml of MnCl₂ and 1 ml of NaOH/NaI were added immediately after drawing the sample was concluded using a Repipetor. The flasks were then stoppered and shaken well. DIW was added to the neck of each flask to create a water seal. 24 samples plus two duplicates were drawn at each station. The total number of samples reported from the rosette was 3389.

The samples were stored in the lab in plastic totes at room temperature for 1.5 hours before analysis. The data were incorporated into the cruise database shortly after analysis.

Thiosulfate normality was calculated at the laboratory temperature for each run and corrected to the laboratory temperature. This temperature ranged between 22.4 and 25.1°C during the first section of A16N_2013 and 19.5 and 25.4°C during the second section of A16N_2013.

Volumetric Calibration

The dispenser used for the standard solution (SOCOREX Calibrex 520) and the burette were calibrated gravimetrically just before the cruise. Oxygen flask volumes were determined gravimetrically with degassed deionized water at AOML. The correction for buoyancy was applied. Flask volumes were corrected to the draw temperature.

Duplicate Samples

Duplicate samples were drawn at two depths on every cast. The samples selected for the duplicates and hence the oxygen flasks were changed for each cast. A total of 243 sets of duplicates were run. The average standard deviation of all sets was 0.17 mol/kg.

Standard deviation of duplicate oxygen analysis performed during A16N_2013. Median was 0.13 mol/kg, IQR was 0.06-0.22 mol/kg, n was 243.

Quality Coding

Preliminary quality code flags have been assigned to the oxygen data. Three were coded 'bad' based on sample bottle mis-trips. Seventeen were flagged based on comparison with the preliminary calibrated CTD oxygen profiles.

Problems

Midway through the first leg titrator AOML 1 failed to read the detector current on two successive titrations. The unit was replaced with AOML 3 on (8/17/13 Station 57). Fresh standards were run at the time of the changeover but no significant change in the standard was observed. Based on this it was concluded that no correction to subsequent oxygen values was indicated. Three cases of flasks were determined to have poorly fitting stoppers and were replaced with different flasks during the cruise, after giving consistently poor replication of the duplicates. At two points in the cruise the NaI/NaOH was found to be sticking and was replaced. None of these problems ever rose to the point that the errors exceed 1 mol/kg.

Cross-over Comparisons

A preliminary analysis of the existence of any systematic bias in the present data set (A16N_2013) relative to past cruises that have intersected or passed along the same line was conducted during the first section of A16N_2013. Discrete oxygen data ($z > 3500$ m) from cruises that have occupied stations along 20 W between 40 and 60 N and the corresponding average oxygen concentration ($z > 3500$ m) from the present cruise.

Nutrients

Principal Investigators: Jia-Zhong Zhang & Calvin Mordy

Analytical Personnel: Eric Wisegarver & Charles Fischer

Institutions: Atlantic Oceanographic and Meteorological Laboratory - NOAA & Pacific Marine

Environmental Laboratory - NOAA

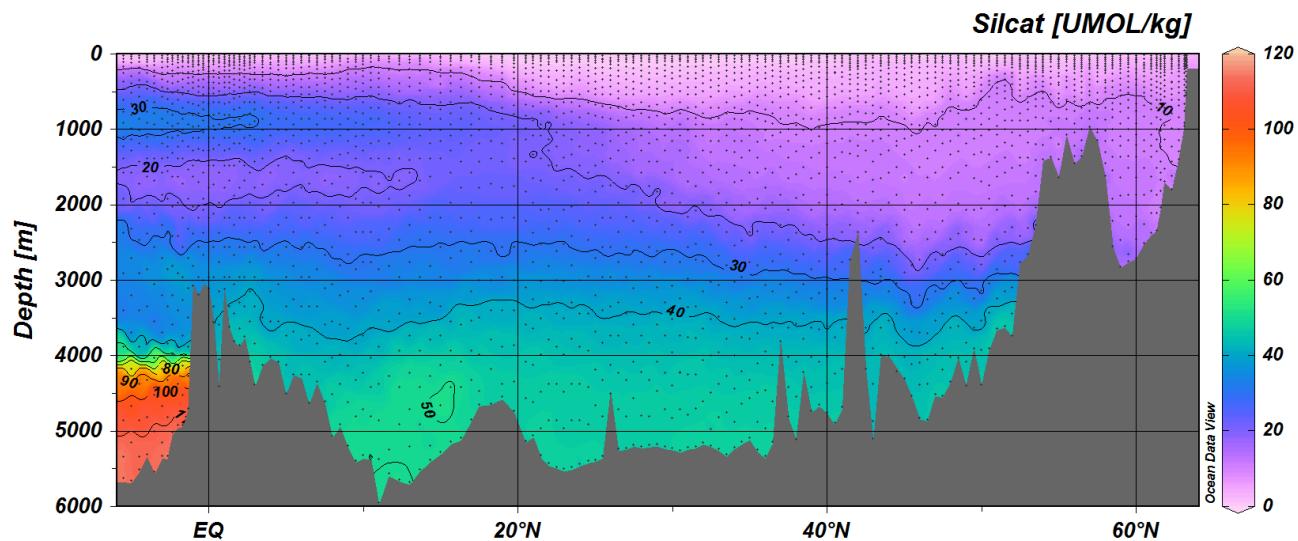


Fig.4.1 A16N_2013 silicate

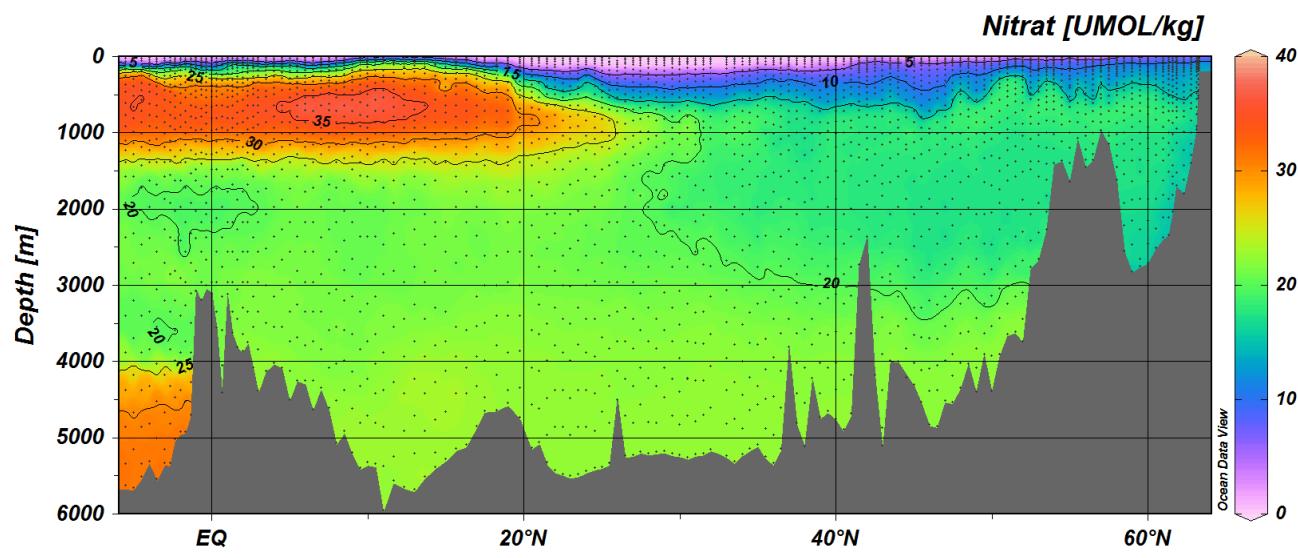


Fig. 4.2: A16N_2013 nitrate

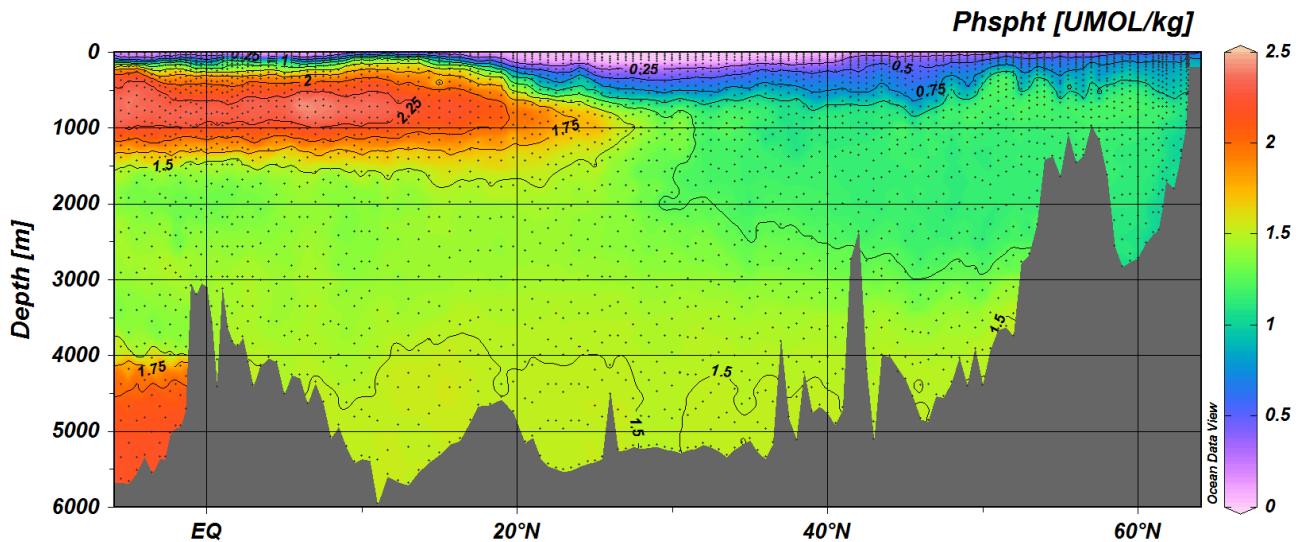


Fig. 4.3 A16N_2013 phosphate

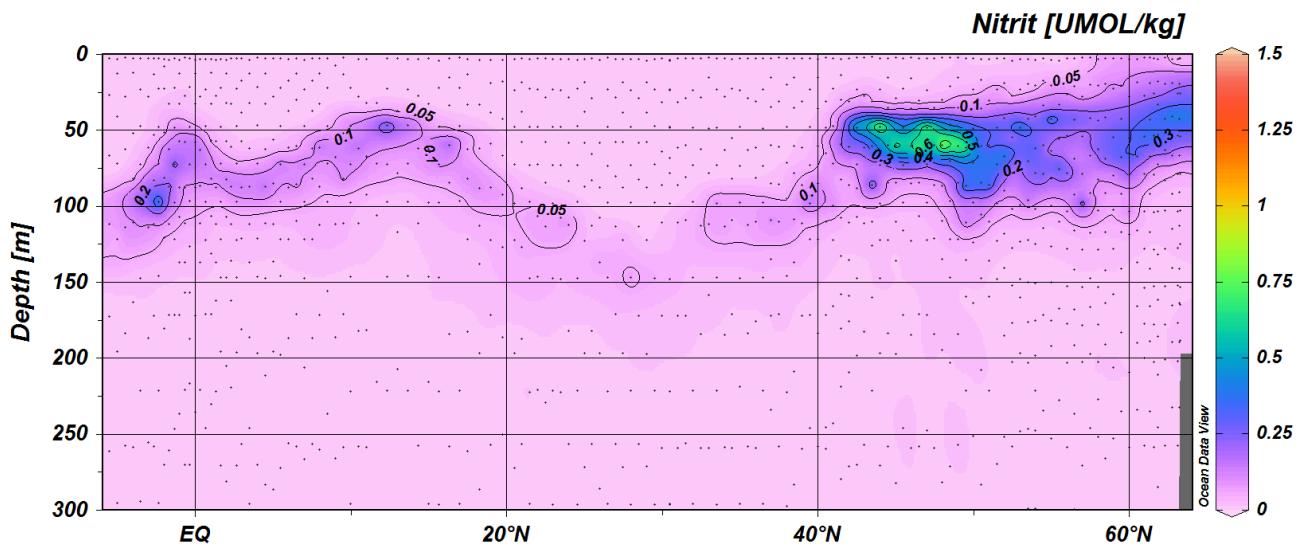


Fig. 4.4: A16N_2013 nitrite

Equipment and Techniques

Dissolved nutrients (phosphate, silicate, nitrate and nitrite) were measured by using an automated continuous flow analytical system with segmented flow and colorimetric detection.

The major components of the nutrient system consisted of an Alpkem auto-sampler, (model 301), two Ismatek pumps, four Lab Alliance monochromator detectors (model 500) and custom software for digitally logging and processing the chromatograms. In addition, glass coils were used for the mixing of the nutrients. Detailed methodologies are described by [Gord94]. All the pump tubing was replaced at least three times during the A16N_2013 cruise.

Silicic acid was analyzed using a modification of [Arms67]. An acidic solution of ammonium molybdate was added to a seawater sample to produce silicomolybdic acid. Oxalic acid was then added to inhibit a secondary reaction with phosphate. Finally, a reaction with ascorbic acid formed the blue compound silicomolybdous acid. The color formation was detected at 814 nm. The use of oxalic acid and ascorbic acid (instead of tartaric acid and stannous chloride [Gord94] were employed to reduce the toxicity of our waste steam.

Nitrate and Nitrite analysis were also a modification of [Arms67]. Nitrate was reduced to nitrite via a copperized cadmium column to form a red azo dye by complexing nitrite with sulfanilamide and N-1-naphthylethylenediamine (NED). Color formation was detected at 540 nm. The same technique was used to measure nitrite, (excluding the reduction step).

Phosphate analysis was based on a technique [Bern67]. An acidic solution of ammonium molybdate was added to the sample to produce phosphomolybdate acid. This was reduced to the blue compound phosphomolybdous acid following the addition of hydrazine sulfate. The color formation was detected at 819 nm.

Sampling and Standards

Nutrient samples were drawn in 30ml HDPE Nalgene sample bottles that had been stored in 10% HCl. The bottles were rinsed 3-4 times with sample prior to filling. A replicate was normally drawn from the deepest rosette sample bottle at each station for quality control. Samples were then brought to room temperature prior to analysis. Freshly mixed working standards were prepared before each analysis. Each analytical run consisted of 3 DIW blanks, 3 matrix blanks (seawater and DIW mixed in the same proportions as in the standards), 4 replicate standards, samples and replicate samples, and then the same set of standards and blanks (with one additional matrix blank) run in the reverse order. Also, one mixed working standard from the previous analytical run was used at the beginning of the new run to determine differences between the two standards. Samples were analyzed from deep water to the surface. Low Nutrient Seawater (LNSW) was used as a wash, base line carrier and medium for the working standards.

The working standards were prepared daily and were made by the addition of 0.2ml of primary nitrite standard and 15.0 ml of a secondary mixed standard (containing silicic acid, nitrate, and phosphate) into a 500ml calibrated volumetric flask of LNSW.

Primary standards were made using dry standards of a high purity that were pre-weighed at PMEL and were dissolved at sea using calibrated lab ware. The secondary mixed standard was prepared by the addition of 30 ml of a nitrate-phosphate primary standard to the silicic acid standard. Nutrient concentrations were reported in moles per liter. Lab temperatures were recorded for each analytical run for later conversion into micromole/kg.

Table 4.1: A16N_2013 summary of sample and replicate analysis.

	Phosphate	Silicic Acid	Nitrate
Number of Samples	4148	4148	4124
Total number of replicates	647	640	645
Mean standard deviation (μM)	0.004	0.06	0.04
Mean Coefficient of Variation (%)	0.40	0.50	0.40

Chlorofluorocarbons (CFCs) and Sulfur Hexafluoride (SF₆)

Principal Investigator: John Bullister

Analytical Personnel: David Wisegarver, Jennifer Hertzberg & Kyra Freeman

Institution: NOAA, Pacific Marine Environmental Laboratory

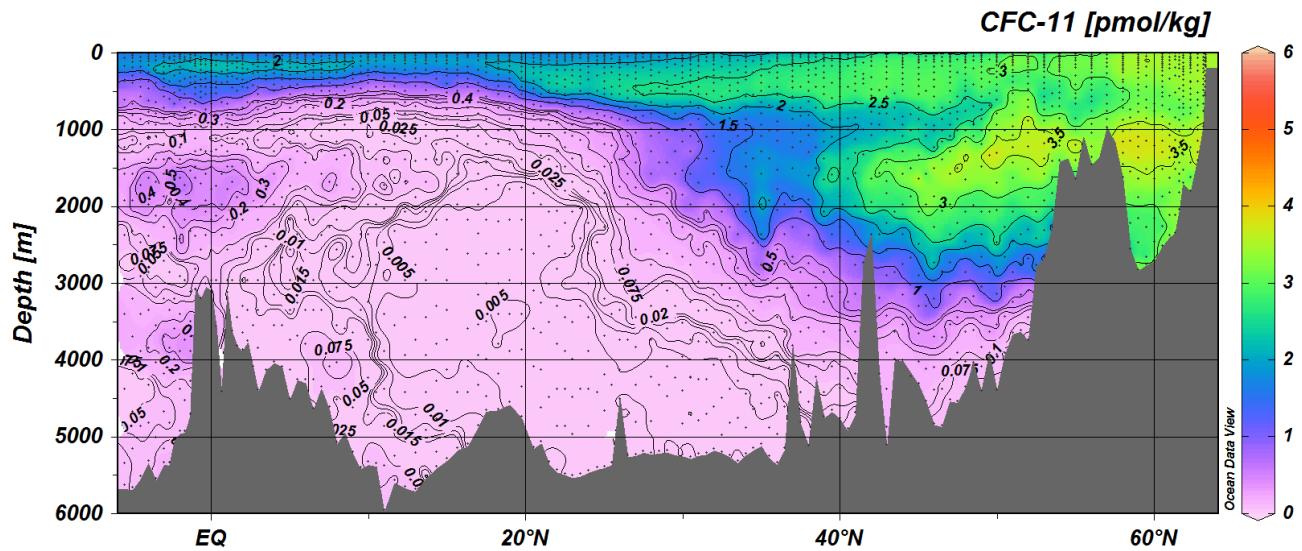


Fig. 5.1: A16N_2013 CFC-11

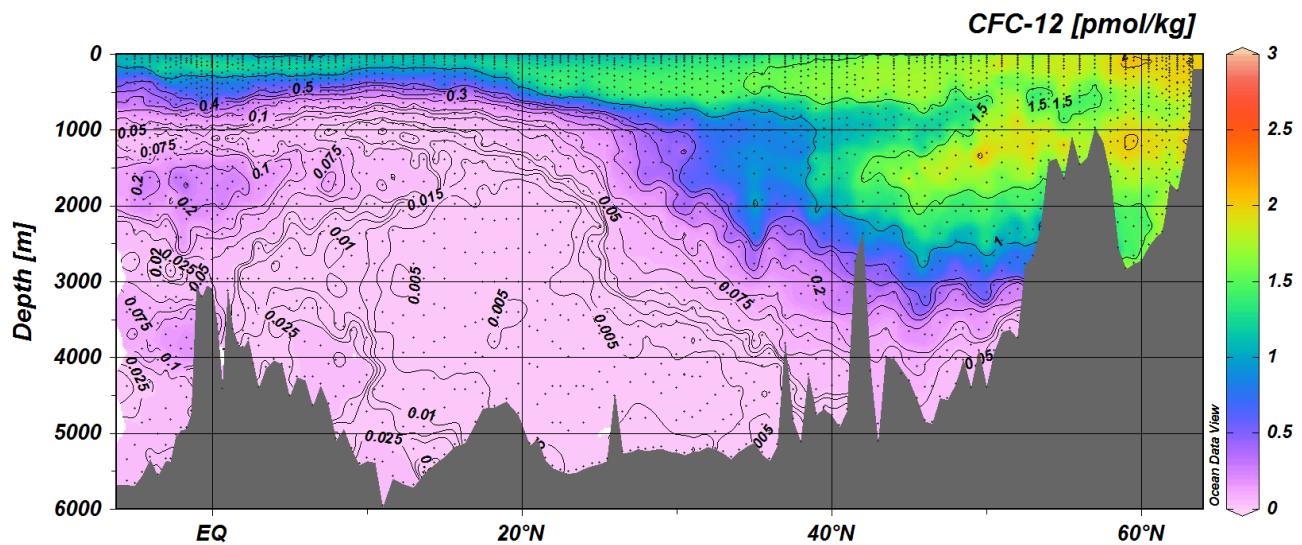


Fig.5.2: A16N_2013 CFC-12

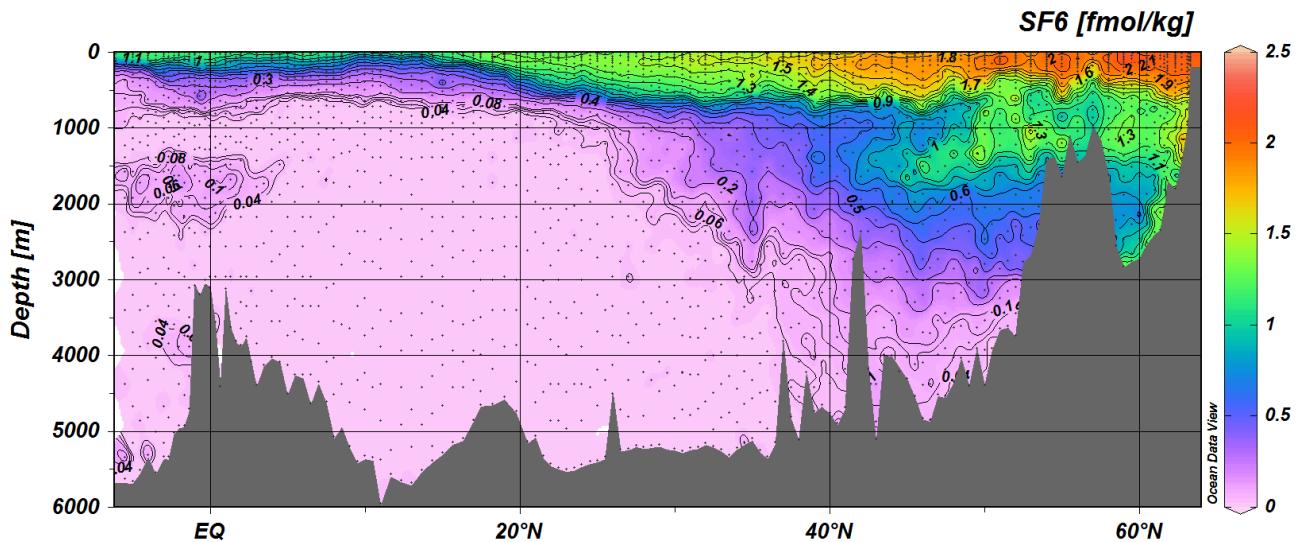


Fig. 5.3: A16N_2013 SF₆

Equipment and Techniques

A PMEL analytical system [Bull08] was used for CFC-11, CFC-12, sulfur hexafluoride (SF₆) and nitrous oxide (N₂O) analysis on the 2013 CLIVAR A16N_2013 expedition. Approximately 2800 samples of dissolved CFC-11, CFC-12, SF₆ ('CFC/SF₆') and N₂O were analyzed. In addition, a small set of samples were taken for the analysis of CF₃SF₅. This compound was injected into the water column along an isopycnal surface (σ -theta=26.88) near 9°N 24°W in 2008 as part of a deliberate tracer release experiment [Bany12]. Several follow-up cruises during the next 30 months monitored the spreading of this compound in the region and this spreading was used to estimate mixing rates. Based on the mapping results for this compound reported in [Bany12] we sampled several stations along the A16N_2013 section at depths of approximately 200m above or below the 26.88 isopycnal to further monitor the spread of this tracer in this region. Some dissolved CF₃SF₅ was detected at these stations and the results are included in the A16N_2013 data report.

In general, the CFC/SF₆ analytical system performed well on the cruise. However, SF₆ measurements in seawater remain extremely challenging. Typical dissolved SF₆ concentrations in modern surface water are about 1-2 fmol kg⁻¹ (1 fmol = femtomole = 10^{-15} moles), approximately 1000 times lower than dissolved CFC-11 and CFC-12 concentrations. The limit of detection for SF₆ on the A16N_2013 cruise was approximately 0.03 fmol kg⁻¹. Improvements in the analytical sensitivity to this compound at low concentrations are essential to make these measurements more routine on future CLIVAR/GO-SHIP cruises.

When taken, water samples collected for dissolved CFC-11, CFC-12 and SF₆ analysis were the first samples drawn from the rosette sample bottles. Care was taken to coordinate the sampling of CFC/SF₆ with other samples to minimize the time between the initial opening of each bottle and the completion of sample drawing. Samples easily impacted by gas exchange (dissolved oxygen, ³He, pCO₂, DIC and pH) were collected within several minutes of the initial opening of each bottle. To minimize contact with air, the CFC/SF₆ samples were drawn directly through the stopcocks of the bottles into 250 ml precision glass syringes equipped with three-way plastic stopcocks. The syringes were immersed in a holding tank of clean surface seawater held at 10°C until 20 minutes before being analyzed. At that time, the syringe was placed in a bath of surface seawater heated to 30°C.

For atmospheric sampling, a 75 m length of 3/8' OD Dekaron tubing was run from the CFC van located on the fantail to the bow of the ship. A flow of air was drawn through this line into the main laboratory using an Air Cadet pump. The air was compressed in the pump, with the downstream pressure held at 1.5 atm. using a back pressure regulator. A tee allowed a flow of 100 ml/min of the compressed air to be directed to the gas sample valves of the CFC/SF₆ analytical systems, while the bulk flow of the air (>7 liters /min) was vented through the back-pressure regulator. Air samples were analyzed only when the relative wind direction was within 60 degrees of the bow of the ship to reduce the possibility of shipboard

contamination. Analysis of bow air was performed at 10 locations along the cruise track. At each location, at least five air measurements were made to determine the precision of the measurements.

Analysis

Concentrations of CFC/SF₆ in air samples, seawater, and gas standards were measured by shipboard electron capture gas chromatography (EC-GC) using techniques modified from those described by Bullister and Weiss [Bull88] and Bullister and Wisegarver [Bull08] as outlined below. For seawater analysis, water was transferred from a glass syringe to a 200 ml glass-sparging chamber. The dissolved gases in the seawater sample were extracted by passing a supply of CFC/SF₆ free purge gas through the sparging chamber for a period of 6 minutes at 150 ml/min. Water vapor was removed from the purge gas during passage through an 18 cm long, 3/8" diameter glass tube packed with the desiccant magnesium perchlorate. The sample gases were concentrated on a cold-trap consisting of a 1/16" OD stainless steel tube with a 2.5 cm section packed tightly with Porapak Q (60-80 mesh), a 15 cm section packed with Carboxen 1000 and a 2.5 cm section packed with MS5A. A Neslab Cryocool CC-100 was used to cool the trap to -65°C. After 6 minutes of purging, the trap was isolated, and it was heated electrically to 175°C. The sample gases held in the trap were then injected onto a precolumn (45 cm of 1/8" O.D. stainless steel tubing packed with 80-100 mesh Porasil B, held at 80°C) for the initial separation of CFC-12, CFC-11, SF₆, and CCl₄ from later eluting compounds.

After the SF₆ and CFC-12 had passed from the pre-column and into the second pre-column (5 cm of 1/8" OD stainless steel tubing packed with MS5A, 80°C) and into the analytical column #1 (210 cm of 1/8" OD stainless steel tubing packed with MS5A and held at 80°C), the outflow from the first precolumn was diverted to the second analytical column (180 cm 1/8" OD stainless steel tubing packed with Porasil B, 80-100 mesh, held at 80°C). The gases remaining after CCl₄ had passed through the first pre-column, were back-flushed from the pre-column and vented. After CFC-12 had passed through the second pre-column, a flow of Argon-Methane (95:5) was used to divert the N₂O to a third analytical column (2 m, Hayesep B, 120°C). Column #3 and the second pre-column were held in a Shimadzu GC8 gas chromatograph with an electron capture detector (ECD) held at 330°C. Columns #1, #2, and the first pre-column were in another Shimadzu GC8 gas chromatograph with ECD. The outflow from column #2 was directed to a Shimadzu Mini2 gas chromatograph (no column) with the ECD held at 250°C.

To measure CF₃SF₅, the main column 1 was replaced with 5' of Carbograph 1AC. All other aspects of the system remained the same. At the conclusion of the stations where CF₃SF₅ measurements were made, the original column 1 was returned to the analytical system.

The analytical system was calibrated frequently using a standard gas of known CFC/SF₆ and N₂O composition. Gas sample loops of known volume were thoroughly flushed with standard gas and injected into the system. The temperature and pressure was recorded so that the amount of gas injected could be calculated. The procedures used to transfer the standard gas to the trap, pre-column, main chromatographic column, and ECD were similar to those used for analyzing water samples. Four sizes of gas sample loops were used. Multiple injections of these loop volumes could be made to allow the system to be calibrated over a relatively wide range of concentrations. Air samples and system blanks (injections of loops of CFC/SF₆ and N₂O free gas) were injected and analyzed in a similar manner. The typical analysis time for seawater, air, standard or blank samples was -11 minutes. Concentrations of the CFC-11 and CFC-12 in air, seawater samples, and gas standards are reported relative to the SIO98 calibration scale [Prin00].

Concentrations of SF₆ in air, seawater samples, and gas standards are reported relative to the CMDL calibration scale. Concentrations in air and standard gas are reported in units of mole fraction CFC in dry gas, and are typically in the parts per trillion (ppt) range. Dissolved CFC concentrations are given in units of picomoles per kilogram seawater (pmol/kg) and SF₆ concentrations in fmol/kg. CFC/SF₆ concentrations in air and seawater samples were determined by fitting their chromatographic peak areas to multi-point calibration curves, generated by injecting multiple sample loops of gas from a working standard (PMEL cylinder 72611) into the instrument. The response of the detector to the range of moles of CFC/SF₆ passing through the detector remained relatively constant during the cruise. Full-range calibration curves were run at intervals of 4-5 days during the cruise. Single injections of a fixed volume of standard gas at one atmosphere were run much more frequently (at intervals of 90 minutes) to monitor short-term changes in detector sensitivity.

The purging efficiency was estimated by re-purging a high-concentration water sample and measuring this residual signal. At a flow rate of 150 cc/mm for 6 minutes, the purging efficiency for both SF₆ and CFC gases was > 99%. The efficiency for N₂O was about 97%.

On this expedition, based on the analysis of more than 150 pairs of duplicate samples, we estimate precisions (1 standard deviation) of about 1% or 0.002 pmol/kg (whichever is greater) for both dissolved CFC-11 and CFC-12 measurements. The estimated precision for SF₆ was 2% or 0.02 fmol/kg, whichever is greater. Overall accuracy of the measurements (a function of the absolute accuracy of the calibration gases, volumetric calibrations of the sample gas loops and purge chamber, errors in fits to the calibration curves and other factors) is estimated to be the greater of 2% or 0.004 pmol/kg for CFC-11 and CFC-12 and the greater of 4% or 0.04 fmol/kg for SF₆.

Analysis Problems

A small number of water samples had anomalously high CFC/SF₆ concentrations relative to adjacent samples. These samples occurred sporadically during the cruise and were not clearly associated with other features in the water column (e.g., dissolved oxygen, salinity, or temperature features). This suggests that these samples were probably contaminated with CFCs/SF₆ during the sampling or analysis processes.

Measured concentrations for these anomalous samples are included in the data file, but are given a quality flag value of either 3 (questionable measurement) or 4 (bad measurement). Less than 2% of samples were flagged as bad or questionable during this voyage. A quality flag of 5 was assigned to samples which were drawn from the rosette but never analyzed due to a variety of reasons (e.g., leaking stopcock, plunger jammed in syringe barrel, etc.).

A small set of duplicate samples from deep bottles were drawn into syringes, where one sample was run immediately and the second was held for various periods of time, to measure any change that might occur in the syringes with time. The results are summarized in table 5.1.

Table 5.1: A16N_2013 Change in concentration over time for duplicate deep samples.

Time Hrs	syr	Sta	Sam	SF ₆ fmol/kg	F12 pmol/kg	F11 pmol/kg	N ₂ O nmol/kg
58	272	92	103	0.0000	0.0007	0.0021	0.205
47	770	93	102	0.0000	0.0000	-0.0005	0.091
39	279	94	105	0.0000	-0.0005	0.0013	0.082
73	478	95	105	0.0000	0.0017	0.0052	0.057
73	474	95	106	0.0000	0.0006	0.0045	0.082
122	266	95	102	0.0000	0.0012	0.0016	0.075
122	760	95	103	0.0000	0.0007	0.0007	0.092
167	772	95	104	0.0000	-0.0034	0.0007	0.480
167	184	95	107	0.0000	0.0005	0.0020	0.433

These results indicate that the rate of change of dissolved CFC-11, CFC-12, and SF₆ concentrations in seawater held in syringes for periods of up to 6 days is very small. A small but significant increase in dissolved N₂O was observed in the stored syringes, perhaps related to biological processes.

Additional Sample Bottle Experiment

In addition, on the transit from Funchal to the section at the start of Leg 2, we conducted an experiment where 18 bottles were closed the same depth in the deep water column in a region of low CFC/SF₆ concentrations.

Table 5.2: A16N_2013 Sampling scheme to test possible changes in CFCs, SF₆, and N₂O in the sample bottles.

Bottle	Time Delay to Sample (hr)
1-4	0
5-8	1
9-12	2
12-16	6
16-18	14

The goal of this experiment was to measure the rate of change of dissolved CFC/SF₆ and N₂O concentrations in closed rosette sample bottles. This information can be used to help estimate how dissolved CFC/SF₆ and N₂O concentrations might change during the 2-3 hour period that water in deep and intermediate samples typically remains in the bottles between the time of closing and time of sampling. Such information can help estimate how much of the low (but non-zero) concentrations of CFC/SF₆ concentrations often observed in deep samples might be due to ingrowth of these compounds with time, perhaps due to slow release from the bottle walls or O-rings. This information can be then used estimate measured concentrations by subtracting appropriate bottle blanks. The following table shows the results of these 'incubation' experiments.

Table 5.3: A16N_2013 Change in SF₆, CFC-12, CFC-11, and N₂O concentration over time for duplicate deep samples.

Time (hrs)	SF ₆ fmol/kg	F12 pmol/kg	F11 pmol/kg	N ₂ O nmol/kg
0	NA	0.0089	0.0134	13.7044
1	NA	0.0090	0.0129	13.9398
2	NA	0.0086	0.0117	13.9406
6	0.00	0.0086	0.0141	13.9406
14	0.00	0.0087	0.0133	13.9908

The changes in SF₆, CFC-11 and CFC-12 concentrations were negligible (within measurement precision) over a 14 hour sampling period. The concentrations of N₂O on bottles held closed for Times=1, 2, 6 and 14 hrs was slightly higher than that measured in the bottle sampled immediately after arrival on deck (Time=0), but is within the precision of the N₂O measurements. As a result of these tests, no bottle blank corrections have been applied to the CFC/SF₆ and N₂O concentrations in this report.

Discrete pCO₂

Principal Investigator: Rik Wanninkhof

Analytical Personnel: Kevin Sullivan & Leticia Barbero

Institution: Atlantic Oceanographic and Meteorological Laboratory - NOAA

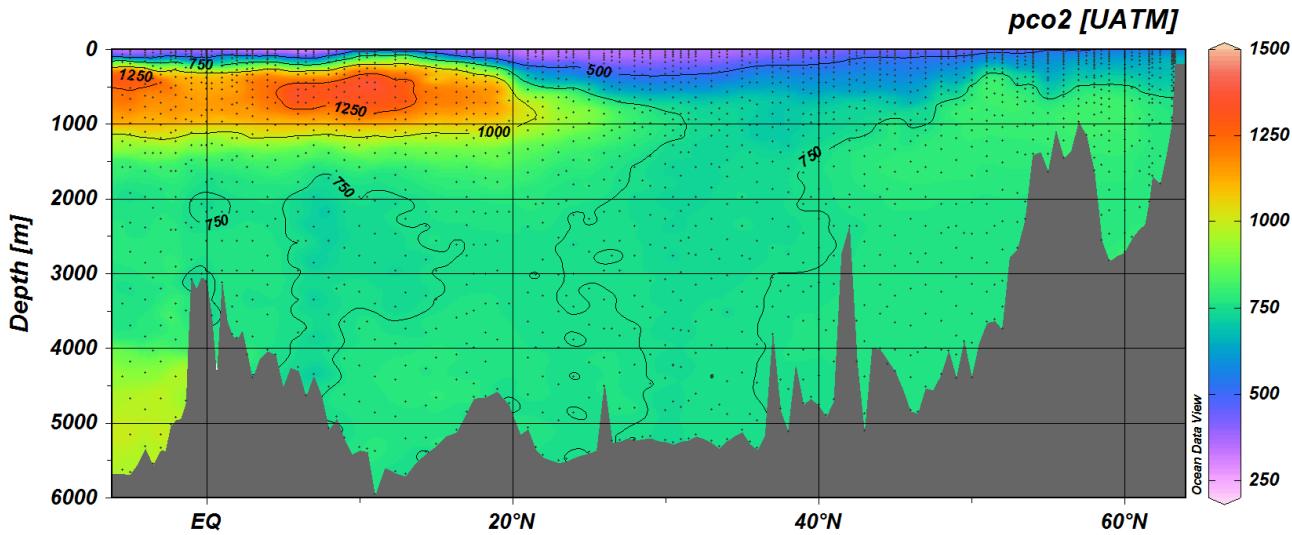


Fig. 6.1 A16N_2013 pCO₂ (20°C)

Equipment and Techniques

The principles of the discrete pCO₂ system are described in [Wann93] and [Chip93]. The major difference in the current system is the method of equilibrating the sample water with the constantly circulating gas phase. This system uses a miniature membrane contactor (Micromodules from Membrana, Inc.), which contain bundles of hydrophobic micro-porous tubes in polycarbonate shells (2.5 x 2.5 x 0.5 cm). The sample water is pumped over the outside of the tubing bundles into the contactors in series at approximately 20 ml/min to a drain. The gas is recirculated in a vented loop, which includes the tubing bundles and a non-dispersive infrared analyzer (LI-COR TM model 840) at approximately 24 ml/min.

The flow rates of the water and gas are chosen with consideration of competing concerns. Faster water and gas flows yield faster equilibration. A slower water flow would allow collection of smaller sample volume; plus a slower gas flow would minimize the pressure increase in the contactor. Additionally, the flow rates are chosen so that the two fluids generate equal pressures at the micro-pores in the tubes to avoid leakage into or out of the tubes. A significant advantage of this instrumental design is the complete immersion of the miniature contactors in the constant temperature bath. Also in the water bath are coils of stainless steel tubing before the contactors that ensure the water and gas enter the contactors at the known equilibration temperature.

The instrumental system employs a large insulated cooler (Igloo Inc.) that accommodates twelve sample bottles, the miniature contactors, a water stirrer, a copper coil connected to a refrigerated circulating water bath, an immersion heater, a 12-position sample distribution valve, two thermistors, and two miniature pumps. The immersion heater works in opposition to the cooler water passing through the copper coil. One thermistor is immersed in the water bath, while the second thermistor is in a sample flow cell after the second contactor. The difference between the two thermistor readings was consistently less than 0.010°C. In a separate enclosure are the 8-port gas distribution valve, the infrared analyzer, a barometer, and other electronic components. The gas distribution valve is connected to the gas pump and to six standard gas cylinders.

The instrumental system was designed and built by Tim Newberger and was supported by C. Sweeney and T. Takahashi. Their skill, assistance, and generosity were essential to the successful use of this instrumental system during this cruise.

Sampling

Samples were drawn from 10 L sample bottles into 500 ml glass bottles using Tygon tubing with a silicone adapter that fit over the drain cock to avoid contamination of DOM samples. Bottles were rinsed twice, the second time while inverted. They were filled from the bottom, overflowing half a volume while taking care not to entrain any bubbles. About 5 ml of water was withdrawn to allow for expansion of the water as it warms and to provide space for the stopper and tubing of the analytical system. Saturated mercuric chloride solution (0.2 ml) was added as a preservative. The sample bottles were sealed with glass stoppers lightly covered with grease and were stored at room temperature for a maximum of twelve hours prior to analysis.

The analysis for pCO₂ were done with the discrete samples at 20°C. A primary water bath was kept within 0.03°C of the analytical temperature; a secondary bath was kept within 0.3°C of the analytical temperature. The majority of the samples were analyzed in batches of twelve bottles, which with standards took approximately 3.5 hours. When twelve bottles were moved into the primary water bath for analysis, the next twelve bottles were moved into the secondary water bath. No sample bottle spent less than two hours in the secondary water bath prior to being moved to the analytical water bath.

The sampling focus was on drawing full casts regularly and partial casts as time permitted. Duplicate samples from the same rosette sample bottle were drawn to check the precision of the sampling and analysis. Discrete samples were collected from the underway (UW) flowing sea water line aboard the ship. The UW samples will be compared to the results for the autonomous pCO₂ instrument. Some discrete UW samples were collected as a station was being completed. Generally, these UW samples were less than 1% different from the samples collected from the top sample bottle.

Over 2300 samples were drawn at 145 stations. About 100 samples were collected from the UW seawater line, mostly during stations. More than fifty sets of duplicate bottles were drawn at numerous depths. The average relative error of these duplicate pairs was 0.18%, while the median relative error was 0.11%.

Standardization

To ensure analytical accuracy, a set of six gas standards (ranging from 288 to 1534 ppm) was run through the analyzer before and after every sample batch. The standards were obtained from Scott-Mann and referenced against primary standards purchased from C.D. Keeling in 1991, which are on the WMO-78 scale.

Table 6.1: A16N 2013 PCO₂ standard table

Cylinder	PPM CO ₂
JB03282	288.46
JB03268	384.14
JB03309	567.40
CA05980	792.51
CA05984	1036.95
CA05940	1533.7

Data Processing

A custom program developed using Lab View TM controls the system and graphically displays the CO₂ concentration as well as the temperature and pressure during the 15-minute equilibration. The CO₂ in the gas phase changes greatly within the first minute of a new sample and then goes through nearly two more oscillations. The oscillations dampen quickly as the concentration asymptotically approaches equilibrium. The flows are stopped, and the program records an average of ten readings from the infrared analyzer along with other sensor readings. Data files from the discrete PCO₂ program are directed to a Matlab program designed for processing data from the continuous PCO₂ systems to calculate the fugacity of the discrete samples at 20°C. The details of the data reduction are described in [Pier09].

Analytical Problems

During the first section of A16N_2013 the refrigerated, circulating water baths were swapped several times, as a unit started to behave erratically. The gas flow meter started to drift and was replaced. No other instrumental problem delayed the sample analysis by more than several minutes during the cruise.

During Leg 2 of A16N_2013 the infrared analyzer values for the standard gases began to show a constant, upward drift shortly after the beginning of section 2. This was a symptom of the analyzer being at the end of its lifespan. During the break in operations caused by the impact of hurricane Humberto, the analyzer was replaced with a new unit of the same model. During analysis of samples from station 113, the 8-position gas distribution valve became clogged and the gas flow was interrupted. The distribution valve was replaced and the system restarted. The gas flow meter stopped reading measurements and gas flow was checked every 12 bottles by means of an external gas flow meter. Due to the loss of time while troubleshooting and bottle backup, one full degree station had to be skipped. During both legs, the laptop controlling the analytical system suffered occasional malfunctions. The laptop was replaced but the malfunctions continued. The error message indicated the problem was with a memory overload or interaction with the KeySpan in the system. Rebooting the computer every 24 samples seemed to greatly decrease the frequency of the malfunctions.

Dissolved Inorganic Carbon (DIC)

Principal Investigators: Richard Feely & Rik Wanninkhof

Analytical Personnel: Robert Castle & Charles Featherstone

Institution: Pacific Marine Environmental Laboratory - NOAA & Atlantic Oceanographic and Meteorological Laboratory - NOAA

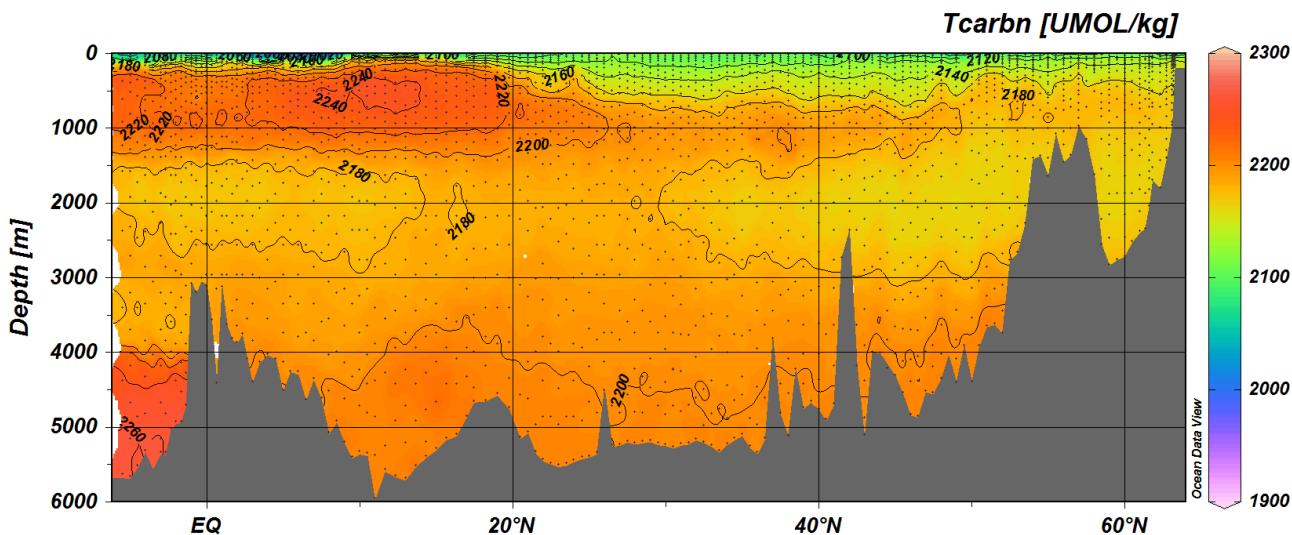


Fig. 7.1 A16N_2013 Dissolved Inorganic carbon (DIC)

Sampling

Samples for TCO₂ (total dissolved CO₂, also referred to as Dissolved Organic Carbon) measurements were drawn according to procedures outlined in the Handbook of Methods for CO₂ Analysis (DOE 1994) from the rosette sample bottles into cleaned 294-mL glass bottles. Bottles were rinsed and filled from the bottom, leaving 6 mL of headspace; care was taken not to entrain any bubbles. After 0.2 mL of saturated HgCl₂ solution was added as a preservative, the sample bottles were sealed with glass stoppers lightly covered with Apiezon-L grease and were stored at room temperature for a maximum of 12 hours prior to analysis.

TCO₂ samples were collected from a variety of depths with one to three replicate samples. Typically the replicate seawater samples were taken from the surface, around 1000 m, and bottom rosette sample bottles and run at different times during the cell. No systematic difference between the replicates was observed.

Analyses

The TCO₂ analytical equipment was set up in a seagoing laboratory van. The analysis was done by coulometry with two analytical systems (AOML3 and AOML4) used simultaneously on the cruise. Each system consisted of a coulometer (UIC, Inc.) coupled with a Dissolved Inorganic Carbon Extractor (DICE) inlet system. DICE was developed by Esa Peltola and Denis Pierrot of NOAA/AOML and Dana Greeley of NOAA/PMEL to modernize a carbon extractor called SOMMA [John85] [John87] [John92] [John93] [John99]. In the coulometric analysis of TCO₂, all carbonate species are converted to CO₂ (gas) by addition of excess hydrogen ion (acid) to the seawater sample, and the evolved CO₂ gas is swept into the titration cell of the coulometer with pure air or compressed nitrogen, where it reacts quantitatively with a proprietary reagent based on ethanamine to generate hydrogen ions. In this process, the solution changes from blue to colorless, triggering a current through the cell and causing coulometrical generation of OH⁻ ions at the anode. The OH⁻ ions react with the H⁺, and the solution turns blue again. A beam of light is shone through the solution, and a photometric detector at the opposite side of the cell senses the change in transmission. Once the percent transmission reaches its original value, the coulometric titration is stopped, and the amount of CO₂ that enters the cell is determined by integrating the total charge during the titration.

The coulometers were calibrated by injecting aliquots of pure CO₂ (99.99%) by means of an 8-port valve outfitted with two sample loops with known gas volumes bracketing the amount of CO₂ extracted from the water samples for the two AOML systems. The stability of each coulometer cell solution was confirmed three different ways: two sets of gas loops were measured at the beginning; also the Certified Reference Material (CRM), Batches 114 and 129, supplied by Dr. A. Dickson of SIO, was measured at the beginning; and the duplicate samples at the beginning, middle, and end of each cell solution. The coulometer cell solution was replaced after 25-27 mg of carbon was titrated, typically after 9-12 hours of continuous use.

The pipette volume was determined by taking aliquots at known temperature of distilled water from the volumes. The weights with the appropriate densities were used to determine the volume of the pipettes. Calculation of the amount of CO₂ injected was according to the CO₂ handbook (DOE 1994). The concentration of CO₂ ([CO₂]) in the samples was determined according to:

$$[\text{CO}_2] = \text{Cal. factor}^* \frac{(\text{Counts-Blank} * \text{Run Time}) * K \text{ mmol/count}}{\text{pipette volume} * \text{density of sample}}$$

where Cal. Factor is the calibration factor, Counts is the instrument reading at the end of the analysis, Blank is the counts/minute determined from blank runs performed at least once for each cell solution, Run Time is the length of coulometric titration (in minutes), and K is the conversion factor from counts to umol. All TCO₂ values were recalculated to a molar weight mol/kg) using density obtained from the CTD's salinity. The TCO₂ values were corrected for dilution by 0.2 mL of saturated HgCl₂ used for sample preservation. The total water volume of the sample bottles was 288 mL (calibrated by Esa Peltola, AOML). The correction factor used for dilution was 1.0007. A correction was also applied for the offset from the CRM. This correction was applied for each cell using the CRM value obtained in the beginning of the cell. The average correction was 1.59 umol/kg for AOML 3 and 1.61 μmol/kg for AOML 4. The average difference of the duplicates was 1.49 μmol/kg for AOML 3 and 1.69 μmol/kg for AOML 4. The results underwent initial quality control on the ship using TCO₂-pressure/ salinity/ oxygen/ phosphate/ nitrate/ silicate/ alkalinity and pH plots.

Two changes to the systems were made from previous cruises. First, the clean air generator that worked poorly on A10 was removed and nitrogen gas was used as the carrier gas instead. Second, the attached salinity cell that had been used to provide salinity values during analysis was removed and a default value of 35.00 was used instead. During data reduction, the CTD salinity was used as in the past. For CRMs, the certified salinity was hard-coded into the program. Removing the salinity sensor resulted in a shorter analysis time since the cell no longer had to be rinsed and filled during analysis, and this allowed us to run more samples without affecting the final data.

Analytical Problems

In general, both systems worked well with AOML 3 more stable than AOML 4. Number 4 experienced several instances of high noise, which may have been caused by erratic carrier gas flow to the cell. We were unable to pinpoint the cause of this, but most of the time the unit performed adequately. Also when pressure in the nitrogen cylinder approached 600 psi, both instruments were sometimes subject to longer titrations.

While in Reykjavik testing the system we found that one of the cells we had been using at the lab was no longer good. We had brought 3 unused cells as spares but they all had the same problem -acetone flowed through the frit much too fast for them to work. By the end of the leg cell #2 was also deemed marginal so we used only cells 10 and 11 for the final 8-10 stations. Because of the increased speed of analysis and the trace metal casts on every other station, we were still able to sample all 24 rosette sample bottles on the odd stations and 15-21 on the even stations.

In Madeira we received 2 new cells from the lab in Miami. With these, we were able to put together 3 cell-cap combinations that worked very well. We used these for most of leg 2. During leg 2, both instruments operated very well. The only problems were that a solenoid valve had to be replaced and the main carrier gas inlet tube to the stripper became clogged. Both were repaired quickly.

A total of 3225 samples were analyzed for discrete dissolved inorganic carbon. The total dissolved inorganic carbon data reported to the database directly from the ship are to be considered preliminary until a more thorough quality assurance can be completed shore side.

Discrete pH Analysis

Principal Investigators: Frank Millero

Analytical Personnel: Ryan Woosley, Carmen Rodriguez & Josh Levy

Institution: Rosenstiel School of Marine and Atmospheric Science/University of Miami

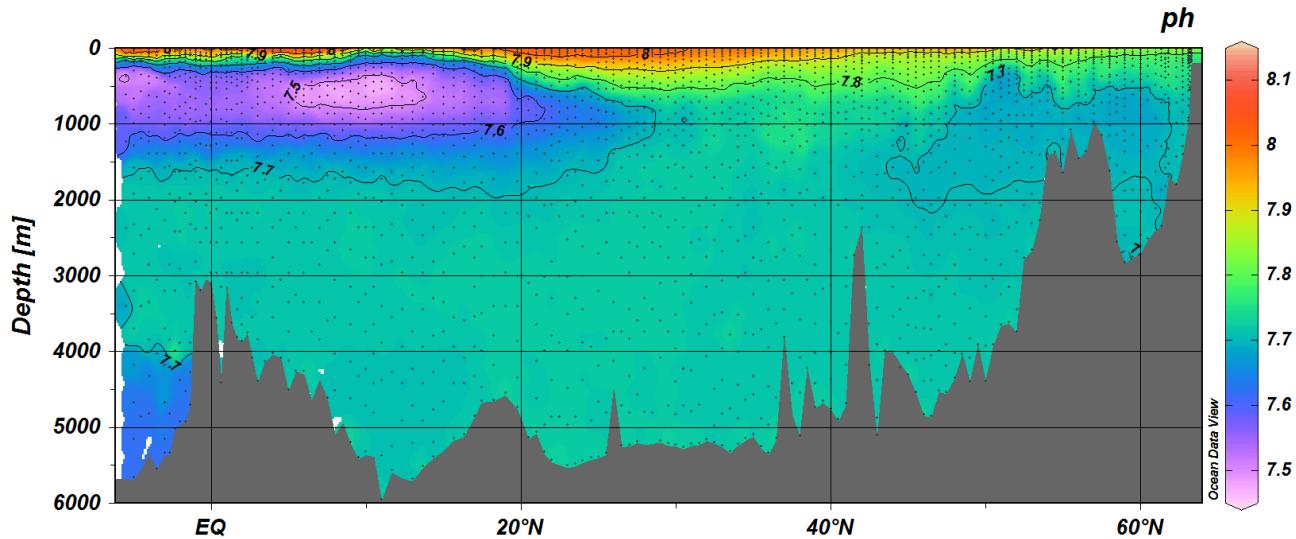


Fig. 8.1: A16N_2013 pH

Sampling

Samples were collected in 50mL borosilicate glass syringes rinsing a minimum of 2 times and thermostated to 25°C before analysis. Two duplicates were collected from each station. Samples were collected on the same bottles as total alkalinity or dissolved inorganic carbon in order to completely characterize the carbon system. One sample per station was collected and analyzed with double the amount of indicator in order to correct for pH changes as a result of adding the indicator, this correction has not been applied to the preliminary data. All data should be considered preliminary.

Analysis

pH ($\mu\text{mol/L}_{\text{seawater}}$) on the seawater scale was measured using a Agilent 8453 spectrophotometer according to the methods outlined by Clayton and Byrne (1993). Since unpurified indicator was used the equations of Lui et al. (2011) were not used. An RTE1O water bath maintained spectrophotometric cell temperature at 25.0°C. A 10cm micro-flow through cell was filled automatically using a Kloehn 6v syringe pump. The sulfonephthalein indicator m-cresol purple (mCP) was also injected automatically by the Kloehn 6v syringe pump into the spectrophotometric cells, and the absorbance of light was measured at four different wavelengths (434 nm, 578 nm, 730 nm, and 488 nm). The ratios of absorbency at the different wavelengths were input and used to calculate pH on the total and seawater scales, incorporating temperature and salinity into the equations. The equations of Dickson and Millero (1987), Dickson and Riley (1979), and Dickson (1990) were used to convert pH from the total to seawater scale. The isobestic point (488nm) will be used for the indicator correction. Salinity data were obtained from the conductivity sensor on the CTD. These data were later corroborated by shipboard measurements. Temperature of the samples was measured immediately after spectrophotometric measurements using a Guildline 9540 digital platinum resistance thermometer.

Reagents

A 1 L batch of mCP indicator dye with a concentrated of ~ 2.0 mM. Un-purified indicator was used, manufacture Sigma, lot # 87H3629.

Standardization

The precision of the data can be accessed from measurements of duplicate samples, certified reference material (CRM) Batch 129 (Dr. Andrew Dickson, UCSD) and TRIS buffers. The measurement of CRM and TRIS was alternated at each station. The mean and standard deviation for the first leg for the CRM5 was 7.8942 ± 0.0037 (n=29) and 8.0775 ± 0.0028 (n=33) for IRIS buffer. The values for leg 2 will be provided once the data have been checked for quality control.

Data Processing

Addition of the indicator affects the pH of the sample, and the degree to which pH is affected is a function of the pH difference between the seawater and indicator. Therefore, a correction is applied for each batch of dye. One sample from each station was measured twice, once normally and a second time with double the amount of indicator. It was insured that the entire pH range was covered over the course of the cruise. The change in the ratio is then plotted versus the change in the isosbestic point to develop an empirical relationship for the effect of the indicator on the pH. This correction has not yet been applied to the samples. The mean and standard deviation of the duplicates was 0.0008 ± 0.0018 (N = 134). The preliminary quality control is shown in Table 8.1.

Table 8.1: A16N_2013 pH quality code assignment.

Number of Samples	1424 (Leg 1)	1682 (Leg 2)
Questionable (QC = 3)	1	86
Bad (QC = 4)	48	61
Lost (QC=5)	3	0
Duplicate (QC = 6)	254	273

Problems

No Major problems occurred in pH analysis during leg 1 or leg 2.

Total Alkalinity

Principal Investigators: Frank Millero

Analytical Personnel: Jennifer Byrne, James Williamson, Kristen Mastropole.

Institution: Rosenstiel School of Marine and Atmospheric Science/University of Miami

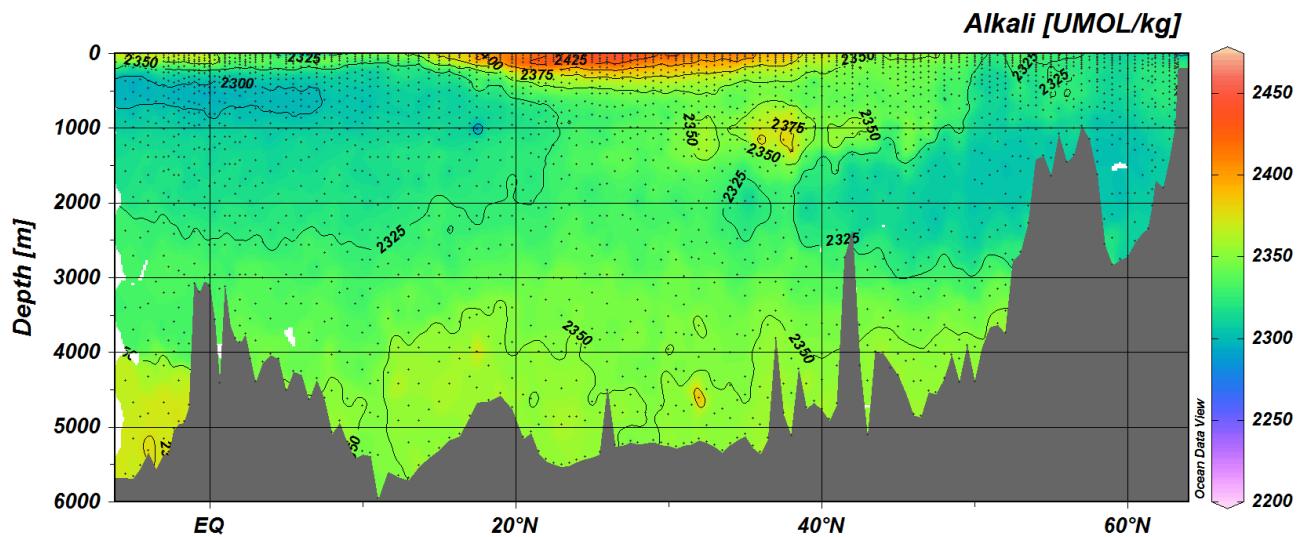


Fig. 9.1: A16N_2013 Alkalinity

Sampling

At each station total alkalinity (TA) samples are drawn from sample bottles into 500 ml borosilicate flasks using silicone tubing that fit over the stopcock. Bottles are rinsed a minimum of three times, then filled from the bottom and allowed to overflow half of the bottle volume. The sampler is careful not to entrain any bubbles during the filling procedure. Approximately 15 ml of water is withdrawn from the flask by halting the sample flow and removing the sampling tube, thus creating a reproducible head-space for thermal expansion during thermal equilibration. The sample bottles are sealed at a ground glass joint with a glass stopper. The samples are then thermostated at 25°C before analysis. Three duplicates are collected at each station. Samples are collected on the same bottles as pH or dissolved inorganic carbon (DIC) in order to completely characterize the carbon system.

Analysis

The sample TA is evaluated from the proton balance at the alkalinity equivalence point, 4.5 at 25°C. This method utilizes a multi-point hydrochloric acid titration of seawater (Dickson 1981). The instrument program uses a Levenberg-Marquardt nonlinear least squares algorithm to calculate the TA, DIC, and pH from the potentiometric titration data. The program is patterned after those developed by Dickson (1981), Johansson and Wedborg (1982), and U.S. Department of Energy (DOE) (1994). The least-squares algorithm of the potentiometric titrations not only give values of TA but also those of DIC, pH, the standard potential of the electrode system (E°), and the first dissociation constant of CO₂ (pK1). Two titration systems, A and B are used for TA analysis. Each of them consists of a Metrohm 765 Dosimat titrator, an Orion 720A, or 720A+, pH meter and a custom designed Plexiglas water-jacketed titration cell (Millero et al, 1993). The titration cell allows for the titration to be conducted in a closed system by incorporating a 5mL ground glass syringe to allow for volume expansion during the acid addition. The seawater samples are equilibrated to a constant temperature of $25 \pm 0.1^\circ\text{C}$ with a water bath (Neslab, RTE-10). The electrodes used to measure the EMF of the sample during a titration are a ROSS glass pH electrode (Orion, model 810100) and a double junction Ag, AgCl reference electrode (Orion, model 900200). The water-jacketed cell is similar to the cells used by Bradshaw and Brewer (1988) except a larger volume (~200 mL) is employed to increase the precision. Each cell has a solenoid fill and drain valve which increases the reproducibility of the volume of sample contained in the cell. A typical titration records the EMF of the solution once it becomes stable (deviation less than 0.09 mV) and adds enough acid to change the voltage a pre-assigned

increment (-13 mV). A full titration (-25 points) takes about 20 minutes. A 6 port valve (VICI, Valco EMTCA-CE) allows 6 samples to be loaded into the instrument and successively measured.

Reagents

A single 50-l batch of -0.25 m HCl acid was prepared in 0.45 m NaCl by dilution of concentrated HCl, AR Select, Mallinckrodt, to yield a total ionic strength similar to seawater of salinity 35.0 ($I = 0.7 \text{ M}$). The acid is standardized by a coulometric technique (Marinenko and Taylor, 1968; Taylor and Smith, 1959) and verified with alkalinity titrations on seawater of known alkalinity. The calibrated molarity of the acid used was $0.24361 \pm 0.0001 \text{ N HCl}$. The acid is stored in 500-ml glass bottles sealed with Apiezon® L grease for use at sea.

Standardization

The reproducibility and precision of measurements are checked using low nutrient surface seawater, a substandard, and Certified Reference Material (CRM) from Dr. Andrew Dickson, Marine Physical Laboratory, La Jolla, California. The CRM is utilized to account for instrument drift over the duration of the cruise and to maintain measurement precision. A CRM was measured on each system on every odd station and LNSW on every even station. Duplicate analysis provide additional quality assurance, and three duplicates are taken at each station. The duplicates are then analyzed on system A, system B, or split between systems A and B. This provides a measure of the precision on the same system and between systems. Laboratory calibrations of the Dosimat burette system with water indicate the systems deliver 3.000 ml of acid (the approximate value for a titration of 200 ml of seawater) to a precision of $\pm 0.0004 \text{ ml}$, resulting in an error of $\pm 0.3 \mu\text{mol/kg}$ in TA.

Data Processing

Measurements on CRM batches 129 and 114 were made. For Leg 1, the difference between the measured and certified values on system A is -0.53 ± 1.85 and on B is 1.08 ± 2.74 . For Leg 2, the difference between the measured and certified values on system A is -1.38 ± 1.91 and on B is 0.29 ± 2.11 . Five different batches of low nutrient surface water were used on leg 1 and an additional 7 batches were used on leg 2. All had standard deviations of $-2 \mu\text{mol/kg}$ or less. The mean and standard deviations of the duplicates for leg 1 were 0.40 ± 1.04 , -0.17 ± 2.61 , and -1.78 ± 2.38 on system A, system B, and one on each system respectively. The mean and standard deviations of the duplicates for leg 2 were 0.31 ± 1.68 , -0.1 ± 2.08 , and -1.22 ± 2.52 on system A, system B, and one on each system, respectively. The preliminary quality controls for both legs are given in Table 9.1.

Table 9.1: A16N_2013 Total Alkalinity quality code assignment.

Number of Samples	1464 (Leg 1)	1733 (Leg 2)
Questionable (QC = 3)	16	83
Bad (QC = 4)	79	38
Lost (QC = 5)	33	8
Duplicate (QC = 6)	336	380

Problems

Only one major problem occurred on leg 1. During set up, one of the water baths stopped cooling. It was determined that a new solenoid and valve was needed. The parts were ordered to repair the bath in Madeira, and a spare one was borrowed from discrete pCO₂. Around station 50 a slight offset of less than 2 umol/kg developed between system A and B. No leaks or problems with the cell were found and there was no decrease in the precision of the instruments. No correction for this offset was made in the preliminary data. On the last station of leg 2 (station 145), samples were run only on TA system A because of a malfunctioning stir plate on system B which was prolonging the titrations. This issue was repaired at sea.

Radiocarbon $^{14}\text{C}/^{13}\text{C}$

Principal Investigators: Ann McNichol

Institution: Woods Hole Oceanographic Institution

A total of 505 samples were collected from 23 stations. Samples were collected in 500 ml airtight glass bottles. Using silicone tubing, the flasks are rinsed 2 times with the water from the sample bottle. While keeping the tubing near the bottom of the flask, the flask is filled and flushed by allowing it to overflow one and a half times its full volume. Once the sample is taken, a small amount (about 30 cc) of water is removed to create a head-space and 0.2ml of 50% saturated mercuric chloride solution is added in the sampling bay. This is the same supply and volume of mercuric chloride solution used for the DIC samples.

After all samples are collected from a station the glass stoppers are dried and greased using M - grease and banded to keep the glass stoppers in place during shipping. The filled bottles are stored in NOSAMS crates inside the ship's laboratory prior to being loaded into a container and shipped back to the United States for analysis.

Dissolved Organic Carbon (DOC)

Principal Investigators: Dennis Hansell

Sampler: Monica Mejia

Institution: Rosenstiel School of Marine and Atmospheric Science/University of Miami

DOC and TDN samples were taken from every sample bottle at approximately every other station. 1670 samples were taken from 72 stations in total. Samples from depths of 250m and shallower were filtered through GF/F filters using in-line filtration. Samples from deeper depths were not filtered. High-density polyethylene 60 ml sample bottles were 10% HCl cleaned and Milli-Q water rinsed. Filters were combusted at 450°C overnight. Filter holders were 0% HCl cleaned and Milli-Q water rinsed. Samples were introduced into the sample bottles by via a pre-cleaned silicone tube. Bottles were rinsed by sample for 3 times before filling. 50-60 ml of water were taken for each sample. Samples were kept frozen in coolers inside the ship's freezer. Frozen samples were shipped back in their coolers for laboratory analysis.

Radiocarbon in DOC

Principal Investigators: Ellen Druffel

Institution: University of California Irvine

1x 32L Black Carbon and 48x 1L DO ^{14}C samples were taken. Samples were taken at 4 stations on Leg 1 of the A16N_2013 cruise. Stations sampled were 10 (60.5°N, 20°W), 16 (57.5°N, 20°W), 36 (47.5°N, 20°W), and 66 (35°N, 20°W).

A total of 40 samples were collected in 250 ml air-tight glass bottles. Using silicone tubing, the flasks are rinsed well with the water from the sample bottle. While keeping the tubing near the bottom of the flask, the flask is filled and allowed to overflow to flush its full volume. Once the sample is taken, a small amount (30 cc) of water is removed to create a head-space and 0.2ml of saturated mercuric chloride solution is added. This is the same supply and volume of mercuric chloride solution used for the DIC samples.

After all samples are collected from a station, the caps are re-tightened as they reach room temperature. The filled bottles are stored inside the ship's laboratory prior to being loaded into a container and shipped back to the United States for analysis.

Radiocarbon DOC Sampling and Analysis

Dissolved organic carbon-14 samples were taken in pre-combusted (540°C/4hours) 1L borosilicate bottles (amber Boston round). We collected 7x DOC samples below 1000m and 7x samples above 1000m at each station. The O₂ minimum zone and permanent thermocline was sampled at each station, however care was taken to avoid sampling the bottom nephloid layer. Samples above 400m depth were filtered using pre-combusted QMA filters and acid cleaned silicone tubing/stainless steel filter manifolds. Samples were immediately frozen after collection and stored at -20°C until analysis at University of

California, Irvine (UCI). Once in the lab, CO₂ will be evolved from DOC via UV oxidation and vacuum line extraction. This CO₂ will then be graphitized and its radiocarbon content measured via accelerator mass spectrometry at the Keck Carbon Cycle Accelerator Mass Spectrometry (KCCAMS) facility at UCI.

Black Carbon in DOC

Principal Investigator: Ellen Druffel

Institution: University of California Irvine

Due to extremely low concentrations of Black carbon in seawater (< 5% of the DOC pool), 1x 8 gallon filtered surface sample was collected from station 16. The concentration and carbon isotopes (¹⁴C and ¹³C) of black carbon in this sample (and all others collected from Repeat Hydrography cruises) will be measured using the benzene polycarboxylic acid (BPCA) method, and these data will be used to estimate the abundance and sources of black carbon in oceanic DOC. Individual BPCA5 will be isolated using a preparative column gas chromatograph (PCGC). These fractions will be combusted to CO₂ gas which will then be graphitized and its radiocarbon content measured via accelerator mass spectrometry at the KCCAMS facility at UCI.

Tritium, Helium and ¹⁸O

Principal Investigators: Peter Schlosser

Institution: Lamont-Doherty Earth Observatory/Columbia University

William Jenkins

Institution: Woods Hole Oceanographic Institution

Analyst: Anthony Daschille,

Institution: Lamont-Doherty Earth Observatory/Columbia University

Helium samples were taken from designated sample bottles in 90 cc 316 type stainless steel gas tight vessels with valves. The samples were then extracted into aluminum silicate glass storage vessels within 24 hours using the at sea gas extraction system. The helium samples are to be shipped to the Lamont-Doherty Earth Observatory of Columbia University Noble Gas Lab for mass spectrometric measurements. A corresponding one-liter water sample was collected from the same sample bottle as the helium sample in a preprocessed glass bottle for degassing back at the shore based laboratory and subsequent tritium determination by ³He in-growth method. 180 samples were collected and shipped to LDEO for analysis.

During A16N_2013, 28 stations were sampled, collecting 510 samples for tritium, 591 samples for helium and 490 samples for ¹⁸O analysis. No duplicate samples were taken.

N₂O Isotopes

Principal Investigator: Bonnie Chang

Institution: University of Washington

Samples were collected for stable isotopic analysis of nitrous oxide (N₂O) dissolved in seawater. 125 ml glass serum bottles were rinsed with approximately 20 ml water, then filled with a bubble free stream using Tygon tubing inserted to the bottle bottom. The bottles were allowed to overflow 3 times (by counting), and the tubing was slowly removed. Approximately 1 ml water was removed to allow for expansion during storage, 0.2 ml saturated mercuric chloride was added, 20 mm straight plug septa (gray butyl, Teflon faced) seals were crimped into place, and the bottles were briefly shaken. Samples were stored at room temperature aboard the R/V Brown for shore-based analysis of the ¹⁵N/¹⁴N of both alpha and beta position N, and ¹⁸O/¹⁶O of dissolved N₂O via mass spectrometry at the University of Washington stable isotope laboratory.

Table 12.1: A16N_2013 Summary of N₂O isotopic sampling along Leg 2.

Station	Depth Range (m)	Bottle Position	Duplicates
72	0-5250	24	2
82	0-5395	24	2
95	0-4560	24	2
99	0-5290	23	3
107	0-5422	23	2
112	0-1700	17	2
116	0-950	15	2
122	0-1300	17	3
130	0-3100	24	3
137	0-1500	17	2
143	0-5698	24	3

$\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ of dissolved NO_3^-

*Principal Investigator: Daniel Sigman
Institution: Princeton University*

Samples were collected for stable isotopic analysis of nitrate (NO_3^-) dissolved in seawater. Full depth profiles were collected every degree of latitude. Sample collection was analogous to that of standard nutrient samples: 30 and 60 ml HDPE bottles were rinsed with sample two to three times (with some water being used to rinse the cap as well) and then filled to the bottle shoulder. 30 ml bottles were used for deeper samples, and 60 ml bottles for the upper water column (where nitrate concentrations were lower). The bottles were then stored frozen in the ship's freezer. These will be later shipped, frozen, to Princeton for shore-based analysis of $^{15}\text{N}/^{14}\text{N}$ and $^{18}\text{O}/^{16}\text{O}$ of the dissolved nitrate.

Density

*Principal Investigator: Frank Millero Institution:
Rosenstiel School of Marine and Atmospheric Science/University of Miami*

Over the course of A16N_2013 Leg 1, 4 stations were sampled (27, 35, 49 & 59) for a total of 96 samples for density. On Leg 2, stations 78, 98, 119, and 141 were sampled for a total of 96 additional samples. Each sample bottle was sampled using a 150 mL HDPE bottle. The bottles were rinsed 3 times, allowed to fill until overflowing, capped, and sealed with Parafilm. This procedure leaves as little head space as possible to minimize evaporation. The sealed samples will be shipped to our lab in Miami where the salinity will be re-measured on a salinometer (Guildline Portosal), and the density will be measured using an Anton-Paar DMA 500 densitometer. Sampling was conducted by personnel from the U Miami group led by Millero.

Chromophoric Dissolved Organic Matter (CDOM)/ Particulate Organic Carbon (POC)

*Principal Investigator: Craig Carlson
Analytical Personnel: Erik Stassinos & Eli Aghassi Institution:
University of California Santa Barbara*

Earth Research Institute (ERI) at the University of California Santa Barbara (UCSB) conducted measurements of Inherent Optical Properties (IOP) with the use of its Alongtrak underway system drawing uncontaminated sea water from the Ronald Brown's underway water feed. In addition, 60mL of water was drawn from each sample bottle on the CTD with nitrile gloves. These samples were filtered after collection and processed with a multiple path length absorption meter to determine CDOM absorption. In conjunction with CDOM filtering and processing, water was drawn from the ship's underway system

and CTD's bottles for measurements of absorption particles (AP), high-precision liquid chromatography (HPLC), phytoplankton pigment, and POC. These will help validate, respectively, outputs from ERI's Deep CDOM Fluorometer and signal from transmissometer on the CTD. In addition to water collection and sampling, a photometer was used daily to collect sun radiance measurements.

AP/HPLC/POC sampling

Water sampled from the ship's uncontaminated seawater system was drawn simultaneously with the CTD's end of cast recovery on a once per day basis to coincide with CDOM sampling. This water was drawn with nitrile gloves and two 2L bottles for high volume sampling of AP and HPLC. These 2L samples were run through a filter rig with supplied vacuum from an aspirator pump and filtered through GF/F 25mm Whatman filters. Samples were then labeled and frozen in liquid nitrogen for post cruise analysis. In conjunction with this sampling, four 2L bottles of water were collected from the CTD; two above and two below 1000m at varying depths for POC. This water was drawn with nitrile gloves and processed through the same filter rig as AP and HPLC, with the exception of combusted GF/F filters instead of pre-packaged. The POC samples were then labeled and frozen along with a NANO pure blank soaked filter for ab analysis.

Underway System Sampling and measurement

An underway lop observing system developed by UCSB, referred to as Alongtrak, was employed in the ship's Hydrolab for in-situ measurements of near-sea surface optical properties. Measurements were made by an automatic scheduled sampling system which controls the supply of un-filtered or 0.2im filtered sea water supply to the systems instruments. These instruments included a LISST particle size distribution meter, an AC-S absorption and attenuation meter, FIRe fluorescenceinductance meter, BB3 fixed angle back-scattering meter, and an 5BE45 Thermosalinograph. Data from these instruments (along with ancillary water flow rate, GPS, and system time) were collected by ERI's proprietary data acquisition system and formatted for long-file ASCII format data files.

CDOM processing and Deep CDOM Fluorometer measurements

Water was collected from all 24 of the CTD's Rosette sample bottles and underway system with nitrile gloves in 60m1 vials once per day and once every second day respectively. This water was then filtered through 0.2im 25mm Nuclepore filters into 40m1 vials preparation to be processed with a World Precision Instruments UltraPath Absorbance Cell set at 200cm path length. Every second day, 18 of the 24 vials were archived for later use in DOM (Dissolved Organic Matter) characterization. Data from the absorbance cell was then processed with Matlab scripts to generate CDOM absorption vs. depth profiles. A WETlabs FLCDRTD-428 CDOM Fluorometer was mounted to the CTD frame and sensor voltage- out signal was recorded and plotted. Data will be processed post-collection with a FLCDRTD calibration file to determine CDOM ppb. Dark casts, consisting of blocking light from the CDOM Fluorometer's lens, were performed at different points during the cruise to track temperature and pressure calibration drift.

Microtops Sun photometer measurements

Several times per day with zero cloud cover, and solar elevation over 100 from horizon, sun radiance measurements were taken with a 5 channel Microtops II Sunphotometer. Microtops data was used to measure temporal variability of AOT (Aerosol Optical Thickness) in the atmosphere.

LADCP

Principal Investigator: Jules Hummon
Analytical Personnel: Oyvind Lundsgaard
Institution: University of Hawaii at Manoa

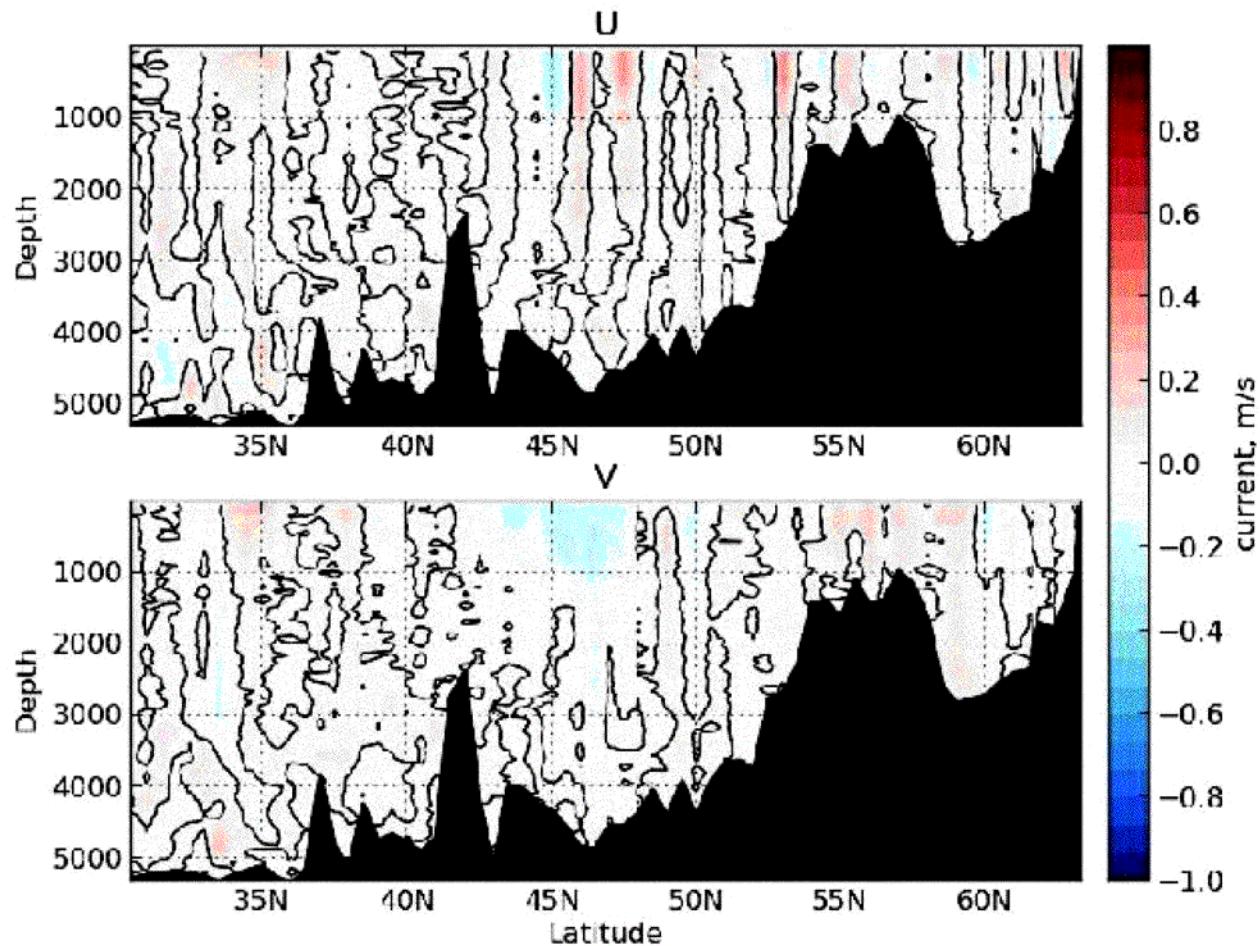


Fig. 16.1: A16N stations 1-70

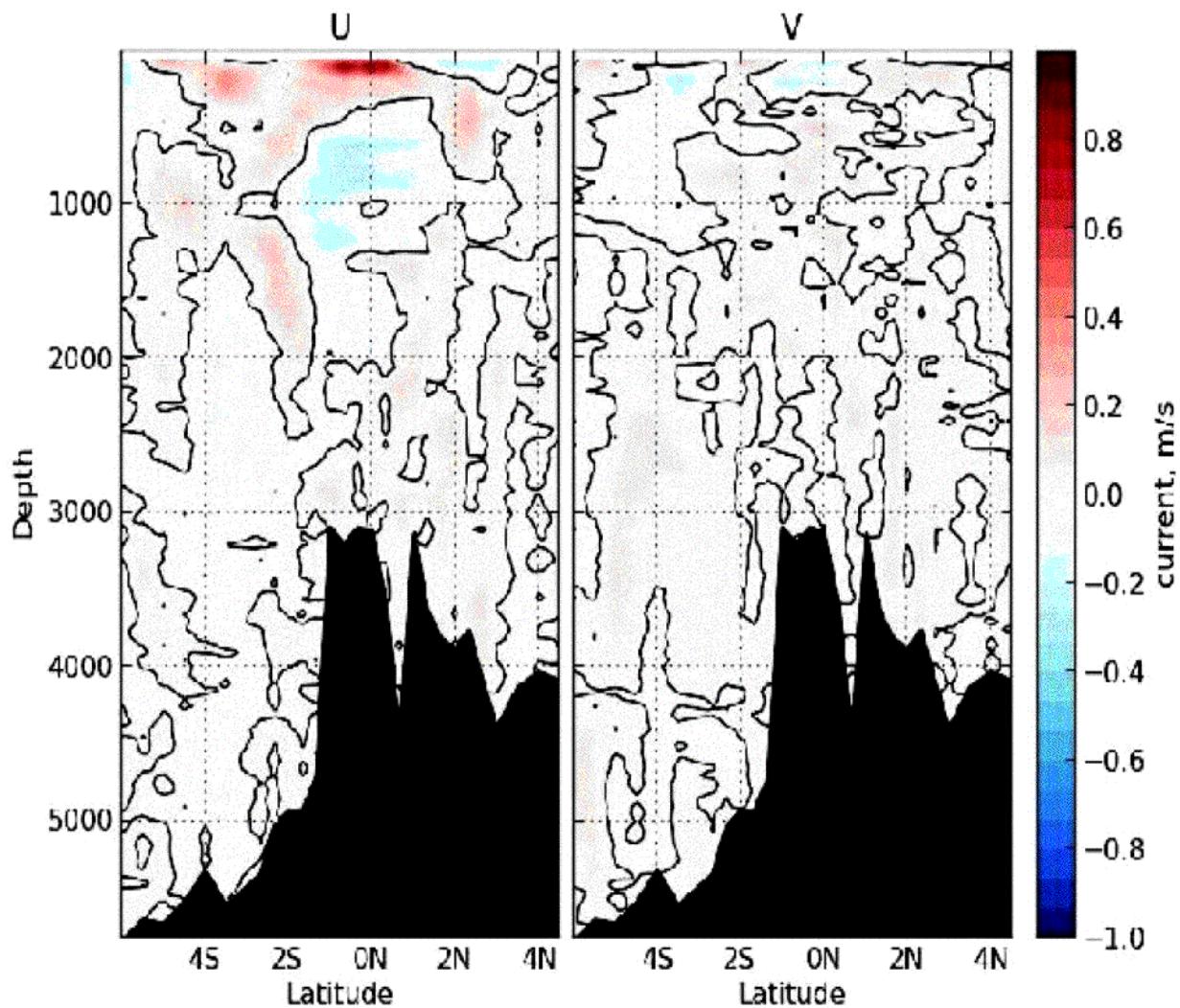


Fig. 16.2: A16N stations 118-145

Equipment and Techniques

Current data was collected using two RDI Workhorse ADCP instruments, pinging at respective frequencies 150 kHz (pointing downwards) and 300 kHz (pointing upwards). This setup gives a theoretical range of 168.2 m looking up, and 340.4 m looking down. The actual range is limited by the amount of scatter in the water, with low scatterer density giving shorter instrument range.

Both instruments were mounted on the CTD rosette, connected to a customized battery. The battery was charged and data retrieved from the instruments between every cast.

Data Processing

Data processing was performed using Andreas Thurnherr's implementation of Martin Visbeck's LADCP inversion method, developed at the Lamont-Doherty Earth Observatory of Columbia University. The code performs a long chain of calculations, including data editing and meshing LADCP data from both instruments with CTD, GPS and shipboard

ADCP data. Currents are calculated using both an inverse method and a shear-based algorithm. The two solutions are compared; agreement increases confidence in the inverse method solution.

The on-ship processed data is to be considered preliminary; full processing of data will occur on shore.

Table 16.1: A16N 2013 LADCP WHP300 Instrument overview (*WH150 used)

Stations	S/N Upward	S/N Downward
1-38	12734	16282*
39-70	10198	16282*
71-95	13330	16282*
96/2	10198	16282*
96/4		1856
118-145		13493

Analytical Problems

Several problems were encountered during the cruise. There was initially a significant deviation between the compasses of the up- and down-looking instruments, symptomatic of a 'hard-iron' effect created by a local magnetic field. The main culprit seems to have been a bottom pinger mounted on the rosette. The issue was largely resolved when the pinger was taken off at station 14. The bottom pinger was deployed on the following stations: 1-13, 42, 45, 74.

There were several instances of beam failure on the wh300 instruments. As a result several different ADCP5 were deployed during the cruise. These instrument changes are summarized in the table above.

After station 55, data quality was severely reduced due to low scatterer density, indicated by a discrepancy between the inverse and shear-inverse solutions. This problem is recurrent in LADCP operations in low scatterer-areas but the effect was more severe than predicted. This results in great error in data south of 38N (with the exception of the equatorial section).

After the loss of the rosette at station 96, only one functioning instrument was left on the ship. To minimize the risk of losing this instrument, it was decided not to deploy it again until reaching the equatorial region. No LADCP data was collected between station 96 (17N) and station 118 (4.5N).

At station 138, no data was recorded due to a depleted battery.

Trace Metal Program

Principal Investigators: Joe Resing

Analytical Personnel: William Landing, Rachel Shelley, Pam Barrett, Peter Morton, Nathan Buck & Randy Morton

Institution: Pacific Marine Environmental Laboratory - NOAA & Florida State University

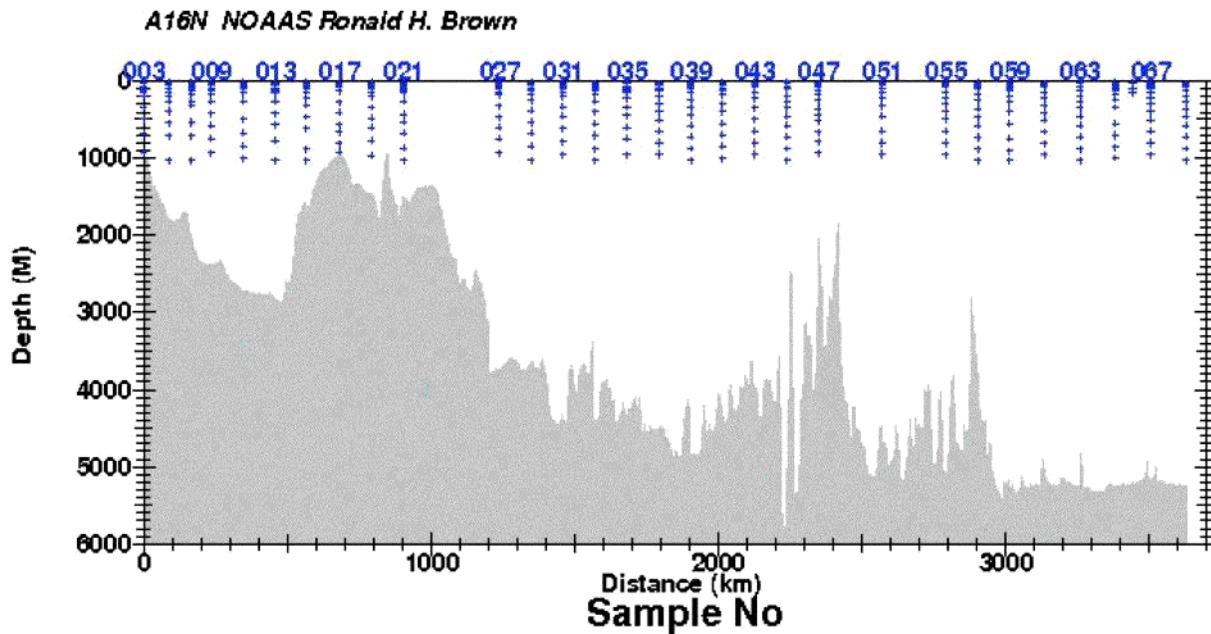


Fig. 17.1: A16N Sample distribution (stations 3-69)

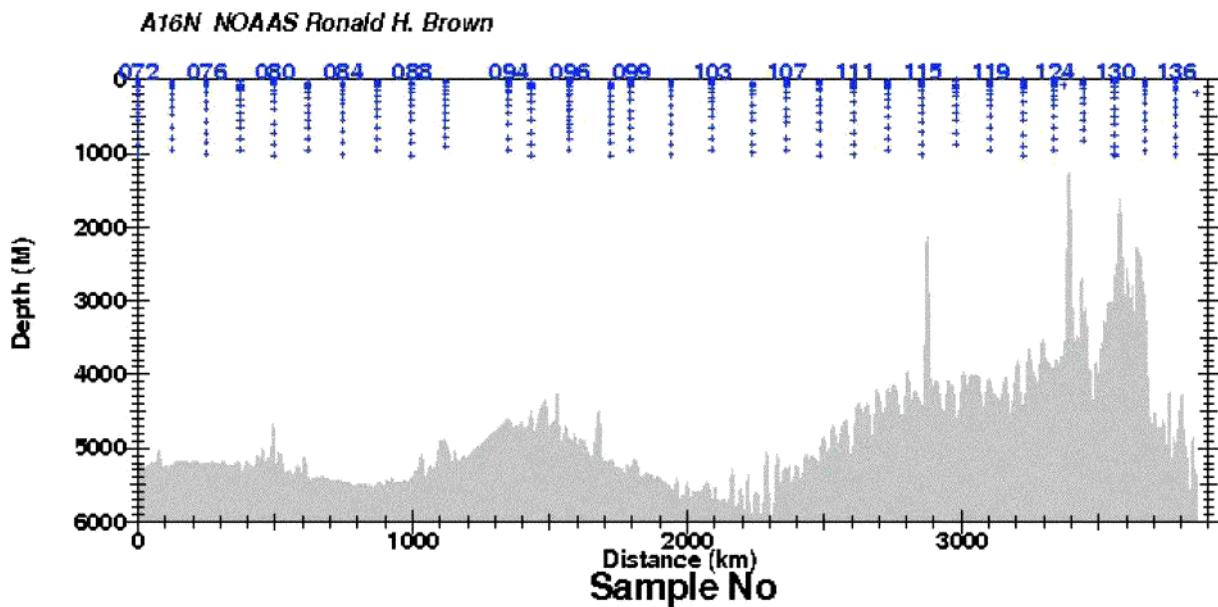


Fig. 17.2: A16N Sample distribution (stations 72-138)

Water Column Sampling

Water-column trace metal samples were collected using a dedicated trace-element rosette with 12 Teflon-coated, 12 L GO-Flo bottles [Meas08] modified with the addition of curved Teflon tubing from the sample valve reaching the bottom of the bottle. Bottles were conditioned for 24 hours with sub-surface (100 m) seawater collected during the test cast. Sub-sampling was conducted in a clean van. Bottles were first sub-sampled for unfiltered seawater samples (nutrients, salinity, unfiltered trace elements) then pressurized with filtered, compressed air. Filtered trace metal subsamples were collected by filtration through 0.4 μ m polycarbonate track-etched 47 mm filters in polypropylene filter holders.

Filtered sub-samples collected in acid-washed 125 mL LDPE bottles were acidified to 0.024M HCl and analyzed shipboard for dissolved Al and Fe using flow injection analysis [Resi94][Meas95]. Preliminary values for dissolved Al concentrations are shown in the following figure. Replicate samples were collected at all depths for post-cruise analysis (FSU, PMEL).

Total suspended matter samples on 0.4 mm PCTE filters were rinsed immediately after collection with 15-20 mL DI water (adjusted to pH 8 with dilute ammonia) and stored for post-cruise analysis (PMEL).

Aerosol Samples

Aerosol samples were collected using a Tisch-5170 High Volume sampler onto 12 Whatman-41 (W41) mixed cellulose ester filters over a 24-hour sampling period. The sampler was automatically activated only when the wind was within 600 of either side of the bow (away from ship smoke). Throughout the cruise, 1 or 3 replicates were processed for instantaneously soluble elements [Buck06] and frozen for subsequent analysis at FSU. The remaining sub-samples were stored frozen to be digested and analyzed for major and trace elements including Al, Ti, Fe, Mn, V, Pb and others (FSU).

While no samples were analyzed at sea, the filters were visually inspected for some indication of the composition of the aerosols collected. From Iceland to Madeira (leg 1), most samples with apparent loading were colored gray, indicating a primarily anthropogenic composition. Approximately one week after leaving Madeira (9-10 September), filters were colored reddishorange, indicating we were entering the Saharan dust plume. The following day Tropical storm/Hurricane Humberto stalked us, and strong unfavorable aft winds inhibited any significant aerosol collection as the R/V Ronald H. Brown evaded the storm. Outside the path of hurricane Humberto, the RN Ronald H. Brown minimized steaming in order to repair the ship's CTD winch, which placed us within a strong Saharan dust deposition event (14-18 September; 15-18 \circ N). For four days, the filters were heavy-laden, resulting in - 50 sub-samples of Saharan dust. The filters for the remainder of the cruise were only lightly loaded.

Rain Samples

Rainwater was collected using a trace element-clean funnel and bottle system in a tall bucket, where falling rain triggers a sensor to open the lid automatically. A minimum of 40 mL of rainwater is necessary to adequately sample a rain event for unfiltered and filtered trace elements, as well as major anions.

During section 1, only a single rain event was sampled (12 August) with minimal volume (40 mL). During section 2, several small rain events were sampled (5, 11-12, 19, 20 September) and an extended intense rain event that lasted approximately four days (23-26 September 2013). During this nearly continuous rain event, more than 3 L of rainwater were collected and sub-sampled between filtered and unfiltered elements. Two sub-samples (both from 24 September 2013) were by shipboard FIA as shown in following table.

Table 17.1: A16N_2013 Shipboard FIA analysis of filtered and unfiltered rain samples collected 24 September 2013

	Fe filtered (nM)	Fe unfiltered (nM)	AI filtered (nM)	AI unfiltered (nM)
Sub-samples 1	1.56	5.29	5.01	23.81
Sub-samples 1	2.41	6.19	13.84	32.85

Ancillary samples

Unfiltered seawater samples (1 L) for Hg analysis were collected from all bottles at the following stations on sections 1 and 2: 7, 15, 31, 51, 59, 69, 82, 94, 98, 103, 109, 117, 130 (D. Krabbenhoft, USGS).

Filtered seawater samples (1 L) for Cu isotope analysis were collected from all bottles at the following stations on sections 1 and 2: 21, 41, 86, 107, 130 (P. Barrett, UW/PMEL).

Filter samples (47 mm, GFF) were collected for Hg methylation gene analysis by filtering seawater (2 L) from all depths at the following stations on section 2: 84, 98, 109, 130 (D. Elias, ORNL).

Event Problems

From Leg 1: Station 11, bottle #7 was hanging by safety line on recovery; bottle #11 spigot was broken during recovery and sample was lost. Station 13, bottle #7 cracked and sample was lost. Station 35: bottle #1 spigot was broken while unloading and sample was lost; bottle #10 was leaking slowly when recovered but closed on deck; bottle #2 likely a miss-trip at shallow depth. Station 41, Ship power failure on downcast at 172 m. Station 45, bottle #2 was leaking slowly when recovered but closed on deck. Stations 49-53, Errors in CTD file; re-termination was necessary. Station 51, bottle #12 misfired at bottom depth. Station 59, bottle #1 misfired, no samples taken.

From Leg 2: Station 72, bottle #3 was hanging by safety line on recovery. Station 76, bottle #10 was not fully open on deployment. Station 88, Winch level wind failed on up-cast at 130 m, rosette was lowered 10 m before continuing up. Station 94, ship lost power on up-cast after Bottle #11 was fired. Station 109, bottle #9 spigot was broken while unloading and sample was lost. Station 111, bottle #8 likely a miss-trip at shallow depth.

Three times during Leg 2 (14 August, 19 September, 27 September), the sector- control for the aerosol sampler was set to "always on" instead of 'automatic', resulting in samples likely contaminated by ship exhaust. During intense rain on 25 September 2013, the sampler was set to "off" for 24 hours.

Arrayed Remote Sensing Deployments

SVP Drifter Deployments

Principal Investigator: Shaun Dolk

Institution: Atlantic Oceanographic and Meteorological Laboratory - NOAA

A total of ten SVP drifters, provided by the Global Drifter Program, were deployed during the cruise. The deployment procedure involved removing the startup magnet and then the plastic packaging before deployment. The drifters were deployed after the completion of the CTD station closest to the target deployment location. Once the ship was re-positioned and began steaming at approximately one knot, the drifter was released from the fantail of the ship. The time and position of each drifter deployment was recorded and transmitted via e-mail to the Drifter Center at AOML (Shaun.Dolk@noaa.gov). The following table shows the location of each SVP deployment made on CLIVAR/Carbon A16N 2013.

Table 18.1: A16N_2013 SVP drifter deployment schedule.

S/N	Latitude	Longitude	Deployment Time
116389	63.12 N	20.00W	08/04/2013 04:53:00
116104	60.96 N	20.01 W	08/05/2013 10:53:00
116386	54.99 N	20.00 W	08/08/2013 04:48:00
116256	51.98 N	20.00 W	08/09/2013 12:49:00
116258	49.51N	20.00W	08/10/2013 21:15:00
116390	48.50 N	20.00 W	08/11/2013 10:08:00
116267	46.00 N	20.00 W	08/12/2013 09:31:00
116280	44.96 N	20.00 W	08/13/2013 12:30:00
116105	41.85 N	20.00 W	08/15/2013 04:50:00
116255	40.00 N	20.00 W	08/16/2013 06:45:00

Argo Float Deployments

Principal Investigator: *Gregory C. Johnson*

Institution: *Pacific Marine Environmental Laboratory - NOAA*

Sixteen ARGO profiling CTD floats were launched during this cruise at the request of WHOI and AOML ARGO groups. These floats are part of the Argo array, a global network of over 3000 profiling floats. The floats are designed to sink to a depth of about 1000m. They then drift freely at depth for about ten days, before sinking to 2000m and then immediately rising to the surface, collecting CTD data as they rise. Conductivity (salinity), temperature, and pressure are measured and recorded at about 73 levels during each float ascent. At the surface, before the next dive begins, the acquired data is transmitted to shore via satellite, along with a location estimate taken while the float sits at the surface. The typical life time of the floats in the water is about four years. All Argo float data is made publicly available on the web in real-time at <http://www.usgoda.org/argo/argo.html>.

All floats were checked on the ship and started at least a day before deployment, by passing a magnet over the 'reset' area on the float. Each float's start-up time was logged. When in position, each float was then launched by carefully lowering it into the water using a hand- held line strung through the supplied deployment straps. Each float was deployed in the protective box the float shipped with. Deployments were done after the completion of the CTD station nearest to the requested deployment location, immediately after the ship had turned, and begun its course to the next station and had reached a speed of approximately one knot. All eight floats were deployed successfully. An e-mail report was sent to WHOI or AOML, depending on who provided the float, to report the float ID number, float start time, exact float deployment time, location, wind speed, wind direction, sea state and deployer's name(s). The following table shows the location of each Argo Float deployment made on CLIVAR/Carbon A16N_2013.

Table 19.1: A16N_2013 Argo float deployment schedule.

S/N IMEI	Latitude	Longitude	Deployment time
7084/046548	34.54 N	20.79 W	08/19/2013 09:12:00
7143/159820	32.50 N	19.43 W	08/22/2013 20:05:00
7162/159921	14.99 N	29.00 W	09/18/2013 19:45:00
7142/159919	14.48 N	29.00 W	09/18/2013 22:19:00
7140/146780	13.64 N	29.00 W	09/19/2013 11:34:22
7148/159124	11.00 N	28.75 W	09/20/2013 20:15:00
7127/159220	8.99 N	27.99 W	09/22/2013 01:10:00
7167/159520	6.99 N	26.99 W	09/23/2013 06:48:00
7144/159422	4.95 N	25.98 W	09/24/2013 11:54:00
7182/046143	1.98 N	25.00 W	09/26/2013 08:40:00
7139/146781	0.99 N	25.00 W	09/27/2013 00:32:00
7041/046593	0.99S	25.00 W	09/28/2013 09:28:00
7160/159563	2.00 S	25.00 W	09/29/2013 03:43:00
7146/159122	4.02S	25.00 W	09/30/2013 12:00:00

APPENDIX

Main Rosette Cast Bottom Data

For each station/cast the following table shows the following information for the bottom of each cast, respectively:

- Station/Cast Number
- GMT Date and Time
- Latitude and Longitude
- Bathymetric Depth (meters)
- Distance Above Bottom (via Altimeter reading, meters)
- Calculated Depth using CTD data (meters)
- CTD Pressure (decibars)

A '-999' for any of these values indicates either an instrument error or data was not given.

Table 20.1: A16N_2013 Cast data (also available at CCHDO website)

SSS/CC	Date & Time	Latitude & Longitude	Bathy Depth	DAB	CTD Depth	CTD Pres
001/01	20130803 23:07:21	63 18.0642 N 20 00.0600 W	191	10.0	191.3	193.1
002/01	20130804 00:58:17	63 13.0386 N 20 00.0846 W	553	9.6	552.7	558.5
003/02	20130804 04:25:37	63 07.0020 N 20 00.1068 W	979	15.0	967.3	978.5
004/01	20130804 08:22:15	62 45.0372 N 19 59.8518 W	1405	9.0	1403	1420.7
005/01	20130804 13:00:11	62 19.9128 N 19 59.8638 W	1801	9.0	1799.3	1823.7
006/01	20130804 19:37:58	61 49.9734 N 19 59.9442 W	1705	10.0	1698.7	1721.3
007/02	20130805 00:22:56	61 36.8466 N 19 59.7666 W	2046	10.3	2043.8	2072.5
008/01	20130805 04:11:37	61 19.9560 N 19 59.6832 W	2350	9.3	2346.3	2380.9
009/01	20130805 08:17:08	60 59.8848 N 20 00.2934 W	2398	18.0	2382.4	2417.7
010/01	20130805 15:01:40	60 29.9658 N 20 00.0150 W	2528	10.5	2520.9	2559
011/02	20130805 21:23:55	60 0.0138 N 19 59.9082 W	2720	10.5	2713	2755.1
012/01	20130806 02:57:55	59 29.8338 N 19 59.8380 W	2766	10.5	2758.7	2801.7
013/01	20130806 08:18:04	58 59.9586 N 19 59.9430 W	2838	10.2	2829.7	2874.1
014/01	20130806 14:58:13	58 29.9712 N 19 59.8986 W	2566	11.0	2564.8	2600.2
015/02	20130806 21:13:50	58 00.1038 N 20 00.0978 W	1631	8.6	1628.5	1649.3
016/01	20130807 01:58:20	57 30.0126 N 19 59.9376 W	1161	10.4	1155.8	1169
017/01	20130807 06:17:11	57 00.0528 N 20 00.0876 W	971	9.5	968.5	979.2
018/01	20130807 11:36:52	56 29.9874 N 19 59.9826 W	1365	10.0	1364.2	1380.4
019/02	20130807 17:33:41	55 59.9916 N 19 59.9904 W	1455	10.0	1451.1	1468.7
020/01	20130807 22:11:47	55 30.0582 N 19 59.9760 W	1091	10.5	1083.7	1095.7
021/01	20130808 02:25:45	54 59.9508 N 19 59.6022 W	1643	11.1	1641.5	1661.9
022/01	20130808 08:07:52	54 29.9484 N 20 0.03240 W	1376	10.7	1375.4	1391.6
023/01	20130808 12:22:52	53 59.9160 N 19 59.8956 W	1413	9.0	1406.4	1423
024/01	20130808 17:14:15	53 30.0504 N 19 59.8056 W	2284	10.1	2279.5	2311.2
025/01	20130808 22:35:07	52 59.9682 N 20 00.0078 W	2672	11.7	2663.9	2703.1
026/01	20130809 04:27:49	52 29.9934 N 20 00.0558 W	2773	10.1	2769.8	2811.1
027/01	20130809 10:03:06	51 59.7402 N 20 00.0168 W	3752	9.8	3743.3	3807.8
028/01	20130809 17:04:37	51 30.0942 N 19 59.9874 W	3632	10.5	3618.8	3680
029/02	20130810 00:03:30	50 59.9766 N 20 00.0570 W	3664	10.3	3653.1	3715
030/01	20130810 06:13:08	50 29.8824 N 19 59.5158 W	3931	10.0	3916	3984.4
031/01	20130810 12:17:14	49 59.9646 N 19 59.9826 W	4402	10.0	4393.7	4475
032/01	20130810 19:26:43	49 30.5016 N 20 00.0888 W	3913	11.5	3908.5	3976.1
033/02	20130811 03:43:27	49 00.0198 N 19 59.4354 W	4407	10.2	4405.2	4486.3
034/01	20130811 09:52:40	48 29.9574 N 19 59.9736 W	4040	10.5	4034	4104.7
035/01	20130811 16:11:57	47 59.9820 N 20 00.0474 W	4361	10.5	4354.8	4434.2
036/01	20130811 23:33:03	47 28.7220 N 19 59.8188 W	4559	11.9	4541.6	4626
037/01	20130812 05:48:31	46 59.9106 N 19 59.5758 W	4538	10.9	4523.9	4607.5
038/01	20130812 12:59:20	46 29.9628 N 20 00.0078 W	4872	10.0	4855.9	4949.2
039/02	20130812 20:41:07	46 00.1374 N 20 00.0294 W	4845	9.0	4832.9	4925.2
040/01	20130813 03:10:49	45 29.8896 N 19 59.9940 W	4553	9.8	4539	4622.2
041/01	20130813 09:09:48	44 59.9838 N 20 00.0306 W	4313	10.9	4307.9	4384.5

042/01	20130813 16:51:37	44 29.8986 N 19 59.8008 W	4224	9.5	4215.8	4289.7
043/02	20130813 23:41:28	43 59.9346 N 20 00.0798 W	4010	10.4	4006.9	4075.1
044/01	20130814 05:46:56	43 30.0204 N 20 00.1938 W	4003	9.2	3993.8	4061.5
045/01	20130814 12:07:34	42 59.9358 N 19 59.9436 W	5162	13.4	5110.4	5210
046/01	20130814 19:34:28	42 30.1926 N 19 59.8470 W	4191	10.3	4186.6	4259
047/02	20130815 02:41:23	41 59.9952 N 19 59.9808 W	2373	14.3	2374.8	2405.4
048/01	20130815 07:54:43	41 29.9298 N 19 59.6268 W	2731	8.4	2734.2	2771.8
049/01	20130815 13:47:27	40 59.9562 N 19 59.9916 W	4710	9.7	4691.3	4777.2
050/01	20130815 21:15:52	40 30.0102 N 20 00.0918 W	4923	10.3	4898.4	4990.1
051/01	20130816 03:46:45	40 00.0012 N 19 59.9826 W	4768	10.2	4763.2	4850.7
052/01	20130816 11:08:02	39 29.9388 N 19 59.9742 W	4674	10.3	4654.8	4738.9
053/02	20130816 19:04:14	38 59.9508 N 19 59.9436 W	4756	9.6	4738.4	4824.7
054/01	20130817 01:25:37	38 29.9916 N 19 59.9652 W	4238	12.1	4231.9	4303.8
055/01	20130817 07:56:02	38 00.1716 N 20 00.3342 W	5119	10.3	5115	5212.3
056/01	20130817 15:54:13	37 30.2370 N 20 00.0750 W	4836	8.6	4818.1	4906.2
057/02	20130817 23:10:38	36 59.9604 N 19 59.9742 W	3822	10.2	3820.8	3881.5
058/01	20130818 05:30:57	36 30.0282 N 20 00.1566 W	5170	9.2	5148.9	5246.5
059/01	20130818 12:12:37	35 59.9862 N 19 59.9646 W	5364	10.4	5342.2	5445.7
060/01	20130818 20:16:05	35 29.9592 N 20 17.0622 W	5280	11.8	5258.2	5358.8
061/01	20130819 03:27:44	35 00.0408 N 20 33.9852 W	5123	10.3	5099.6	5195
062/01	20130819 11:34:38	34 30.0474 N 20 51.0198 W	5177	9.9	5155.4	5252.3
063/02	20130819 20:10:33	34 00.1056 N 21 07.8168 W	5244	10.5	5224.5	5323.2
064/01	20130820 03:21:04	33 29.9700 N 21 23.9904 W	5343	9.3	5321.8	5423.3
065/01	20130820 10:25:37	32 59.9646 N 21 41.0082 W	5265	9.3	5246.6	5345.5
066/01	20130820 18:29:42	32 30.1104 N 21 57.9852 W	5214	10.6	5200.2	5297.4
067/02	20130821 02:43:51	32 00.0030 N 22 15.0042 W	5178	9.8	5159.8	5255.6
068/01	20130821 09:41:54	31 30.0036 N 22 32.0328 W	5232	9.2	5214.3	5311.6
069/02	20130821 17:46:32	31 00.0192 N 22 49.0944 W	5248	8.1	5228.4	5325.9
070/01	20130822 00:46:14	30 30.0276 N 23 05.9550 W	5290	10.0	5271	5369.5
071/01	20130903 08:14:33	30 29.9820 N 23 06.0948 W	5288	10.4	5271.3	5369.8
072/01	20130903 15:16:48	30 00.0480 N 23 22.0110 W	5254	10.6	5234.1	5331.3
073/01	20130903 23:27:53	29 30.1500 N 23 39.1080 W	5241	12.6	5219.4	5315.9
074/01	20130904 06:37:49	28 59.9886 N 23 56.0982 W	5202	9.7	5182.3	5277.5
075/01	20130904 14:42:14	28 29.9742 N 24 13.0038 W	5220	14.1	5193.2	5288.5
076/02	20130904 22:56:59	28 00.1302 N 24 30.2034 W	5233	10.4	5211.9	5307.6
077/01	20130905 06:08:27	27 29.9904 N 24 47.0544 W	5206	9.8	5195.6	5290.5
078/01	20130905 13:17:24	27 00.0390 N 25 3.96660 W	5250	9.9	5236	5332
079/01	20130905 21:25:30	26 30.0888 N 25 21.1020 W	5262	12.0	5241.4	5337.4
080/01	20130906 04:32:55	25 59.9148 N 25 37.9428 W	4490	10.8	4512.2	4586.9
081/01	20130906 12:41:37	25 29.9664 N 25 54.0744 W	5366	24.4	5337.7	5436.2
082/02	20130906 20:48:57	25 00.0240 N 26 11.0034 W	5408	8.6	5392.4	5492.4
083/01	20130907 03:47:42	24 34.0998 N 26 25.9410 W	5428	16.3	5402.7	5502.9
084/01	20130907 12:52:16	23 59.9814 N 26 45.0240 W	5469	25.5	5441.7	5542.9
085/01	20130907 21:06:37	23 30.1446 N 27 02.0706 W	5517	27.1	5487.5	5589.9
086/01	20130908 04:44:41	23 00.0378 N 27 18.9420 W	5536	17.0	5508.2	5611.1
087/01	20130908 13:14:11	22 29.9838 N 27 35.9508 W	5499	10.0	5483.9	5585.9
088/02	20130908 21:42:49	22 00.1452 N 27 53.2302 W	5463	14.8	5439	5539.3
089/01	20130909 05:30:26	21 29.9886 N 28 09.0192 W	5358	17.0	5335.4	5432.4
090/01	20130909 13:06:33	20 59.9820 N 28 25.9836 W	5083	10.8	5063	5151.6
091/01	20130909 21:12:56	20 30.2604 N 28 43.1118 W	5159	9.8	5140.8	5231.6
092/01	20130912 20:28:02	17 29.4960 N 29 00.0228 W	4671	9.8	4657.5	4733.8
093/01	20130913 05:30:52	18 14.9958 N 29 00.1284 W	4655	16.4	4642.7	4718.7
094/01	20130913 14:55:59	18 59.9922 N 29 00.0030 W	4580	18.0	4554.7	4628.5
095/01	20130914 00:05:07	19 45.0828 N 28 59.8986 W	4758	8.7	4740.3	4819.4
096/02	20130915 19:24:48	17 00.2988 N 29 00.3378 W	4891	497.9	2920.4	2956.1
096/04	20130915 03:36:21	17 00.4470 N 28 59.9754 W	4873	9.9	4852.4	4933.9
097/01	20130915 11:49:45	16 19.9488 N 28 59.9274 W	5126	14.4	5098.9	5187.4
098/02	20130918 21:03:21	15 40.1058 N 28 59.6652 W	5175	14.0	5149.1	5238.8
099/02	20130919 17:22:54	14 59.9958 N 29 00.0024 W	5313	10.5	5287	5380.7
100/01	20130919 00:50:58	14 19.9470 N 28 59.9940 W	5413	10.0	5391.7	5488.4
101/01	20130919 08:07:56	13 39.9468 N 29 00.0396 W	5539	15.4	5514.1	5614.4
102/01	20130920 16:44:40	13 00.1350 N 29 00.0108 W	5714	11.7	5688.1	5793.7
103/02	20130920 01:15:32	12 20.0478 N 29 00.0246 W	5671	9.0	5648.8	5753
104/01	20130920 08:44:35	11 39.9666 N 29 00.0846 W	5600	15.3	5567.8	5669.3
105/02	20130921 17:34:27	11 00.6174 N 28 59.5404 W	5987	15.4	5953.6	6067.4

106/01	20130921 00:46:13	10 30.0516 N 28 44.9226 W	5386	10.2	5353.2	5447.9
107/01	20130921 07:22:22	10 00.0228 N 28 30.0312 W	5367	15.9	5327	5420.8
108/01	20130922 15:23:54	9 30.0546 N 28 15.0372 W	5418	10.7	5406.1	5502.2
109/02	20130921 23:06:44	8 59.9784 N 27 59.9004 W	5218	10.6	5207.4	5297.4
110/01	20130922 06:07:29	8 30.0432 N 27 45.0282 W	4949	15.9	4921.1	5002.7
111/02	20130922 14:19:11	8 00.0018 N 27 29.9970 W	5096	11.0	5075	5160.9
112/01	20130922 21:17:16	7 30.0888 N 27 14.9886 W	4634	11.0	4616.4	4689.4
113/01	20130923 03:54:20	7 00.0204 N 26 59.9238 W	4374	10.7	4354.4	4420.6
114/01	20130923 11:32:10	6 30.0372 N 26 45.0552 W	4657	15.1	4633.4	4706.8
115/02	20130923 19:09:01	5 59.8212 N 26 30.3024 W	4301	6.4	4262.4	4326.1
116/01	20130924 02:05:50	5 30.0030 N 26 15.0534 W	4261	10.9	4255.5	4319
117/01	20130924 08:41:09	4 59.9256 N 26 00.0018 W	4530	14.9	4507.4	4577.4
118/01	20130924 16:24:55	4 30.1044 N 25 44.8716 W	4090	11.2	4085.1	4144.4
119/02	20130925 00:05:56	4 00.1614 N 25 30.1530 W	4037	10.3	4031.7	4089.7
120/01	20130925 06:56:45	3 30.0090 N 25 15.0306 W	4133	14.7	4128.2	4188.4
121/02	20130925 14:47:07	2 59.9994 N 25 00.0006 W	4420	9.2	4399.1	4466.1
122/01	20130925 20:04:47	2 40.0500 N 25 00.0018 W	4097	9.0	4093.3	4152.7
123/01	20130926 01:04:23	2 20.0046 N 25 00.0600 W	3768	11.6	3758.8	3810.4
124/01	20130926 05:57:31	1 59.9838 N 25 00.0264 W	3884	14.0	3872.9	3927.1
125/01	20130926 11:45:52	1 39.9138 N 25 00.0366 W	3823	13.2	3812.9	3865.7
126/01	20130926 17:16:34	1 20.0178 N 25 00.0168 W	3635	9.5	3629.6	3678.3
127/02	20130926 22:55:40	1 00.9564 N 25 00.0114 W	3138	10.8	3128.8	3167
128/01	20130927 04:00:44	0 39.9978 N 25 00.0096 W	4439	13.6	4420.3	4487.9
129/01	20130927 09:13:50	0 20.0856 N 24 59.9346 W	3591	19.3	3562.5	3609.8
130/02	20130927 15:31:35	0 0.04740 S 24 59.3934 W	3094	11.1	3117.6	3155.6
131/01	20130927 21:32:54	0 19.9386 S 25 00.1296 W	3049	79.7	3011.5	3047.5
132/01	20130928 02:19:47	0 39.9678 S 25 00.0354 W	3213	9.8	3199.4	3239.1
133/01	20130928 06:56:10	0 59.7552 S 24 59.8602 W	3057	12.8	3086.4	3123.9
134/01	20130928 13:16:10	1 19.9536 S 25 00.0144 W	4729	10.1	4711.5	4786.9
135/01	20130928 18:58:19	1 39.9252 S 24 59.9748 W	4945	9.5	4927.5	5008.8
136/02	20130929 01:46:18	1 59.9496 S 24 59.9550 W	4961	8.9	4933.9	5015.5
137/01	20130929 07:24:54	2 19.9932 S 24 59.9712 W	5042	13.8	5020.3	5104.3
138/02	20130929 13:41:11	2 40.0164 S 25 00.0090 W	5372	9.6	5341.9	5435.4
139/01	20130929 19:53:37	2 59.9904 S 24 59.9790 W	5367	9.0	5343.5	5437.1
140/01	20130930 02:46:34	3 29.9754 S 24 59.9652 W	5570	7.4	5549.2	5649.1
141/01	20130930 09:39:54	3 59.9934 S 24 59.8902 W	5346	14.2	5314.5	5407.2
142/01	20130930 16:33:24	4 29.9322 S 25 00.0006 W	5552	11.2	5521.2	5620.4
143/01	20130930 23:41:19	4 59.9706 S 25 00.0288 W	5692	9.2	5664.4	5768.1
144/01	20131001 06:49:33	5 29.9682 S 24 59.9898 W	5681	16.1	5632.5	5735.3
145/01	20131001 13:56:28	5 59.8944 S 25 00.0066 W	5808	9.2	5781.3	5888.8

Trace Metal Cast Bottom Data

For each station/cast the following table shows the following information for the bottom of each cast, respectively:

- Station/Cast Number
- Latitude and Longitude
- Bathymetric Depth (meters)
- Calculated Depth using CTD data (meters)
- CTD Pressure (decibars)

A '-999' for any of these values indicates either an instrument error or data was not given.

Table 20.2: A16N 2013 Trace metal cast bottom data

SSS/CC	Latitude & Longitude	Bathy Depth	CTD Depth	CTD Pres
003/01	63 6.9258 N 20 0.084 W	977	979.3	989.2
005/02	62 19.9236 N 19 59.8014 W	1801	1051.3	1062
007/01	61 36.8526 N 19 59.7942 W	2045	1040.1	1050.7
009/02	60 59.8836 N 20 0.6972 W	2395	951.8	961.3
011/01	60 0.0138 N 19 59.9088 W	2720	1026.1	1036.5
013/02	58 59.9604 N 20 0.0624 W	2835	1043.4	1054
015/01	58 0.102 N 20 0.0936 W	1631	1036.1	1046.6
017/02	57 0.1386 N 20 0.0426 W	971	936	945.2
019/01	55 59.9952 N 19 59.9886 W	1455	974.1	983.8
021/02	54 59.79 N 19 59.505 W	1637	1039.8	1050.2
027/02	51 59.7024 N 20 0.1674 W	3747	954.6	964.1
029/01	50 59.9796 N 20 0.0564 W	3665	1039	1049.5
031/02	50 0.0378 N 20 0.0798 W	4401	966.6	976.1
033/01	49 0.024 N 19 59.8074 W	4406	1050.6	1061.1
035/02	47 59.8248 N 19 59.8398 W	4364	969.1	978.5
037/02	46 59.592 N 19 59.5596 W	4538	1036.9	1047
039/01	46 0.1374 N 20 0.0282 W	4839	1038	1048.2
041/02	44 59.9952 N 20 0.129 W	4302	1020.5	1030.5
043/01	43 59.9424 N 20 0.006 W	4005	965	974.3
045/02	43 0.0036 N 19 59.8776 W	5165	1049.3	1059.7
047/01	41 59.8164 N 19 59.9874 W	2204	951.5	960.7
051/02	40 0.0042 N 19 59.9826 W	4783	964.9	975.3
055/02	38 0.1704 N 20 0.3324 W	5114	968.9	978.2
057/01	36 59.9706 N 19 59.9736 W	3819	1041.7	1051.9
059/02	35 59.985 N 19 59.9652 W	5362	1038.9	1049.1
061/02	35 0.0852 N 20 34.0038 W	5114	968.7	978
063/01	34 0.0882 N 21 7.9218 W	5243	1043.7	1053.8
065/02	33 0.0348 N 21 40.8564 W	5266	1010.5	1020.2
066/02	32 30.111 N 21 57.9858 W	5214	162.3	163.4
067/01	31 59.8092 N 22 15.0624 W	5180	964.7	973.7
069/01	31 0.0198 N 22 49.0938 W	5250	1038.3	1048.3
072/02	30 0.0378 N 23 22.0206 W	5255	1029.6	1039.5
074/02	28 59.9928 N 23 56.0988 W	5202	973.6	982.7
076/01	28 0.015 N 24 30.0522 W	5235	1014	1023.7
078/02	27 0.0378 N 25 3.9702 W	5255	975.3	984.5
080/02	25 59.9148 N 25 37.941 W	4506	1040.9	1050.9

082/01	25 0.0078 N 26 10.9908 W	5410	959.4	968.4
084/02	24 0.006 N 26 44.9856 W	5472	1039.1	1049.1
086/02	23 0.0264 N 27 18.9324 W	5535	963.7	972.7
088/01	22 0.0156 N 27 53.1432 W	5461	1036.6	1046.5
090/02	21 0.0282 N 28 25.899 W	5083	911.5	919.9
093/02	18 15.0222 N 29 0.0804 W	4661	1036.3	1046.3
094/02	18 59.9928 N 29 0.003 W	4579	962.7	971.7
096/01	16 59.9526 N 28 59.976 W	4895	967	976.2
096/03	17 0.6396N29 0.7686W	4868	812.1	819.4
098/01	15 39.996 N 28 59.7306 W	5172	1033.2	1043.2
099/01	15 0.231 N 28 59.1072 W	5312	959.3	968.4
101/02	13 39.9462 N 29 0.0384 W	5542	1035.7	1045.7
103/01	12 19.9224 N 29 0.2028 W	5668	967.5	976.6
105/01	11 0.3426 N 28 59.7696 W	5977	998.7	1008.3
107/02	10 0.0222 N 28 29.958 W	5386	962.6	971.7
109/01	9 0.0984 N 28 0.015 W	5237	1035.5	1045.5
111/01	8 0.0318 N 27 29.9562 W	5095	1035.6	1045.4
113/02	7 0.0066 N 26 59.9112 W	4375	958.6	967.4
115/01	5 59.9226 N 26 30.1656 W	4301	1035.1	1044.8
117/02	4 59.925 N 26 0.0042 W	4531	887	894.9
119/01	4 0.0894 N 25 30.1644 W	4038	961.5	970.3
121/01	2 59.982 N 25 0.0672 W	4419	1036.3	1046.1
124/02	1 59.985 N 25 0.0252 W	3883	960.5	969.5
125/02	1 39.8616 N 25 0.0036 W	3821	100.9	101.4
127/01	10.9762 N 25 0.0354 W	3133	838	845.5
130/01	0 0.1494 S 24 59.7666 W	3114	1008.8	1018.4
130/03	0 0.0984 N 24 58.6794 W	3271	1031.3	1041.1
133/02	0 59.9496 S 24 59.7528 W	2996	984.7	994
136/01	1 59.9274 S 24 59.994 W	4964	1036	1045.9
138/01	2 40.0062 S 24 59.9976 W	5371	196	197.2

Bottle Quality Codes and Comments

Quality evaluation of data included comparison of bottle salinity and bottle oxygen data with CTDO data using plots of differences; and review of various property plots and vertical sections of the station profiles and adjoining stations. Comments from the Sample Logs and the results of investigations into bottle problems and anomalous sample values are included in this report. Sample number in this table is the cast number times 100 plus the bottle position number.

Table 20.3: A16N_2013 Bottle quality codes and comments.

Station/ Cast	Bottle Number	Parameter	Quality Code	Comments
1/1	104	Bottle	3	Leak on bottom end cap. CFC and He skip sample.
1/1	104	02	4	Bottle value low for CTD up and down profile as well as supporting parameters. Bottle leak reported.
1/1	110	Refc.Temp.	3	SBE35 low vs. CTDT1/CTDT2. Code questionable.
1/1	110	Salinity	3	Bottle value high vs CTDC1/CTDC2. Code questionable.
2/1	102	02	3	Bottle value low for profile and supporting parameters.
2/1	113	Refc.Temp.	3	SBE35 low vs CTDT1/CTDT2. Code questionable.
2/1	115	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
3/2	214	02	3	Sample value high for CTD profile, adjacent casts and supporting parameters. Code questionable.
4/1	116	Bottle	4	Missed trip, 02 temp 3 degrees high. CMS: Other parameters support missed trip.
4/1	116	Nitrite	4	Missed trip.
4/1	116	Nitrate	4	Missed trip.
4/1	116	02	4	Missed trip, value high for depth in water column.
4/1	116	Phosphate	4	Missed trip.
4/1	116	Salinity	4	Missed trip, value low for depth in water column.
4/1	116	Silicate	4	Missed trip.
6/1	101	Salinity	3	Sample value high vs. calculated CTDS1/CTDS2. Code questionable.
6/1	102	Bottle	3	Stopcock ring fell off. Bottle leaking. Replaced O-ring.
6/1	121	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
6/1	124	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
8/1	101	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
8/1	123	Refc.Temp.	3	5BE35 high vs CTDT1/CTDT2. Code questionable.
9/1	102	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
9/1	114	02	5	Sample lost. Not reported.
9/1	122	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
10/1	105	02	3	Sample value is not reasonable vs. CTD profile, adjacent cast or supporting parameters. Code questionable.
10/1	123	Refc.Temp.	3	5BE35 high for CTDT1/CTDT2. Code questionable.
11/2	218	salinity	4	Sample value high vs. CTDC1/CTDC2. Code questionable.
13/1	101	salinity	3	Sample values high for lower part of profile vs CTDS1/CTDS2. Code questionable.
13/1	102	salinity	3	Sample values high for lower part of profile vs CTDS1/CTDS2. Code questionable.

13/1	103	Salinity	3	Sample values high for lower part of profile vs CTDS1/CTDS2. Code questionable.
13/1	104	Salinity	3	Sample values high for lower part of profile vs CTDS1/CTDS2. Code questionable.
13/1	105	salinity	3	Sample values high for lower part of profile vs CTDS1/CTDS2. Code questionable.
13/1	106	salinity	3	Sample values high for lower part of profile vs CTDS1/CTDS2. Code questionable.
13/1	107	Salinity	3	Sample values high for lower part of profile vs CTDS1/CTDS2. Code questionable.
13/1	108	Salinity	3	Sample values high for lower part of profile vs CTDS1/CTDS2. Code questionable.
13/1	112	Refc.Temp.	5	5BE35 values over written before upload.
13/1	113	Refc.Temp.	5	5BE35 values over written before upload.
13/1	114	Refc.Temp.	5	5BE35 values over written before upload.
13/1	115	Refc.Temp.	5	5BE35 values over written before upload.
13/1	116	Refc.Temp.	5	5BE35 values over written before upload.
13/1	117	Bottle	3	Bottle leaked after vent opened. Stopped leaking after PCO2 sample drawn.
13/1	117	Refc.Temp.	5	5BE35 values over written before upload.
13/1	118	Refc.Temp.	5	5BE35 values over written before upload.
13/1	119	Refc.Temp.	5	5BE35 values over written before upload.
13/1	120	Refc.Temp.	5	5BE35 values over written before upload.
13/1	121	Refc.Temp.	5	5BE35 values over written before upload.
13/1	122	Refc.Temp.	5	5BE35 values over written before upload.
13/1	123	Refc.Temp.	5	5BE35 values over written before upload.
13/1	124	Refc.Temp.	5	5BE35 values over written before upload.
14/1	102	Bottle	3	Stopcock disk popped off. No water after DOC drawn.
14/1	107	Salinity	5	Sample lost, not reported.
14/1	111	Salinity	4	Bottle value high vs calculated CTDS1/CTDS2. Code questionable.
14/1	123	Salinity	4	Bottle value high vs calculated CTDS1/CTDS2. Code bad.
15/2	204	Salinity	3	Bottle value high vs CTDC1/CTDC2. Code questionable.
16/1	102	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
16/1	108	Bottle	3	Spigot pushed into bottle. O-ring off. No samples after 02 drawn.
16/1	118	Refc.Temp.	5	5BE35 data not recovered.
16/1	119	Refc.Temp.	5	5BE35 data not recovered.
16/1	120	Refc.Temp.	5	5BE35 data not recovered.
17/1	117	Bottle	3	Bottle 16 lanyard caught inside top end cap of 17 Slow leak from bottle.
18/1	106	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable
18/1	107	Refc.Temp.	5	Bottle tripped 3 seconds before 108 Not enough time to record SBE35 data. Value not recovered.
18/1	123	Refc.Temp.	5	Bottle tripped 2 seconds before 124 Not enough time to record SBE35 data. Value not recovered.
19/2	201	Salinity	3	Sample value high vs CTDS1/CTDS2. Code questionable.
19/2	202	Bottle	3	Stopcock disk fell off. No samples after CFC5 drawn.
21/1	105	Refc.Temp.	4	5BE35 irregular vs. CTDT1/CTDT2. Code questionable
22/1	104	Bottle	3	O-ring came off after before DOC drawn. Sampling continued.

22/1	104	02	3	Sample value low for CTD profile and supporting parameters. Code questionable.
22/1	114	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
23/1	105	Salinity	3	Sample value high for CTDC1/CTDC2. Code questionable.
23/1	106	02	3	Sample value high for supporting parameters. Code questionable.
23/1	121	Refc.Temp.	4	5BE35 low for CTDT1/CTDT2. Code bad.
23/1	121	Salinity	4	Sample value orders of magnitude low for CTDS1/CTDS2. Possible mis-sample.
24/1	110	02	3	Sample value high for supporting parameters and profile.
				Code questionable.
24/1	122	Salinity	3	Sample value high for CTDC1/CTDC2. Code questionable.
25/1	123	02	4	Sample value low for profile, adjoining stations and supporting parameters. Code bad.
25/1	123	Refc.Temp.	4	5BE35 high vs CTDC1/CTDC2. Code bad.
26/1	104	Bottle	5	Bottom end cap closed on lanyard. No seal made. All Water lost/ not reported.
26/1	106	02	3	Sample value high for profile, adjoining stations and supporting parameters. Code questionable.
26/1	106	Salinity	3	Sample value high for profile, adjoining stations and supporting parameters. Code questionable.
26/1	110	Bottle	3	O-ring dislodged. Spigot pushed inside rosette sample. Water lost after DIC sample drawn.
27/1	112	02	3	Sample value high for profile, adjoining stations and supporting parameters. Code questionable.
27/1	123	Refc.Temp.	4	5BE35 high vs. CTDT1/CTDT2. Code questionable.
28/1	106	Salinity	4	Bottle value high vs. CTDC1/CTDC2. Value matches btl 13. Possibly missampled or run out of order.
28/1	123	Refc.Temp.	4	5BE35 high vs. CTDT1//CTDT2. Code questionable.
29/2	219	02	2	02 temperature sensor inoperable. Replaced after sample.
29/2	223	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code questionable.
30/1	120	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
31/1	112	02	3	Sample value high for profile, adjoining stations and supporting parameters. Code questionable.
31/1	115	Salinity	5	Sample not found in case. Not reported.
31/1	121	Bottle	3	Bottom end cap leak. No water left for salinity sample.
31/1	121	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
31/1	122	Salinity	4	Sample value low for calculated CTDS1/CTDS2. Code questionable.
32/1	102	Salinity	3	Sample value high vs. CTDC1/CTDC2. Sample value matches bottle 106. Possible missample. Code questionable.
32/1	123	Refc.Temp.	4	5BE35 low vs CTDC1 and high vs. CTDC2. Code bad.
33/2	222	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code bad.
34/1	121	Bottle	3	Dribble leak from bottom end cap. O-ring changed after sampling.
34/1	123	Refc.Temp.	4	5BE35 high vs. CTDC1/CTDC2. Code bad.
35/1	112	Refc.Temp.	3	Sample value high vs CTDT1/CTDT2. Code questionable.
35/1	112	Salinity	4	Sample value high vs CTDC1/CTDC2. Code questionable.
36/1	106	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code questionable.

36/1	109	Salinity	4	Sample value matches 110 Possible missample.
36/1	122	Refc.Temp.	4	5BE35 low vs CTDC1 and high vs CTDC2. Code bad.
36/1	123	Bottle	3	Spigot O-ring dislodged. Spigot pushed into Niskin. TALK last sample drawn.
37/1	104	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
37/1	121	Refc.Temp.	3	5BE35 low vs. CTDC1/CTDC2. Code questionable.
37/1	122	Refc.Temp.	3	5BE35 low vs. CTDC1/CTDC2. Code questionable.
37/1	123	Refc.Temp.	4	5BE35 low vs. CTDC1/CTDC2. Code bad.
38/1	123	Refc.Temp.	4	5BE35 low vs CTDC1/CTDC2. Code bad.
38/1	124	Refc.Temp.	3	5BE35 high vs CTDC1/CTDC2. Code bad.
39/2	211	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
40/1	123	Refc.Temp.	4	5BE35 high vs. CTDC1/CTDC2. Code bad.
41/1	102	Bottle	3	Petcock not completely pulled out on deployment. Slight leak on recovery.
41/1	104	Bottle	3	Petcock not completely pulled out on deployment. Slight leak on recovery.
41/1	119	02	3	Sample value low vs profile, adjacent casts and supporting parameters. Code questionable.
42/1	110	Ref.Temp.	4	5BE35 irregular vs CTDT1/CTDT2. Code bad.
43/2	206	02	3	Sample value high vs profile, adjacent casts and supporting parameters. Code questionable.
43/2	209	Salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable.
45/1	101	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
45/1	102	Bottle	3	Spigot pushed in on recovery. All parameters sampled.
45/1	124	Ref.Temp.	4	5BE35 high vs. CTDT1/CTDT2. Code questionable.
46/1	110	Refc.Temp.	4	5BE35 high vs CTDC1/CTDC2. Code questionable.
46/1	110	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
46/1	123	Refc.Temp.	4	5BE35 low vs CTDC1/CTDC2. Code bad.
47/2	203	Refc.Temp.	3	5BE35 irregular vs. CTDT1/CTDT2. Code questionable.
48/1	109	Salinity	4	Sample value low vs CTDC1/CTDC2. Code questionable.
48/1	122	Refc.Temp.	4	5BE35 low vs CTDC1/CTDC2. Code questionable.
48/1	123	Refc.Temp.	4	5BE35 low vs CTDC1 and high vs. CTDC2. Code bad.
49/1	104	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
49/1	105	Salinity	4	Sample value high vs CTDC1/CTDC2. Sample value matches bottle 106. Possible missample. Code bad.
50/1	102	Bottle	5	O-ring came off. Spigot forced inside bottle. No samples drawn or reported.
50/1	103	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad.
50/1	113	Salinity	3	Sample value high for CTDC1/CTDC2. Code questionable.
50/1	121	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
50/1	122	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
50/1	123	Salinity	5	Sample not found in case.
51/1	107	Bottle	3	0-ring broke rosette bottle leaking.
51/1	121	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
52/1	110	Bottle	3	Spigot pushed into niskin. Spigot recovered. All samples drawn.
52/1	117	Bottle	3	Spigot pushed into niskin. Spigot recovered. All samples drawn.
52/1	120	Refc.Temp.	4	5BE35 irregular vs. CTDT1/CTDT2. Code bad.

53/2	223	Refc.Temp.	3	5BE35 irregular for CTDT1/CTDT2. Code questionable.
53/2	224	Refc.Temp.	4	5BE35 high & irregular vs CTDT1/CTDT2. Code bad.
54/1	111	Salinity	5	Sample not reported, missing or lost.
54/1	121	Refc.Temp.	4	Sample irregular vs CTDT1/CTDT2. Code bad.
54/1	122	Refc.Temp.	4	Sample irregular vs CTDT1/CTDT2. Code bad.
55/1	101	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
55/1	102	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
55/1	108	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
56/1	108	02	3	Sample value low for profile & adjoining stations. Code questionable.
57/2	209	Salinity	4	Sample value low vs. CTDC1/CTDC2. Code bad.
57/2	210	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code questionable.
57/2	221	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
58/1	102	Salinity	3	Sample high for profile vs. CTDC1/CTDC2. Code questionable.
58/1	114	Salinity	4	Sample high for profile vs. CTDC1/CTDC2. Sample value matches bottle 115 Possible missample. Code bad.
58/1	115	02	3	Sample low for profile, adjoining stations and supporting parameters. Code questionable.
58/1	120	Refc.Temp.	4	5BE35 irregular vs. CTDT1/CTDT2. Code bad.
59/1	110	Refc.Temp.	4	5BE35 irregular vs. CTDT1/CTDT2. Code bad.
59/1	111	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
60/1	121	Salinity	4	Sample value low vs. CTDC1/CTDC2. Code bad.
61/1	109	Salinity	4	Sample value high vs. CTDC1/CTDC2. Does not fit profile data, code bad.
61/1	121	Salinity	4	Sample value low vs. CTDC1/CTDC2. Value matches bottle 20. Possibly missampled. Code bad.
62/1	110	Refc.Temp.	4	5BE35 irregular vs. CTDT1/CTDT2. Code bad.
63/2	222	Salinity	4	Sample value low vs. CTDC1/CTDC2. Code questionable.
64/1	112	02	3	Sample value low for CTD profile, adjacent casts and supporting parameters. Code questionable.
64/1	122	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code bad.
64/1	123	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable.
65/1	122	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable.
66/1	112	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code bad.
66/1	112	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable.
66/1	124	Refc.Temp.	4	5BE35 irregular vs. CTDT1/CTDT2. Code questionable.
67/2	208	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
68/1	102	Salinity	5	Sample not in sample case.
68/1	105	02	3	Sample value high for profile and adjoining casts. Code questionable.
68/1	112	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
69/2	204	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
69/2	205	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
69/2	214	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
70/1	121	Salinity	4	Sample value low vs. CTDC1/CTDC2. Sample does not match profile, code bad.
71/1	115	Salinity	4	Sample value low vs. CTDC1/CTDC2. Sample matches rosette sample bottle 14 value. Possible missample.

71/1	119	Salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable.
71/1	122	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code bad.
71/1	122	Salinity	4	Sample value low vs CTDC1/CTDC2. Code bad.
72/1	112	Refc.Temp.	4	5BE35 irregular read vs. CTDT1/CTDT2. Code bad.
73/1	108	Bottle	4	Lanyard caught in top end cap. CFC, DIC, PH and TALK not sampled.
73/1	108	02	4	Sample value low for profile. Top end cap not closed properly. Assumed missed trip.
73/1	108	Salinity	4	Sample value high for profile. Top end cap not closed properly. Sample contaminated.
73/1	115	Salinity	4	Sample value matches btl 16 Possibly missampled.
74/1	101	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
75/1	105	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
75/1	109	02	5	Sample lost.
76/2	221	Salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable.
76/2	222	Salinity	4	Sample value low vs CTDC1/CTDC2. Code bad.
77/1	106	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
77/1	110	Refc.Temp.	3	5BE35 low vs CTDT1/CTDT2. Code questionable.
77/1	112	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	113	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	114	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	115	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	116	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	117	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	118	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	119	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	120	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	120	Salinity	4	Sample value high vs CTDC1/CTDC2. Code questionable.
77/1	121	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	121	Total ALK	5	Sample note reported. Missing.
77/1	122	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	123	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
77/1	124	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	101	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	102	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	103	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	104	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	105	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.

				uploaded. Data lost.
78/1	106	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	107	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	108	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	109	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	110	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	111	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	112	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	113	Refc.Temp.	5	SBE35 file over written before data could be uploaded. Data lost.
78/1	114	Refc.Temp.	5	SBE35 file over written before data could be uploaded. Data lost.
78/1	115	Refc.Temp.	5	SBE35 file over written before data could be uploaded. Data lost.
78/1	116	Refc.Temp.	5	SBE35 file over written before data could be uploaded. Data lost.
78/1	117	Refc.Temp.	5	SBE35 file over written before data could be uploaded. Data lost.
78/1	118	Refc.Temp.	5	SBE35 file over written before data could be uploaded. Data lost.
78/1	119	Refc.Temp.	5	SBE35 file over written before data could be uploaded. Data lost.
78/1	120	Refc.Temp.	5	SBE35 file over written before data could be uploaded. Data lost.
78/1	120	Salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable.
78/1	121	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	122	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	123	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
78/1	124	Refc.Temp.	5	5BE35 file over written before data could be uploaded. Data lost.
79/1	114	Refc.Temp.	4	5BE35 high vs. CTDT1/CTDT2. Code bad.
79/1	117	Salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable.
79/1	122	pH	5	Sample not reported. Missing.
80/1	101	Bottle	2	Winch wire wrap issues. Package stopped at -143Sdbar and went back down 30m to 146Sdbar before starting back towards surface.
80/1	102	Bottle	2	Winch wire wrap issues. Package stopped at -143Sdbar and went back down 30m to 146Sdbar before starting back towards surface.
80/1	103	Bottle	2	Winch wire wrap issues. Package stopped at -143Sdbar and went back down 30m to 146Sdbar before starting back towards surface.
80/1	104	Bottle	2	Winch wire wrap issues. Package stopped at -143Sdbar and went back down 30m to 146Sdbar before starting back towards surface.
80/1	105	Bottle	2	Winch wire wrap issues. Package stopped at -143Sdbar

				and went back down 30m to 146Sdbar before starting back towards surface.
80/1	106	Bottle	2	Winch wire wrap issues. Package stopped at -143Sdbar and went back down 30m to 146Sdbar before starting back towards surface.
80/1	107	Bottle	2	Winch wire wrap issues. Package stopped at -143Sdbar and went back down 30m to 146Sdbar before starting back towards surface.
80/1	108	Bottle	2	Winch wire wrap issues. Package stopped at -143Sdbar and went back down 30m to 146Sdbar before starting back towards surface.
80/1	109	Bottle	2	Winch wire wrap issues. Package stopped at -143Sdbar and went back down 30m to 146Sdbar before starting back towards surface.
80/1	121	Refc.Temp.	5	Bottle tripped 15 seconds before 122 Not enough time to record 5BE35 data.
80/1	122	Bottle	4	Bottle 22 and 21 accidentally tripped at same depth. O2, PCO2 and nutrients only drawn from both niskin 21 and 22
80/1	122	pH	5	Sample lost. Sample not reported. Missing.
81/1	113	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable
81/1	116	pH.	5	Sample not reported. Missing.
81/1	121	Bottle	3	Vent left open before cast. Bottle leaking during sampling.
81/1	122	Bottle	3	Vent left open before cast. Bottle leaking during sampling.
81/1	122	Refc.Temp.	4	SBE35 low vs. CTDT1/CTDT2. Code bad.
81/1	123	Bottle	3	Vent left open before cast. Bottle leaking during sampling.
81/1	124	Bottle	3	Vent left open before cast. Bottle leaking during sampling.
82/2	201	Total Alk	5	Sample value not reported. Missing.
82/2	217	Salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable.
83/1	107	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
83/1	115	Refc.Temp.	3	5BE35 low vs CTDT1/CTDT2. Code questionable.
83/1	119	Refc.Temp.	3	5BE35 low vs CTDT1/CTDT2. Code questionable.
83/1	119	Salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable
83/1	120	Salinity	4	Sample value high vs CTDC1/CTDC2. Value matches btl 22 Possibly missampled or run out of order.
83/1	121	Salinity	4	Sample value high vs CTDC1/CTDC2. Code bad.
84/1	101	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for several tens of meters before starting back towards surface.
84/1	101	salinity	4	Sample value low vs CTDC1/CTDC2. Value matches btl 2 Possibly missampled. Code questionable.
84/1	102	Bottle	3	Spigot ring came off. Bottle empty before salinity and CDOM could be drawn. Spigot replaced after sampling.
84/1	103	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	104	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	105	Bottle	2	Winch wire wrap issues. Package stopped repeated

				during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	106	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	107	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	108	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	109	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	110	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	111	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	112	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	113	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	114	Bottle	2	Winch wire wrap issues. Package stopped repeated during upcast and descended back towards bottom for tens of meters before starting back towards surface.
84/1	115	Refc.Temp.	5	Xx sec wait was not observed for bottle trip. SBE35 data missing from bottle 15 of this cast.
84/1	118	Refc.Temp.	4	5B35 high vs. CTDT1/CTDT2. Code bad
84/1	119	salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable.
84/1	122	Refc.Temp.	3	5B35 high vs. CTDT1/CTDT2. Code questionable.
84/1	122	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
85/1	101	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	102	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	103	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	104	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	105	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	106	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	106	Salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable.
85/1	107	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	108	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m

				before starting back towards surface.
85/1	109	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	110	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	111	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	112	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	113	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	114	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	115	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	116	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	117	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	118	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	119	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	120	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	121	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	122	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	122	Salinity	5	Sample missing/lost.
85/1	123	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
85/1	123	Salinity	4	Sample value high vs CTDC1/CTDC2. Value matches btl 20 Possibly missampled or run out of order. Code bad.
85/1	124	Bottle	2	Winch wire wrap issues. Package stopped at 149m on upcast and descended back towards bottom for ~15m before starting back towards surface.
86/1	106	CC14	5	Sample log noted as sampled. Sample not found.
86/1	106	CFC-11	5	Sample log noted as sampled. Sample not found.
86/1	106	CFC-12	5	Sample log noted as sampled. Sample not found.
86/1	106	SF6	5	Sample log noted as sampled. Sample not found.
86/1	120	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
86/1	121	Refc.Temp.	4	5BE35 high vs. CTDT1/CTDT2. Code bad.

86/1	121	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
87/1	101	02	2	High O2 sample temp noted on sample log. Value appears normal. No other problems noted.
87/1	116	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code bad.
87/1	119	Salinity	3	Sample value low vs CTDC1/CTDC2. Code questionable.
88/2	216	pH.	5	Sample not reported. Missing.
88/2	219	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
89/1	104	Salinity	3	Sample value high vs CTDC1/CTDC2. Code questionable.
89/1	108	Salinity	4	Suppression switch not increased through analysis. Sample value incorrect.
89/1	109	Salinity	4	Suppression switch not increased through analysis. Sample value incorrect.
89/1	110	Salinity	4	Suppression switch not increased through analysis. Sample value incorrect.
89/1	111	Salinity	4	Suppression switch not increased through analysis. Sample value incorrect.
89/1	112	Salinity	4	Suppression switch not increased through analysis. Sample value incorrect.
89/1	113	Salinity	4	Suppression switch not increased through analysis. Sample value incorrect.
89/1	114	salinity	4	Suppression switch not increased through analysis. Sample value incorrect.
89/1	115	Salinity	4	Suppression switch not increased through analysis. Sample value incorrect.
90/1	106	Bottle	3	Bottle leaking out of bottom. Water samples not recovered.
90/1	113	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
90/1	122	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
90/1	122	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad.
91/1	117	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code questionable.
91/1	117	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable
91/1	119	Refc.Temp.	4	5BE35 high vs. CTDT1/CTDT2. Code questionable.
92/1	101	TAlk	5	Sample lost, not reported.
93/1	120	02	5	Sample lost, not reported.
93/1	120	Salinity	4	Sample value low vs. CTDC1/CTDC2. Code questionable
94/1	102	Bottle	3	Slight leak from bottom end cap. Nutrients, salinity and CDOM sampled only.
94/1	107	02	5	Sample not reported. Missing.
94/1	117	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable
95/1	121	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad.
95/1	124	Salinity	5	Sample not reported.
96/4	401	Salinity	4	Sample value high vs. CTDC1/CTDC2. Sample value matches bottle 2 Possible missample. Code questionable
96/4	403	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code questionable
96/4	419	Bottle	5	Bottle did not fire. Not reported.
96/4	421	Bottle	5	Bottle did not fire. Not reported.
97/1	101	Salinity	4	Sample value high vs. CTDC1/CTDC2. Sample value matches CTD btl 102. Possible missample. Code bad
97/1	102	Salinity	4	Sample value high vs. CTDC1/CTDC2. Sample value matches CTD btl 101. Possible missample. Code bad
97/1	103	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad.
97/1	104	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code questionable

97/1	105	Bottle	5	Bottle did not trip. Sample lost! not reported.
97/1	107	Salinity	3	Sample value high vs. CTDC1!CTDC2. Code questionable
97/1	110	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable
97/1	113	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable
97/1	115	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable
97/1	119	Bottle	3	Bottle did not trip. Nutrients sampled at a later time.
97/1	120	Bottle	5	Bottle did not trip. Sample lost/ not reported.
97/1	122	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code bad
98/2	203	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable
98/2	204	Salinity	3	Sample value high vs. CTDC1!CTDC2. Code questionable
98/2	205	Bottle	5	Bottle did not trip. Sample lost! not reported.
98/2	211	Salinity	3	Sample value high vs. CTDC1!CTDC2. Code questionable
98/2	221	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable
98/2	222	Refc.Temp.	4	5BE35 high vs. CTDT1!CTDT2. Code bad.
98/2	223	Refc.Temp.	3	5BE35 irregular vs. CTDT1!CTDT2. Code questionable
99/2	209	Bottle	5	Bottle did not trip close. No values reported.
99/2	217	Salinity	4	Sample value high vs. CTDC1!CTDC2. Does not match profile. Code questionable
99/2	222	Refc.Temp.	4	5BE35 high vs. CTDT1/CTDT2. Code bad.
100/1	117	Bottle	5	Bottle not fired. Not reported.
100/1	120	Bottle	3	Leak from bottom end cap. Water drained, No samples taken.
100/1	121	Salinity	3	Sample value low vs. CTDC1!CTDC2. Code questionable
100/1	123	Refc.Temp.	4	5BE35 high vs. CTDT1!CTDT2. Code questionable
100/1	123	Salinity	3	Sample value low vs. CTDC1!CTDC2. Code questionable
101/1	101	Salinity	4	Sample value high vs. CTDC1!CTDC2. Sample value matches bottle 103. Possible missample. Code bad.
101/1	117	Bottle	5	Bottle not tripped. Not reported.
101/1	121	Refc.Temp.	3	5BE35 irregular vs. CTDT1!CTDT2. Code questionable
101/1	122	Refc.Temp.	4	5BE35 irregular vs. CTDT1!CTDT2. Code questionable
101/1	124	Bottle	3	Vent found slightly open by first sampler.
102/1	123	Salinity	3	Sample value high vs. CTDC1!CTDC2. Code questionable.
103/2	217	Bottle	5	Bottle not tripped. Carousel head replaced after sampling. Sample value low vs. CTDC1/CTDC2.
103/2	221	Salinity	3	Sample Value does not match profile. Code questionable.
103/2	222	Salinity	4	Sample value low vs. CTDC1!CTDC2. Value does not match profile. Code bad.
104/1	121	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable
104/1	123	Refc.Temp.	4	5BE35 high vs. CTDT1/CTDT2. Code bad.
104/1	124	Bottle	5	Lanyard caught between bottles. Bottom end cap could not close. Water sample drained out of bottle bottom.
105/2	201	Salinity	3	Sample value high vs. CTDC1!CTDC2. Code questionable.
105/2	223	Refc.Temp.	3	5BE35 low vs. CTDT1!CTDT2. Code questionable.
106/1	118	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
106/1	122	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable.
107/1	121	Refc.Temp.	3	5BE35 irregular vs. CTDT1!CTDT2. Code questionable.
107/1	123	Salinity	3	Sample value high vs. CTDC1!CTDC2. Code questionable.
107/1	124	Bottle	5	Bottle not tripped.
109/2	221	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.

109/2	222	Bottle	5	Bottom end cap did not close.
109/2	223	Salinity	4	Sample value high vs. CTDC1!CTDC2. Code questionable.
109/2	224	Bottle	5	Bottom end cap did not close. Not reported.
111/2	214	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
111/2	220	Refc.Temp.	4	5BE35 high vs. CTDT1!CTDT2. Code bad.
111/2	223	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad.
112/1	120	Refc.Temp.	4	5BE35 low vs. CTDT1!CTDT2. Code bad.
112/1	121	Salinity	3	Sample value low vs. CTDC1!CTDC2. Code questionable.
112/1	122	Salinity	4	Sample value high vs. CTDC1!CTDC2. Code bad.
112/1	123	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
112/1	124	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad.
113/1	115	Bottle	3	Leak from nozzle. C14-DIC and DOC not sampled.
113/1	124	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad.
114/1	115	Bottle	3	Spigot disk/stop cock pulled off. O-ring replaced.
114/1	121	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
114/1	122	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad.
114/1	123	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
115/2	219	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code bad.
115/2	219	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable.
115/2	220	Refc.Temp.	4	5BE35 irregular vs. CTDT1/CTDT2. Code bad.
115/2	221	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
115/2	222	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code questionable.
116/1	120	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
116/1	121	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
116/1	122	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
116/1	123	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
117/1	117	Refc.Temp.	3	5BE35 irregular vs. CTDT1/CTDT2. Code questionable.
117/1	122	Refc.Temp.	4	15 second wait for SBE35 not observed after firing bottle.
118/1	113	Bottle	5	Bottle did not trip close. Not reported.
118/1	124	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
119/2	201	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
119/2	206	Total Alk	5	Sample value not reported, lost.
119/2	220	Bottle	3	Bottle leaked from bottom end cap after vent opened.
120/1	103	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
120/1	105	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
120/1	106	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
120/1	120	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
121/2	219	Refc.Temp.	4	5BE35 value low vs CTDT1/CTDT2. Code bad.
121/2	219	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
122/1	101	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
122/1	106	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
122/1	110	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
123/1	103	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
123/1	104	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
123/1	115	Bottle	3	O-ring slips off spigot. Spigot slips into rosette bottle.
123/1	116	Refc.Temp.	3	5BE35 value high vs. CTDT1/CTDT2. Code questionable.
123/1	117	Bottle	3	O-ring slips off spigot. Spigot slips into rosette bottle.

124/1	101	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
124/1	103	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
124/1	114	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable.
124/1	120	Refc.Temp.	4	5BE35 high vs. CTDT1/CTDT2. Code questionable.
125/1	101	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
125/1	104	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
125/1	112	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	113	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	114	Bottle	3	0-ring and disk came off spigot.
125/1	114	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	115	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	116	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	117	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	118	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	119	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	119	Salinity	5	Sample not reported, missing or lost.
125/1	120	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	121	DIC	5	Sample lost/ not reported.
125/1	121	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	121	Salinity	4	Sample value low vs. CTDC1/CTDC2. Code bad.
125/1	122	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	123	Refc.Temp.	5	5BE35 data memory over written. Data lost.
125/1	124	Refc.Temp.	5	5BE35 data memory overwritten. Data lost.
126/1	101	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
126/1	103	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
126/1	114	Bottle	3	0-ring and disk came off spigot.
127/2	201	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
127/2	202	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
127/2	203	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable
127/2	204	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable
127/2	214	Bottle	3	0-ring and disk came off spigot.
127/2	220	Refc.Temp.	4	Sample value low vs. CTDT1/CTDT2. Code bad.
127/2	220	Salinity	4	Sample value low vs. CTDC1/CTDC2. Code bad.
127/2	221	Refc.Temp.	4	Sample value high vs. CTDT1/CTDT2. Code bad.
128/1	111	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable
130/2	203	Bottle	2	Bottle ran out of water after 018/016. Tritium, nutrients and salinity not sampled.
130/2	218	Bottle	3	Spigot disk came off. Spigot pushed into niskin bottle. Bottle out of water. N20 isotope, pH, TALK, d15N, 018/016, tritium, nutrients, and salinity not sampled.
130/2	220	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
130/2	220	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad.
131/1	101	Salinity	4	Sample value high vs. CTDC1/CTDC2. Possible missample. Code bad.
131/1	121	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable
132/1	101	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable
132/1	112	Bottle	4	Samples analysis indicate mis-trip.
132/1	112	02	4	Sample value high vs CTD. Other parameters indicate possible mis-trip.

132/1	112	Salinity	4	Sample value high vs. CTDC1/CTDC2. Sample value does not fit profile. Code bad. Parameters indicate mis-trip.
132/1	117	Salinity	4	Sample value high vs. CTDC1/CTDC2. Sample value does not fit profile. Code bad.
132/1	121	Refc.Temp.	4	5BE35 irregular vs. CTDT1/CTDT2. Code bad.
132/1	121	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
132/1	122	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
132/1	123	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
133/1	111	02	5	Sample lost, not reported.
133/1	114	Refc.Temp.	4	5BE35 irregular read vs. CTDT1/CTDT2. Code questionable.
133/1	120	Refc.Temp.	4	5BE35 high vs. CTDT1/CTDT2. Code bad.
133/1	120	Salinity	3	Sample value high vs. CTDC1/CTDC2. Code questionable.
133/1	121	Salinity	4	Sample value low vs. CTDC1/CTDC2. Code bad.
134/1	120	Refc.Temp.	4	5BE35 low vs. CTDT1/CTDT2. Code bad.
134/1	120	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable.
134/1	122	Salinity	3	Sample value low vs. CTDC1/CTDC2. Code questionable.
136/2	205	Salinity	4	Sample value high vs CTDC1/CTDC2. Code bad.
136/2	218	Refc.Temp.	4	5BE35 irregular vs. CTDT1/CTDT2. Code bad.
136/2	219	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
137/1	117	Bottle	3	Leaking from valve after lanyard caught on recovery.
137/1	117	Refc.Temp.	3	5BE35 high vs. CTDT1/CTDT2. Code questionable.
137/1	120	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
137/1	120	Salinity	4	Sample value low vs CTDC1/CTDC2. Code bad.
139/1	112	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	113	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	114	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	115	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	116	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	117	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	118	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	119	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	120	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	121	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	122	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	123	Refc.Temp.	5	5BE35 data memory over written. Data lost.
139/1	124	Refc.Temp.	5	5BE35 data memory over written. Data lost.
140/1	119	Refc.Temp.	3	5BE35 low vs. CTDT1/CTDT2. Code questionable.
141/1	120	Refc.Temp.	4	Sample value low vs. CTDC1/CTDC2. Code bad.
141/1	120	Salinity	4	Sample value high vs. CTDC1/CTDC2. Code bad. Numerous bad salinity samples reported from this rosette sample. Rosette bottle possibly leaking.
145/1	120	Refc.Temp.	3	SBE35 high vs. CTDT1/CTDT2. Code questionable

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CCHDO Data Processing Notes

Date	Person	Data Type	Action	Summary
2013-10-14	Schatzman, Courtney	BTL	Submitted	to go online
2013-10-15	Staff, CCHDO	BTL	Website Update	Available under 'Files as received' The following files are now available online under 'Files as received', unprocessed by the CCHDO. a16n_hy1.csv
2013-11-26	Schatzman, Courtney	BTL	Submitted	Updated bottle quality codes and headers.
2013-12-16	Staff, CCHDO	BTL	Website Update	Available under 'Files as received' The following files are now available online under 'Files as received', unprocessed by the CCHDO. a16n_hy1.csv
2013-12-17	Wisegarver, Eric	NUTS	Submitted	to go online
2013-12-19	Staff, CCHDO	FE/AL/MN/HG_SPEC/METH YLHG/PMB CU ISO/PTERO POD/TSM_FILTERED	Website Update	Available under 'Files as received' The following files are now available online under 'Files as received', unprocessed by the CCHDO. 131210_Post_Cruise_A16N.csv
2014-01-03	Staff, CCHDO	BTL/NUTS	Website Update	Available under 'Files as received' The following files are now available online under 'Files as received', unprocessed by the CCHDO. A16N Nutrient Data_131217_NoTM.txt
2014-03-17	Schatzman, Courtney	BTL	status update	Preliminary Bottle data are preliminary until CTD data have been finalized.
2014-03-18	McTaggart, Kristy	CTD	status update	to be submitted in 2-3 wks The final CTD/O2 data from A16N will be submitted within the next couple of weeks.
2014-04-08	Staff, CCHDO	CTD	Website Update	Available under 'Files as received' The following files are now available online under 'Files as received', unprocessed by the CCHDO. a16n_final_ct1.zip
2014-04-08	McTaggart, Kristy	CTDOXY	Submitted	final data, to go online These are final CTDO profile data. Documentation for these data will be included in the Chief Scientist's copy of the cruise report to be submitted at a later date.
2014-04-10	McTaggart, Kristy	CTD	re-Submitted	revised data set, to go online These CTD profiles should replace the ones submitted yesterday, 4/9/14. These data files have been properly formatted.
2014-04-10	McTaggart, Kristy	BTL	Submitted	Final data to go online These final CTDO and bottle salinity data are in .SEA format and should be merged into the a16n_hy1.csv file.
2014-05-12	Staff, CCHDO	CTDO	Website Update	Available under 'Files as received' The following files are now available online under 'Files as received', unprocessed by the CCHDO. a16n_final.sea
2014-05-12	Staff, CCHDO	CTD	Website Update	Available under 'Files as received' The following files are now available online under 'Files as received', unprocessed by the CCHDO. a16n_final_ct1.zip
2014-05-13	Staff, CCHDO	SUM	Website Update	Available under 'Files as received' The following files are now available online under 'Files as received', unprocessed by the CCHDO. a16n.sum
2014-05-13	Quintero, Alex	SUM	Submitted	to go online SUM file from Alex Quintero submitted via email on 2014-05-12
2014-05-14	Staff, CCHDO	BTL	Website Update	Available under 'Files as received' The following files are now available online under 'Files as received', unprocessed by the CCHDO. a16n_hy1.csv
2014-05-14	Quintero, Alex	BTL	Submitted	Corrected format.; to go online
2014-05-23	Berys, Carolina	BTL-NUTS-CTDO-CTD	Website Update	Exchange, netCDF, and WOCE files online. SUM, CTD, and bottle with nutrient and CTDO updates

=====

A16N 2013 33RO20130803 processing - SUM/CTD/BTL/merge - CTDPRS, CTDTMP, CTDSAL,
CTDOXY, SALNTY, CTDRAW, THETA, SILCAT, NITRAT, NITRIT, PHSPHT, NUT_TMP
=====

2014-05-23

C Berys

.. contents:: :depth: 2

Submission

=====

filename	submitted by	date	data type	id
A16N Nutrient Data_131217_NoTM.txt	Eric Wisegarver	2013-12-17	BTL/NUTS	1118
a16n_final.sea	Kristy McTaggart	2014-04-10	CTDO	1156
a16n_final_ct1.zip	Kristy McTaggart	2014-04-10	CTD	1155
a16n.sum	Alex Quintero	2014-05-13	SUM	1167
a16n_hy1.csv	Alex Quintero	2014-05-14	BTL	1169

Parameters

A16N Nutrient Data_131217_NoTM.txt

~~~~~

- SILCAT [1]\_ [4]\_-
- NITRAT [1]\_ [4]\_-
- NITRIT [1]\_ [4]\_-
- PHSPHT [1]\_ [4]\_-
- NUT\_TMP [3]\_ [4]\_-

a16n\_final.sea

~~~~~

- CTDPRS [4]_-
- CTDTMP [4]_-
- CTDSAL [1]_ [4]_-
- SALNTY [1]_ [4]_-
- CTDOXY [1]_ [4]_-
- CTDRAW [3]_ [4]_-
- THETA [3]_ [4]_-

a16n_final_ct1.zip

~~~~~

- CTDPRS
- CTDTMP
- CTDSAL [1]\_-
- SALNTY [1]\_-
- CTDOXY [1]\_-
- CTDRAW [3]\_-
- THETA [3]\_-

a16n\_hy1.csv

~~~~~

- CTDPRS [4]_-
- CTDTMP [4]_-
- CTDSAL [1]_ [4]_-
- SALNTY [1]_ [4]_-
- CTDOXY [1]_ [4]_-
- OXYGEN [1]_-
- SILCAT [1]_ [4]_-
- NITRAT [1]_ [4]_-
- NITRIT [1]_ [4]_-
- PHSPHT [1]_ [4]_-

```

- CFC-11 [1]_
- CFC-12 [1]_
- SF6 [1]_
- TCARBON [1]_
- ALKALI [1]_
- PH_SWS [1]_
- TRITUM [1]_ [2]_
- HELIUM [1]_ [2]_
- DELC13 [1]_ [2]_
- DELC14 [1]_ [2]_
- CCL4 [1]_ [2]_
- POC [1]_ [2]_
- DOC [1]_ [2]_
- TDN [1]_ [2]_ [3]_
- N2O [1]_ [3]_
- SALTREF [1]_ [3]_
- CF3SF5 [1]_ [3]_
- PCO2 [1]_
- PCO2TMP
- DELN15_N2O [1]_ [2]_ [3]_
- SPN2O [1]_ [2]_ [3]_
- DELO18_N2O [1]_ [2]_ [3]_
- PH_TMP
- 14C_DOC [1]_ [2]_ [3]_
- BLACKC [1]_ [2]_ [3]_
- DEL15N_NO3 [1]_ [2]_ [3]_
- DEL18O_NO3 [1]_ [2]_ [3]_
- O18/O16-LDEO [1]_ [2]_ [3]_
- O18/O16-TAMU [1]_ [2]_ [3]_
- CDOM_ABS@325 [1]_ [2]_ [3]_
- CDOM_ABS@340 [1]_ [2]_ [3]_
- CDOM_ABS@380 [1]_ [2]_ [3]_
- CDOM_ABS@412 [1]_ [2]_ [3]_
- CDOM_ABS@443 [1]_ [2]_ [3]_
- CDOM_ABS@490 [1]_ [2]_ [3]_
- CDOM_ABS@555 [1]_ [2]_ [3]_
- CDOM [1]_ [2]_ [3]_
- REFTMP [1]_ [3]_
- SIGMA-THETA [3]_
- SIGMA-1 [3]_
- SIGMA-2 [3]_
- SIGMA-3 [3]_
- SIGMA-4 [3]_

... [1] parameter has quality flag column
... [2] parameter only has fill values/no reported measured data
... [3] not in WOCE bottle file
... [4] merged, see merge_

```

Process
=====

Changes

```

A16N Nutrient Data_131217_NoTM.txt
~~~~~
a16n_final.sea
~~~~~
- SALNTY changed from -9.0000 to -999.0000 where flagged 9

a16n_final_ctl.zip
~~~~~
- added comma at the end of units line for stations 126-145

a16n.sum
~~~~~

```

```

a16n_hy1.csv
~~~~~
- REFTMP changed from -9.0000 to -999.0000 where flagged 5
- CTDPRS units changed from "DBARS" to "DBAR"
- PCO2 units changed from "UATM@T" to "UATM"
- PCO2TMP units changed from "DEG_C" to "DEG C"
- TCO2 changed to TCARBON
- PH_TMP units changed from "DEG_C" to "DEG C"
- SIGMA-THETA changed to SIG0, units changed from "" to "KG/M^3"
- PH_SWS changed from nan to -999.0000
- O18/O16-LDEO and O18/O16-TAMU changed to DELO18-LDEO and DELO18-TAMU (NOTE:
these are not recognized parameters and the columns do not contain data)
- NOTE: several unrecognized parameters, all are empty except theta columns

.. _merge:

Merge
-----
A16N Nutrient Data_131217_NoTM.txt
~~~~~
Merged A16N Nutrient Data_131217_NoTM.txt into 33RO20130803_hy1.csv using hydro
0.8.0-117-g2f13399.

:New parameters: SILCAT, SILCAT_FLAG_W, NITRAT, NITRAT_FLAG_W, NITRIT,
NITRIT_FLAG_W, PHSPHT, PHSPHT_FLAG_W, NUT_TMP

All comment lines from original file copied back in following merge.
33RO20130803_hy1.csv opened in JOA with no apparent problems.

a16n_final.sea
~~~~~
Merged a16n_final.sea into 33RO20130803_hy1.csv using hydro 0.8.0-117-g2f13399.

:New parameters: CTDPRS, CTDTMP, CTDSAL, CTDSAL_FLAG_W, CTDOXY, CTDOXY_FLAG_W,
SALNTY, SALNTY_FLAG_W, CTDRAW, THETA

All comment lines from original file copied back in following merge.
33RO20130803_hy1.csv opened in JOA with no apparent problems.

a16n_final_ctl1.zip
~~~~~
a16n.sum
~~~~~
a16n_hy1.csv
~~~~~

Conversion
-----
===== ===== =====
file converted from software
=====
33RO20130803_nc_hyd.zip 33RO20130803_hy1.csv hydro 0.8.0-117-g2f13399
33RO20130803hy.txt 33RO20130803_hy1.csv hydro 0.8.0-117-g2f13399
33RO20130803_nc_ctd.zip 33RO20130803_ctl1.csv hydro 0.8.0-117-g2f13399
===== ===== =====

All converted files opened in JOA with no apparent problems.

Directories
=====
:working directory:
 /data/co2clivar-atlantic/a16/a16n_33RO20130803/original/2014.05.23_BTL-NUTS-
CTDO-CTD_CBG
:cruise directory:
 /data/co2clivar-atlantic/a16/a16n_33RO20130803

```

```

Updated Files Manifest
=====
===== file stamp =====
33RO20130803_hy1.csv 20140522SIOCCHCBG
33RO20130803_nc_hyd.zip 20140522SIOCCHCBG
33RO20130803_ct1.zip 20140410PMELNOAAKEM
33RO20130803hy.txt
33RO20130803su.txt
33RO20130803_nc_ctd.zip 20140410PMELNOAAKEM
=====

2014-05-28 Millero, Frank pH/TALK Submitted to go online
2014-06-02 Staff, CCHDO PH/ALKALI Website Update Available under 'Files as received'
The following files are now available online under 'Files as received', unprocessed by the CCHDO.
A16N TA Submit.xlsx
A16N pH Submit.xlsx
2014-06-03 Kozyr, Alex PH/ALKALI Update pending Updated qual flags will be submitted by
CDIAC
Some problems in the data were discovered by Bob Key. Data not available until data quality determined and flags are assigned. Update will come from Alex Kozyr at CDIAC.
2014-06-17 Lee, Rox maps Website Update Maps created
=====
33RO20130803 processing - Maps
=====

2014-06-17

R Lee

.. contents:: :depth: 2

Process
=====

Changes
-----
- Maps created from 33RO20130803_hy1.csv

Directories
=====
:working directory:
 /data/co2clivar/atlantic/a16/a16n_33RO20130803/original/2014.06.17_maps_RJL
:cruise directory:
 /data/co2clivar/atlantic/a16/a16n_33RO20130803

Updated Files Manifest
=====
===== file stamp =====
33RO20130803_trk.jpg
33RO20130803_trk.gif
=====

2014-06-19 Staff, CCHDO PCO2/TCARBON Submitted Received and sent to CDIAC for processing
Data will be resubmitted and made available after processing.
The following files were sent to CDIAC:
TCO2_pCO2_update.doc
a16n-20140619_pCO2_TCO2_FinalQC.csv
2014-06-19 Castle, Robert pCO2_TCO2 Submitted Updated
Updated flags and values for discrete pCO2 and TCO2.

```

- 2014-06-20 Kozyr, Alex TCO2/ALK/pH/pCO2 Submitted final data to go online
The final TCARBON and PCO2 data from R. Wanninkhof, ALKALI and PH_SWS from F. Millero. Bob Key and Alex Kozyr performed additional QC, some flags have been changed.
- 2014-06-23 Staff, CCHDO TCARBON/ALKALI/PH/PCO2 Website Update Available under 'Files as received'
The following files are now available online under 'Files as received', unprocessed by the CCHDO.
33RO20130803_TCARBON_ALKALI_PH_PCO2_final_hy1.csv
- 2014-06-26 Kappa, Jerry CrsRpt Website Update PDF version online
I've placed a new PDF version of the cruise report: 33RO20130803do.pdf
into the directory: http://cchdo.ucsd.edu/data/co2clivar/atlantic/a16/a16n_33RO20130803/
It includes all the reports provided by the cruise PIs, summary pages and CCHDO data processing notes, as well as a linked Table of Contents and links to figures, tables and appendices.