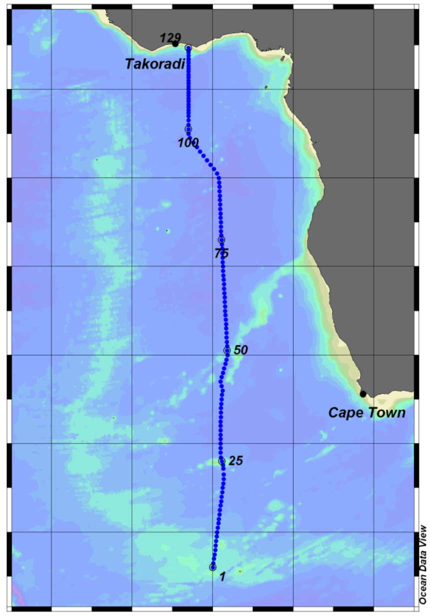
CRUISE REPORT: A13.5

(Updated FEB 2011)



HIGHLIGHTS

Cruise Summary Information

WOCE Section Designation	**A13.5**
Expedition designation (ExpoCodes)	**33RO20100308**
Chief Scientist	**Dr. John L. Bullister/NOAA/PMEL**
Co-Chief Scientist	**Dr. Robert M. Key/Princeton**
Dates	2010 MAR 8 - 2010 April 18
Ship	R/V *Ronald H. Brown*
Ports of call	Cape Town, South Africa - Takoradi, Ghana
Geographic Boundaries	4° 42.65' N 3° 0.11' W 1° 49.98' E 54° 0.04' S
Stations	130
Floats and drifters deployed	8 Argo floats, 18 surface drifters deployed
Moorings deployed or recovered	0

Chief Scientist Contact Information

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LINKS TO SELECT LOCATIONS

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	Bottle Data Oxygen CFCs
Acoustic Doppler Current Profiler (ADCP)	DIC phT LADCP
Thermosalinograph	Alkalinity fCO_2 Underway fCO_2
XBT and/or XCTD	
Meteorological Observations	
Atmospheric Chemistry Data	**Acknowledgments**
Data Processing Notes	

CLIVAR/Carbon A13.5 Cruise Report

NOAA Ship *Ronald H. Brown*
8 March 2010 - 18 April 2010
Cape Town, South Africa - Takoradi, Ghana

ExpoCode: 33RO20100308

Chief Scientist:
Dr. John L. Bullister
National Oceanic and Atmospheric Administration
Pacific Marine Environmental Laboratory

Co-Chief Scientist:
Dr. Robert M. Key
Princeton University

Cruise Report
6 December 2010

Data Manager (shore-based)
Mary Carol Johnson
Shipboard Technical Support/Oceanographic Data Facility
Scripps Institution of Oceanography/UC San Diego
La Jolla, CA

Data Management (shipboard):
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Princeton University
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Ivy Frenger
Swiss Federal Institute of Technology
Zurich, Switzerland

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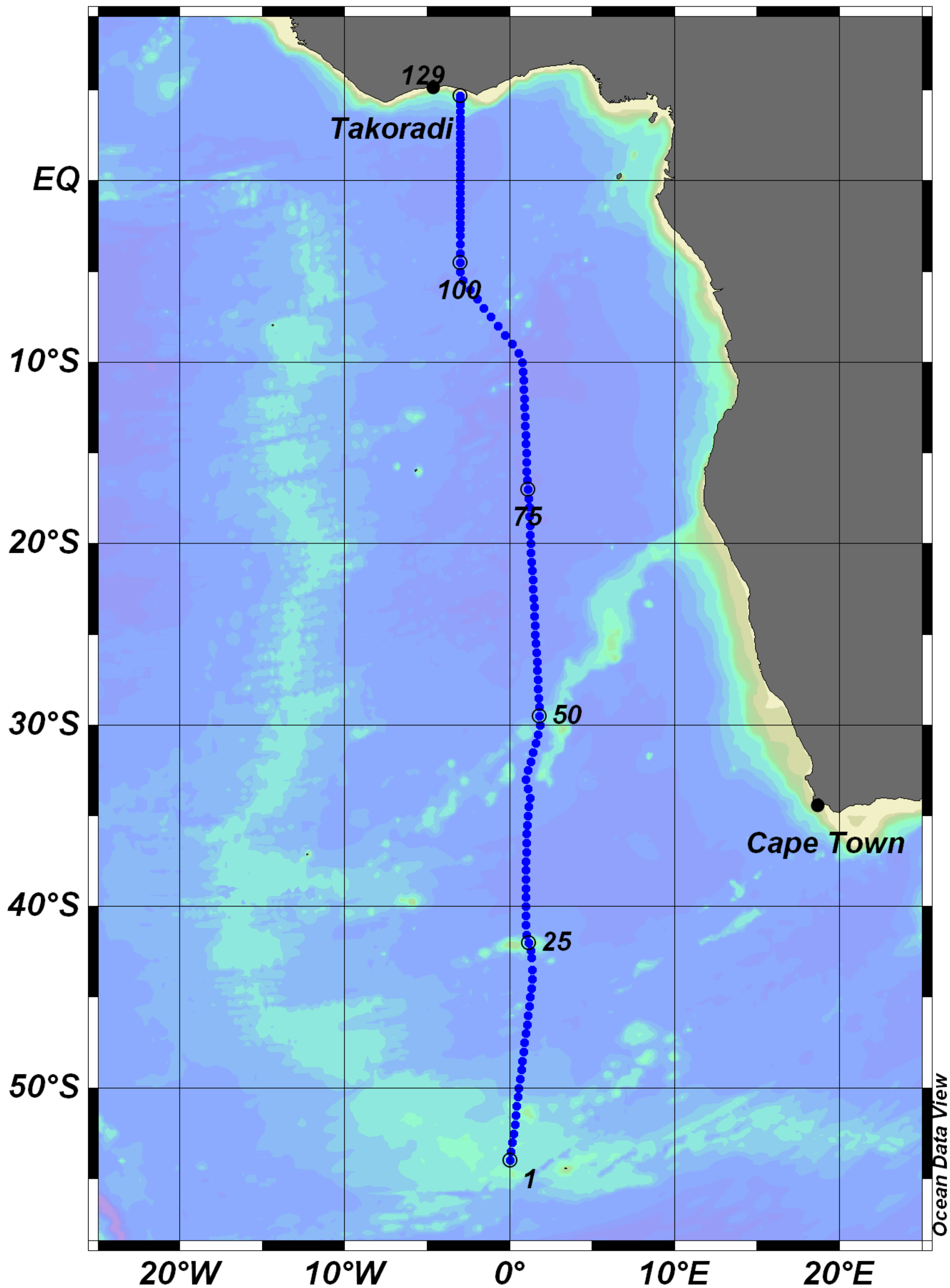
Abstract:

CLIVAR Repeat Hydrography Cruise A13.5 in the South Atlantic on NOAA ship *Ronald H. Brown* was completed successfully during the period 8 March 2010- 18 April 2010. This cruise is part of a decadal series of repeat hydrography sections jointly funded by NOAA-OGP and NSF-OCE as part of the CLIVAR/CO_2/hydrography/tracer program (http://ushydro.ucsd.edu). The goal of the effort is to occupy a set of hydrographic transects over the global ocean with full water column measurements to study physical and hydrographic changes over time. The 2010 A13.5 expedition began in Cape Town, South Africa and ended in Takoradi, Ghana. Academic institutions and NOAA research laboratories participated on the cruise. The A13.5 section ran nominally (~3°W-1°E) along the prime meridian from approximately 54°S to 5°N, repeating a section occupied on the AJAX expedition in 1983/1984. A total of 129 full water column CTD/O_2/LADCP/rosette casts were completed along the A13.5 section at ~30 nautical mile (nm) spacing, with closer (20 nm) spacing between 3°S and 3°N. Approximately 3123 water samples were collected on these casts for analyses of a variety of parameters, including salinity, dissolved oxygen, nutrients, chlorofluorocarbons, (CFCs), SF_6, dissolved inorganic carbon (DIC), alkalinity, fCO_2, pH, carbon isotopes, dissolved organic carbon (DOC), total dissolved nitrogen (TDN), tritium and helium.

Underway data collection included upper-ocean current measurements from the shipboard ADCP, surface oceanographic (temperature, salinity, fCO_2) and meteorological parameters from the ship's underway systems, bathymetric data and atmospheric measurements of CO_2, CFCs, SF_6 and ozone).

Data from this cruise are available at:
http://cchdo.ucsd.edu/data_access/show_cruise?Exp°Code=33RO20100308



CLIVAR/Carbon A13.5 Station Locations

Introduction

The CLIVAR Repeat Hydrography Program focuses on the need to monitor inventories of CO_2, 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 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 CO_2 and transient tracers into intermediate and deep water 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

Cruise Operations

A sea-going science team gathered from multiple oceanographic institutions and nations participated on the CLIVAR/Carbon A13.5 cruise. Several other science programs were supported with no dedicated cruise participant. The science team and their responsibilities are listed below.

CLIVAR/Carbon A13.5 Participating Institutions

Abbreviation	Institution
AOML	Atlantic Oceanographic and Meteorological Laboratory - NOAA
CDIAC	Carbon Dioxide Information Analysis Center
ETH	Swiss Federal Institute of Technology
LDEO	Lamont-Doherty Earth Observatory/Columbia University
MLML	Moss Landing Marine Laboratory
NOAA	National Oceanic and Atmospheric Administration
Penn State	Pennsylvania State University
PMEL	Pacific Marine Environmental Laboratory - NOAA
Princeton	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
U Colorado	University of Colorado
U Ghana	University of Ghana
U Hawaii	University of Hawaii at Manoa
WHOI	Woods Hole Oceanographic Institution

Principal Programs of CLIVAR/Carbon A13.5 Cruise

Analysis	Institution	Principal Investigator	email
CTDO	NOAA/PMEL NOAA/AOML	Gregory Johnson Molly Baringer	Gregory.C.Johnson@noaa.gov Molly.Baringer@noaa.gov
ADCP/Lowered ADCP	U Hawaii	Eric Firing	efiring@hawaii.edu
Salinity	NOAA/AOML	Molly Baringer	Molly.Baringer@noaa.gov
Total CO_2 (DIC)	NOAA/PMEL NOAA/AOML	Richard Feely Rik Wanninkhof	Richard.A.Feely@noaa.gov Rik.Wanninkhof@noaa.gov
UW & Discrete fCO_2	NOAA/AOML	Rik Wanninkhof	Rik.Wanninkhof@noaa.gov
Nutrients	NOAA/AOML NOAA/PMEL	Jia-Zhong Zhang Calvin Mordy	Jia-Zhong.Zhang@noaa.gov Calvin.W.Mordy@noaa.gov
Dissolved O2	NOAA/AOML RSMAS	Molly Baringer Chris Langdon	Molly.Baringer@noaa.gov clangdon@rsmas.miami.edu
Total Alkalinity/pH	SIO	Andrew Dickson	adickson@ucsd.edu
CFCs & SF6	NOAA/PMEL	John Bullister	John.L.Bullister@noaa.gov
3He/Tritium	LDEO WHOI	Peter Schlosser William Jenkins	peters@ldeo.columbia.edu wjenkins@whoi.edu
DOC/TDN	RSMAS	Dennis Hansell	dhansell@rsmas.miami.edu
14C/13C	Princeton WHOI	Robert Key Ann McNichol	key@princeton.edu amcnichol@whoi.edu
Transmissometry	TAMU	Wilf Gardner	wgardner@ocean.tamu.edu
Data Management	SIO SIO	James Swift Kristin Sanborn	jswift@ucsd.edu ksanborn@ucsd.edu
Argo Float deployments	NOAA/PMEL	Gregory C. Johnson	Gregory.C.Johnson@noaa.gov
Drifter Deployment	NOAA/AOML	Shaun Dolk	Shaun.Dolk@noaa.gov
Underway surface ocean, meteorological and bathymetry data	NOAA	Ship personnel	

Scientific Personnel on the CLIVAR/Carbon A13.5 Cruise

Duties	Name	Affiliation	email
Chief Scientist	John Bullister	PMEL	John.L.Bullister@noaa.gov
Co-Chief Scientist	Robert Key	Princeton	key@princeton.edu
Observer	Benjamin Osei Botwe	U Ghana	boseibotwe@yahoo.co.uk
Data Management	Mary Carol Johnson	SIO	mcj@ucsd.edu
CTD	Kristy McTaggart	PMEL	Kristene.E.Mctaggart@noaa.gov
CTD/ET/Salinity	Kyle Seaton	AOML	Kyle.Seaton@noaa.gov
CTD Helper	Maria Herrmann	Penn State	mxh367@psu.edu
CTD Helper	Katherine Morrice	MLML	kmorrice@mlml.calstate.edu
Chief Scientist Helper	Ivy Frenger	ETH	ivy.frenger@env.ethz.ch
Chief Survey Tech.	Jonathan Shannahoff	NOAA	
ADCP/LADCP	Francois Ascani	U Hawaii	fascani@hawaii.edu
Salinity	James Farrington	AOML	James.W.Farrington@noaa.gov
Dissolved O2	George Berberian	AOML	George.Berberian@noaa.gov
Dissolved O2	Chris Langdon	RSMAS	clangdon@rsmas.miami.edu
Nutrients	Calvin Mordy	PMEL	Calvin.W.Mordy@noaa.gov
Nutrients	Charles Fischer	AOML	Charles.Fischer@noaa.gov
Total CO_2 (DIC)	Cynthia Peacock	PMEL	cynthia.peacock@noaa.gov
Total CO_2 (DIC)	Alex Kozyr	CDIAC	ako@cdiac.ornl.gov
fCO_2 UW & Discrete	Kevin Sullivan	AOML	Kevin.Sullivan@noaa.gov
fCO_2 Discrete	Geun-Ha Park	AOML	Geun-Ha.Park@noaa.gov
CFCs & SF6	David Wisegarver	PMEL	David.Wisegarver@noaa.gov
CFCs & SF6	Patrick Boylan	U Colorado	Patrick.Boylan@Colorado.EDU
Total Alkalinity	Laura Fantozzi	SIO	lfantozzi@ucsd.edu
Total Alkalinity	Emily Bockmon	SIO	ytakeshita@ucsd.edu
pH	Adam Radich	SIO	jradich@ucsd.edu
pH	Yui Takeshita	SIO	ebockmon@ucsd.edu
3He/Tritium	Anthony Dachille	LDEO	dachille@ldeo.columbia.edu
DOC/TDN	Darcy Metzler	RSMAS	dmetzler@rsmas.miami.edu

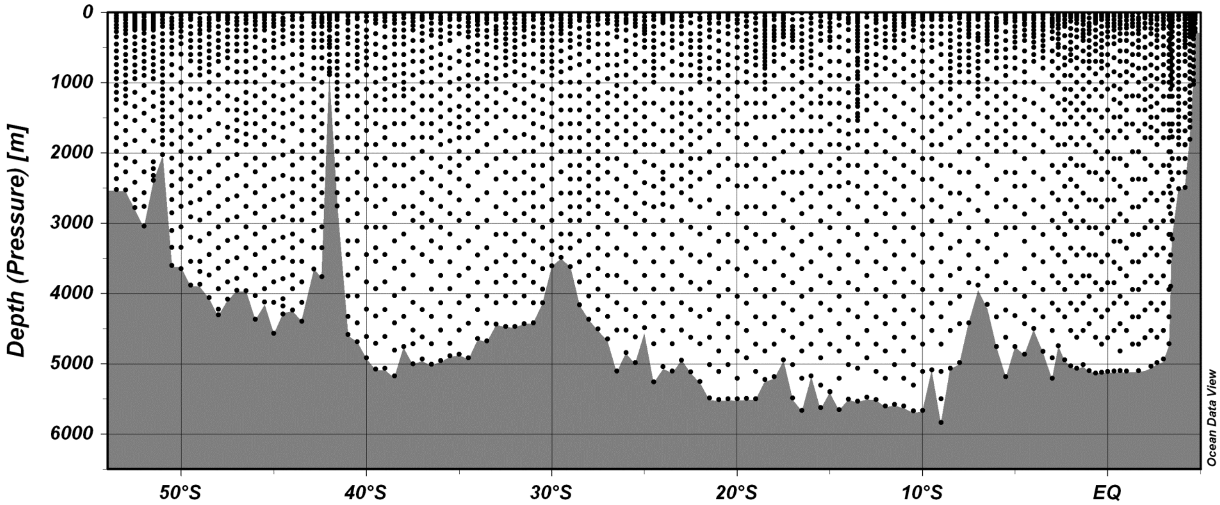


Figure 1 *The distribution of bottle samples along the CLIVAR A13.5 section in 2010*

Bottle Sampling and Data Processing

After a 1-day delay, NOAA Ship Ronald H. Brown departed Cape Town, South Africa on 8 March 2010 at 1400 UTC and ended in Takoradi, Ghana on 18 April 2010.

A total of 130 stations were occupied during the A13.5 cruise. One test station (Sta. 998) was occupied on the transit from Cape Town to the southern end of the A13.5 section, and Sta.1 – Sta. 129 were occupied on the A13.5 section. The section was run from south to north. A total 133 CTD/O_2/LADCP/rosette casts (including 1 test cast and 3 reoccupations at stations 72, 79, and 82) were collected. Eight Argo floats and 18 surface drifters were deployed. CTD/O_2 data, LADCP data, and water samples (up to 24) were collected on most rosette casts, in most cases to within 10 meters of the bottom.

A 24 position, 11 liter bottle rosette frame was used on this cruise. Salinity, dissolved oxygen, and nutrient samples were collected and analyzed from essentially all of the water samples collected. Water samples were also measured for CFCs, SF_6 ,fCO_2, total CO_2 (DIC), total alkalinity, and pH on most of the samples. Additional samples were collected for ^{3}He, tritium, ^{13}C/ ^{14}C, and DOC/TDN.

Water Sampling

The NOAA Ship Ronald H. Brown has two Markey DESH-5 winches. The Aft winch was used for the test cast (station 998) and Stations 1-48 and 72/3-79/1. The Forward winch was used for stations 49-72/1 and 79/3-129. All but 5 rosette casts were lowered to within 3-20 meters of the bottom, using both the pinger and/or altimeter to determine distance.

Rather than close the bottles at the same (standard) depths at each station, four sampling plans were used in rotation to choose the vertical sampling depths throughout the CLIVAR/Carbon A13.5 section. The goal was to provide better coverage and spatial patterns for later gridding of the various data sets.

Each bottle on the rosette had a unique serial number. This bottle identification was maintained independently of the bottle position on the rosette, which was used for sample identification. Three bottles (at trip positions 17, 22 and 23) were replaced on this cruise, and various bottle parts were occasionally changed or repaired (see Appendix). Bottle 17 was changed out after station 8 due to repeated problems with leaking; bottle 23 apparently closed in air at the start of station 82/1 and later imploded at depth, irreparably damaging bottle 22 in the process.

Rosette maintenance was performed on a regular basis. O-rings were changed and lanyards repaired as necessary. Bottle maintenance was performed after each cast to insure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed.

The 24-place SBE32 carousel had occasional problems releasing individual bottle lanyards, causing mis-tripped bottles on a number of casts. Repair attempts and bottle height/lanyard adjustments were made as the cruise continued, but these problems were not completely resolved during the cruise.

Bottle Sampling

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

- Chlorofluorocarbons (CFCs) and SF_6
- Helium-3
- Dissolved oxygen
- pH
- Partial pressure CO_2 (fCO_2)
- Dissolved Inorganic Carbon (DIC)
- Total Alkalinity (TAlk)
- Carbon-13 (^{13}C) and Carbon-14 (^{14}C) isotopes
- Dissolved Organic Carbon (DOC)/Total Dissolved Nitrogen (TDN)
- Tritium
- Nutrients
- Salinity

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 accurate logging of the samples as they were collected, and to insure that sampling progressed in the proper drawing order.

Normal sampling practice included opening the drain valve before the air vent on each bottle. If any water escaped at this point it was noted as an air leak. 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 (see Appendix). Drawing oxygen samples also involved taking the sample draw temperature from the bottle. The temperature was noted on the sample log and was sometimes useful in determining leaking or mis-tripped bottles.

Once individual samples had been drawn and properly prepared, they were distributed for analysis. On-board analyses were performed on computer-assisted (PC) analytical equipment networked to the data processing computer for centralized data management.

Bottle Data Processing

Water samples collected and properties analyzed shipboard were managed centrally in a relational database (PostgreSQL-8.0.3) run on a Linux computer system. A web service (OpenAcs-5.2.2 and AOLServer-4.0.10) front-end provided ship-wide access to CTD and water sample data. Web-based facilities included on-demand arbitrary property-property plots and vertical sections as well as data uploads and downloads.

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

Analytical results were provided on a regular basis by the 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) [Joyce, 1994].

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.

References:

Joyce, T. ed., and Corry, C. ed., "Requirements for WOCE Hydrographic Programme Data Reporting," Report WHPO 90-1, WOCE Report No. 67/91 3.1, pp. 52-55, WOCE Hydrographic Programme Office, Woods Hole, MA, USA (May 1994, Rev. 2), UNPUBLISHED MANUSCRIPT

CTD

Kristy McTaggart, PMEL
(PI's Gregory Johnson, PMEL; Molly Baringer, AOML)

Chief Scientist:	John Bullister
Co-Chief Scientist:	Robert Key
Data Manager:	Mary Johnson (from shore)
CTD Watchstander:	Maria Hermann, Katie Morrice
Quality Control/Processing:	Kristy McTaggart
Sample Salinity Analyst:	Kyle Seaton, James Farrington
Sample Oxygen Analyst:	Chris Langdon, George Berberian
Survey Technician:	Jonathan Shannahoff
Ship's Electronics Technician:	Jeff Hill

CTD Underwater Packages

CTD/O_2 profiles were collected using one underwater package for the entire cruise. Sea-Bird instrumentation was mounted in a 24-position aluminum frame with 24 11-liter Niskin bottles. Instruments and sensors mounted in the 24-position frame included:

Instrument/Sensor	Serial No.	Calib. Date	Comment
SBE 9*plus*CTD + Paroscientific Digiquartz Pressure sensor	09P8431-0315 93450-209	27-Jul-2007 9-Jul-2007	stations 998, 1-72/2 stations 72/3-129
Primary pump circuit			
SBE 3*plus*temperature	03P-4569	9-Sep-2009	primary T
SBE 4C conductivity	04C-3068	9-Sep-2009	primary C
SBE 43 oxygen	43-0312	26-Sep-2009	stations 998, 1-76
	43-0313	5-Sep-2009	stations 77-129
SBE 5 pump	05T-0787		stations 998, 1-77
	05T-3481		stations 78-129
Secondary pump circuit:			
SBE 3*plus*temperature	03P-4335	4-Sep-2009	secondary T
SBE 4C conductivity	04C-3157	9-Sep-2009	secondary C
SBE5 pump	05T-2850		stations 998, 1-129
SBE 32 carousel	3229830-0407		24-position
SBE 35RT Temperature (internally recording)	35RT54996-0064	20-Jun-2009	stations 998, 1-72/2 102-129
RDI Workhorse 300 kHz LADCP	12734 (downward) unknown (upward)		
Simrad 807 altimeter	98110		
Wetlabs CStar transmissometer	CST-507DR		
Benthos pinger	1006 or 1134		
Markey DESH-5 Winches:			
Aft / 0.375" cable	single conductor		stations 998, 1-48, 72/3-79/2
Forward / 0.322" cable	three conductors		stations 49-72/2 , 79/3-129

CTD Data Acquisition

The CTD data acquisition system consisted of an SBE-11*plus* (V1) deck unit s/n 367 and a networked Dell Optiplex 755 PC workstation running Windows XP Professional. SBE SeaSave v.7.18c software was used for data acquisition and to close bottles on the rosette. Real-time digital data were backed up onto Survey and PMEL networked PCs. No real-time data were lost.

CTD deployments were initiated by the console watch after the ship had stopped on station. The watch maintained a CTD Cast log containing a description of each deployment, a record of every attempt to close a bottle, and any pertinent comments.

Once the deck watch had deployed the rosette, the winch operator would lower it to a minimum of 10 meters. The CTD sensor pumps were configured with a 60 second startup delay, and were usually on by this time. The console operator checked the CTD data for proper sensor operation, waited an additional 60 seconds for sensors to stabilize, instructed the winch operator to bring the package to the surface, pause for 10 seconds, and descend 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 varied depending on sea cable tension and the sea state.

The console watch monitored the progress of the deployment and quality of the CTD data through interactive graphics and operational displays. Additionally, the watch created a sample log for the deployment that would be later used to record the correspondence between rosette bottles and analytical samples taken. The altimeter channel, CTD pressure, wire-out, pinger, and bathymetric depth were all monitored to determine the distance of the package from the bottom, usually allowing a safe approach to within 10 meters.

Bottles were closed on the up cast by operating an on-screen control, and were tripped 30 seconds after stopping at the trip location to allow the rosette wake to dissipate and the bottles to flush. The winch operator was instructed to proceed to the next bottle stop 10-20 seconds after closing bottles to ensure that stable CTD data were associated with the trip.

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

Normally the CTD sensors were rinsed after each station using syringes fitted with Tygon tubing and filled with a fresh solution of dilute Triton-X in de-ionized water. The syringes were generally left on the CTD between casts, with the temperature and conductivity sensors immersed in the rinsing solution, to guard against airborne contaminants.

Acquisition Problems

The CTD was initially connected to the aft winch, with a new termination on the 0.375-inch single-conductor EM cable. Test cast 998 produced three modulo errors. Secondary temperature sensor s/n 4335 was lower than the primary by about 7°C throughout the profile. The correct calibration coefficients were entered into the configuration file post-cast. Secondary conductivity sensor s/n 3157 dropped out (to 0 kHz) around 3500 dbar on the downcast but came back around 3300 dbar on the upcast to within 0.002 mS/cm of the primary. The secondary conductivity cable was replaced after the cast. Also, the load cell was removed from the lifting bail because it appeared that the connector and cable could interfere with or even damage the carousel latches.

While on the aft winch (stations 998,1-48), modulo errors occurred on each cast and numbered from 1 to 140. The number of errors increasing with wind speed and sea state. Processed data had to be edited for spikes and gaps in various PTCO data channels. In spite of repeated efforts, these modulo errors were never completely resolved.

Eventually the package was switched to the forward winch 0.322-inch three-conductor cable for stations 49-72. Modulo errors were few at first but increased to as many as 185 with choppier seas and level wind problems. A broken strand in the outer armor of the winch cable was noticed at station 67. The protruding section was removed during station 67 and the ends were taped. All subsequent casts using the forward winch cable were stopped at 4268 m wire out to inspect the area and re-tape it if necessary. During station 72 cast 1, communication was lost to the carousel. The modem board in CTD s/n 315 was suspect, so it was replaced with CTD s/n 209. Unfortunately, this didn't remedy the problem as expected and the package was moved to a new termination on the aft winch.

Modulo error counts were high on the aft winch (stations 72 cast 3 through 79 cast 1). Processed data had to be edited for spikes and gaps in any one of the PTCO data channels. Gaps and crossovers in the winch cable were discovered >5600m wire out as a possible source of noise and imbalance within the drum.

Blown sea cable fuses in the deck unit owing to a faulty sea cable pigtail necessitated moving the package to a new termination on the forward winch. This termination did not include the armor in the negative (ground) conductor. Profiles were successfully collected on this termination from station 79 cast 3 to the end of the cruise with only occasional modulo errors.

The transmissometer worked intermittently between stations 1-16 in spite of troubleshooting efforts. The cable was suspect and the instrument was removed from the underwater package for stations 17-18. Since this had no effect on the modulo errors at that time, and since the instrument and cable tested OK in the lab, it was put back on the frame for station 19 and worked well thereafter for the most part. Problem casts included stations 2, 5, 7, 10, 14, 16, 29, 31, 65-69, and 70.

Oxygen voltage presented "pulses" in profiles from 2300 dbar to depth beginning at station 73 (CTD s/n 209). The pulses occurred approximately every 200 dbar, were low by about 0.5 umol/kg, and lasted for 20-30 dbar. Oxygen sensor s/n 312 was replaced by s/n 313 after station 76. The primary pump was replaced after station 77. The oxygen cable was moved from V0 to V2 after station 78. On V2, the pulses were more frequent but less pronounced, and were usually within 2500-4000 dbar. The oxygen cable was replaced after station 95.

The secondary plumbing air-bleed was clogged at station 32, affecting secondary conductivity data from 0-50 dbar. After this cast, sensor differences were monitored closely at the beginning of each cast and the package was soaked at 50 dbar if necessary. The air-bleed was successfully cleared by station 36.

CTD Data Processing

The reduction of profile data began with a standard suite of processing modules using Sea-Bird Data Processing Version 7.19 software 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, t0, t1, c0, c1, oxygen voltage, and oxygen. 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 conductivity was automatically advanced in the V1 deck unit by 0.073 seconds. Primary conductivity sensor s/n 3068 was aligned by -0.026 seconds in ALIGNCTD for a net advance of 0.047 seconds. Secondary conductivity sensor s/n 3157 was advanced by 0.053 seconds in ALIGNCTD. It was not necessary to align temperature or oxygen.
BOTTLESUM	averages burst data over an 8-second interval (+/- 4 seconds of the confirm bit) and derives both primary and secondary salinity, primary potential temperature, and primary potential density anomaly. Oxygen values (in µmol/kg) were derived in DATCNV and averaged in BOTTLESUM, as recommended recently by Sea-Bird.
WILDEDIT	makes two passes through the data in 100 scan bins. The first pass flags points greater than 2 standard deviations; the second pass removes points greater than 20 standard deviations from the mean with the flagged points excluded. Data were kept within 100 standard deviations of the mean (i.e. all data).

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 and the thermal anomaly time constant, 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.
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 cause 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, N^2, and linearly interpolates temperature, conductivity, and oxygen voltage over those records where N^2 is less than or equal to -1×10^{-5} s^{-2}. Seventeen profiles failed the criteria in the top 3-9 dbars. These data were retained by program deloop_post.m and were flagged as questionable in the final WOCE formatted files.

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

Pressure Calibration

Pressure calibrations for the CTD instruments used during this cruise were pre-cruise. No additional adjustments were applied. On deck pressure readings prior to each cast were examined and remained within 0.5 dbar of calibration. Differences between first and last submerged pressures for each cast were also examined and the residual pressure offsets were less than 0.5 dbar.

Temperature Calibration

A viscous heating correction of -0.0006°C was applied at sea as recommended by Sea-Bird. Post-cruise, a linearly interpolated temperature sensor drift correction using pre and post-cruise calibration data for the midpoint of the cruise was determined for each sensor, including the SBE 35 reference sensor. Viscous and drift corrections are applied to profile data using program calctd.m, and to burst data using calclo.m.

Data from the SBE 35 reference temperature sensor was evaluated post-cruise. Although there was some drift over the cruise (i.e. station dependence) and changes with pressure, these corrections were too small to apply. The corrected primary temperature data are within about +/- 0.2 mK of the corrected reference sensor.

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 both conductivity sensors, stations were separated into three calibration groupings. Program calcop2.m (a constant conductivity offset, a linear pressure-dependent correction to conductivity, and a 2nd order polynomial conductivity slope as a function of station number) produced the best fit to sample data for the primary conductivity sensor (s/n 3068) for the first two groupings. Program calcop0.m (a constant conductivity offset, a linear pressure-dependent correction, and an overall slope) produced the best fit for the third grouping:

stations	1-40	41-57	58-129
number of points used	844	351	1448
total number of points	927	397	1710
% of points used in fit	91.05%	88.41%	84.68%
fit standard deviation	0.0009685	0.0010860	0.0012660
fit bias	-0.0014230	-0.0039545	-0.0051065
fit co pressure fudge	-3.2962181e-07	-1.2495243e-07	-4.5641049e-08
min fit slope	1.0000620	1.0001431	1.0001838
max fit slope	1.0001078	1.0002188	1.0001838

Conductivity calibrations were applied to profile data using program calctd.m and to burst data using calclo.m. CTD-bottle conductivity differences plotted against station number (Figure 1) and pressure (Figure 2) allow a visual assessment of the success of the fits.

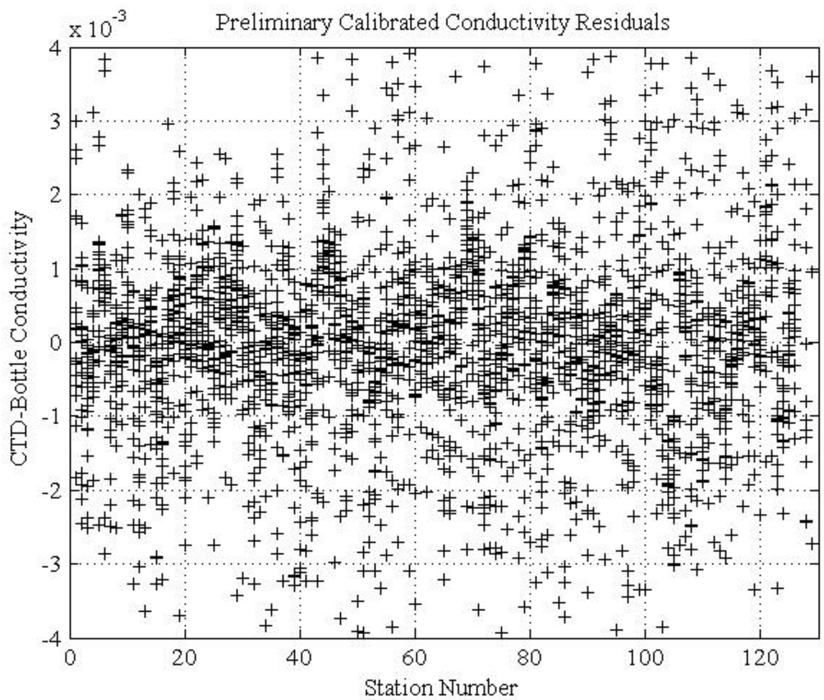


Figure 1.1 *Final sensor CTD-bottle conductivity residuals vs. station number*

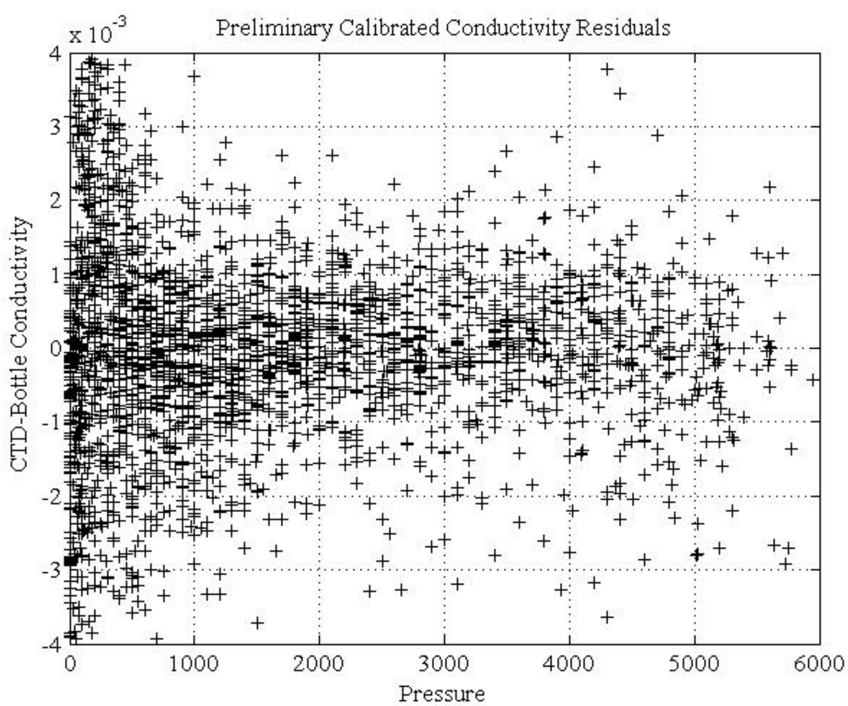


Figure 1.2 *Final sensor CTD-bottle conductivity residuals vs. pressure*

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(D1*P+D2*T)*dVdt)*Os*exp(Tcor*T)*exp(Pcor*P/(273.15+T))
```

Where:

```
Ox is the CTD oxygen (in μmol/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)
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 (1.9263e-4) 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. Program addoxy.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 nine station groupings. These groupings were determined by visual inspection:

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Stns	Soc_Range	Vof	Tau	Tcor	Pcor	Points	Used	StdDev
1-13	0.4672-0.4672	-0.4523	7.4163	0.0009	0.0390	299	83.6%	0.7771 00
7 only	0.4723-0.4723	-0.4495	7.4163	0.0009	0.0390	20	87.0%	0.6190 00
14-28	0.4688-0.4688	-0.4422	6.3112	0.0002	0.0385	347	92.2%	0.7987 00
29-37	0.4772-0.4806	-0.4518	5.5664	0.0001	0.0388	214	91.6%	0.8147 10
38-51	0.4826-0.4826	-0.4583	7.2746	0.0001	0.0392	335	91.3%	0.6983 00
52-70	0.4901-0.4961	-0.4765	7.8596	-0.0004	0.0394	446	87.9%	0.6977 10
71-76	0.4886-0.4910	-0.4546	6.9079	-0.0003	0.0386	154	90.3%	1.0436 10

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Stns	Soc_Range	Vof	Tau	Tcor	Pcor	Points	Used	StdDev
77	0.4473-0.4473	-0.4397	2.2679	0.0015	0.0406	24	95.8%	1.3709 00
78	0.4670-0.4670	-0.4588	10.099	0.0012	0.0403	23	95.7%	0.7904 00
79-85	0.4794-0.4794	-0.4635	6.5813	0.0008	0.0394	178	86.5%	0.7211 00
86-129	0.4809-0.4829	-0.4672	7.5176	0.0007	0.0397	1023	90.0%	0.8508 10

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

Primary sensor CTD - bottle oxygen differences plotted against station number (Figure 3) and pressure (Figure 4) allow a visual assessment of the success of the fits.

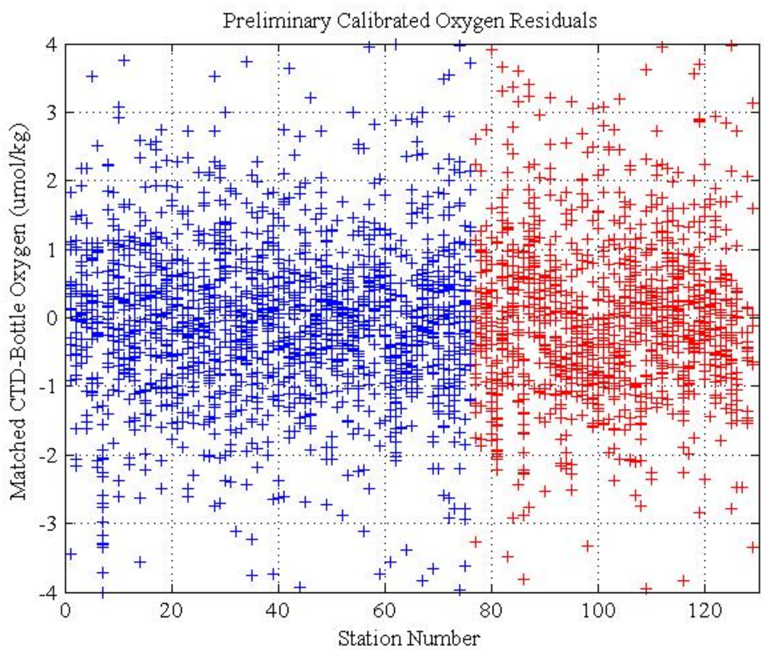

Figure 1.3 *Final sensor CTD-bottle oxygen residuals vs. station number*

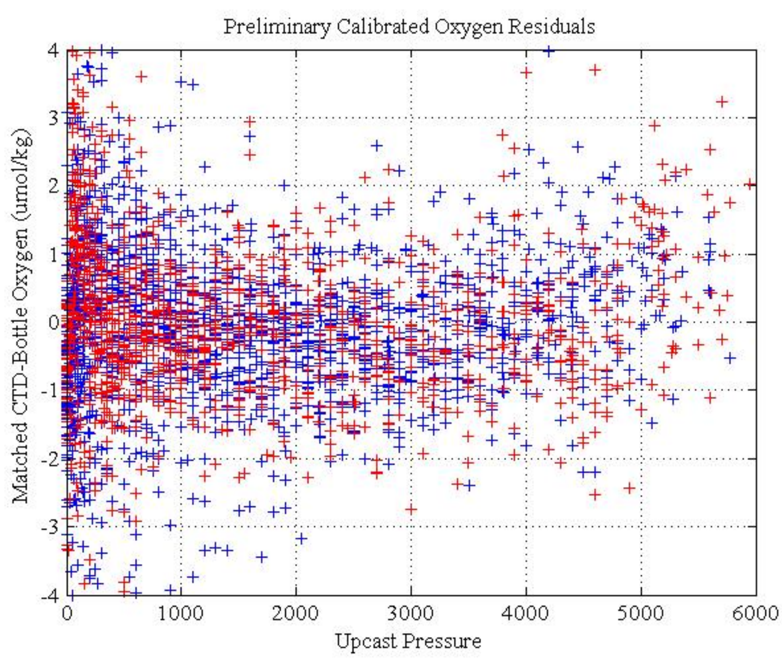

Figure 1.4 *Final sensor CTD-bottle oxygen residuals vs. pressure*

Final Processing

Program interp_a13k.m was used to examine temperature, salinity, and oxygen profiles at 30 stations, despiking single points (WOCE quality flag 7) or interpolating over sections of bad data (WOCE quality flag 6) where needed.

Quality flags for sample salinities were amended from values determined at sea by viewing plots of calibrated CTD profiles and sample salinities generated by program plot_th_sa.m. Similarly, recommendations for sample oxygens were forwarded to Chris Langdon after viewing plots of calibrated CTD/O_2 profiles and sample oxygens generated by plot_pr_ox.m.

Program ctd_to_csv.m converted ASCII CTD data files to the WOCE Exchange format for submission to CCHDO. The header information came from Mary Johnson's .SUM file dated June 4, 2010.

Program clb_to_sea.m read calibrated CTD data associated with bottle data, and Mary Johnson's .SEA file dated June 2, 2010, and output an abbreviated .SEA file of CTD and flagged sample salinity data for submission to CCHDO.

Salinity (discrete)

Kyle Seaton, AOML; James Farrington, AOML)
(PIs: Gregory Johnson, PMEL; Molly Baringer, AOML)

Salinity Analysis

Equipment and Techniques

A single Guildline Autosal Model 8400B salinometer (S/N 61668), located in the aft Hydro lab, was used for all salinity measurements. The salinometer was connected to a computer to aid measurement. The Autosal's water bath temperature was set to 24°C, which the Autosal is designed to automatically maintain. The laboratory's temperature was also set and maintained to just below 24°C, to help further stabilize reading values and improve accuracy. As an additional safeguard the Autosal was powered through a UPS to prevent any power related issues.

Salinity analyses were performed after samples had equilibrated to laboratory temperature, usually within 12 to 24 hours after collection. The salinometer was standardized for each group of samples analyzed (usually 1.5-2.5 casts and up to 65 samples) using two bottles of standard seawater: one at the beginning and 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-147 was used to standardize all casts.

Sampling and Data Processing

Approximately 3000 salinity measurements were taken and approximately 140 vials of standard seawater (SSW) were used. A duplicate sample was drawn from each cast to determine total analytical precision. 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'.

Dissolved Oxygen

George Berberian, AOML; Chris Langdon, RSMAS)
(PI: Chris Langdon, RSMAS)

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Samplers:	Chris Langdon (12 noon – 12 midnight) George Berberian (12 midnight – 12 noon) AOML 4309 Rickenbacker Causeway Miami, FL 33149 George.Berberian@noaa.gov

Equipment and Techniques

Dissolved oxygen analyses were performed with an automated titrator using amperometric end-point detection [Culberson, 1987]. 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 18.5-22.5°C. Thiosulfate was dispensed by a 2 ml Gilmont 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 [1965], with modifications by Culberson et al. [1991], was used. Four replicate 10 ml iodate standards were run every 3-4 days. 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 five times during the cruise. This method was found during pre-cruise testing to produce a more reproducible blank value than the value determined as the intercept of a standard curve. The temperature-corrected molarity of the thiosulfate titrant was determined as given by Dickson [1994].

Sampling and Data Processing

Dissolved oxygen samples were drawn from Niskin bottles into calibrated 125-150 ml iodine titration flasks using silicon tubing to avoid contamination of DOC and CDOM samples. Bottles were rinsed three times and filled from the bottom, overflowing three volumes while taking care not to entrain any bubbles. The draw temperature was taken using a digital thermometer with a flexible thermistor probe that was inserted into the flask while the sample was being drawn during the overflow period. These temperatures were used to calculate umol/kg concentrations, and provide a diagnostic check of Niskin bottle integrity. 1 ml of

MnCl2 and 1 ml of NaOH/NaI were added immediately after drawing the sample was concluded using a Re-pipetor. 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 from each station. The total number of samples collected from the rosette was 3341.

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 normalities were calculated from each standardization and corrected to the laboratory temperature.

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

A total of 172 sets of duplicates were run. The average standard deviation of all sets was 0.18 umol/kg.

Problems

Three oxygen flasks were removed and replaced with different flasks during the cruise, after giving consistently high values. Duplicates were collected using each questionable flask and analyzed; if the values differed significantly, the flask was removed. The following flasks were tested and replaced:

Original Flask	Replacement Flask	Replaced After Station
13	83	16
42	82	16
52	92	16

References

Carpenter, J. H., "The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method," *Limnology and Oceanography*, **10**, pp. 141-143 (1965).

Culberson, C. H. and Huang, S., "Automated amperometric oxygen titration," *Deep-Sea Res.*, **34**, pp. 875-880. (1987).

Culberson, C. H., Knapp, G., Stalcup, M., Williams, R. T., and Zemlyak, F., "A comparison of methods for the determination of dissolved oxygen in seawater," Report WHPO 91-2, WOCE Hydrographic Programme Office (Aug. 1991).

Dickson, A. G., "Determination of dissolved oxygen in seawater by Winkler titration," WHP Operations and Methods (1994a).

Nutrients

Calvin Mordy, PMEL; Charles Fischer, AOML
(PIs: Calvin Mordy, PMEL, Jia-Zhong Zhang, AOML)

Nutrient samples were collected from the Niskin bottles in acid-washed sample bottles after at least three seawater rinses. Sample analysis typically began within 1 hour of sample collection after the samples had warmed to room temperature while kept in the dark. Nutrients were analyzed with a continuous flow analyzer (CFA) using the standard and analysis protocols for the WOCE hydrographic program as set forth in the manual by L.I. Gordon, *et al.*

Analytical Methods

3049 samples were taken at discrete depths and analyzed for phosphate (PO_4^{-3}), nitrate (NO_3^-), nitrite (NO_2^-) and orthosilicic acid (H_4SiO_4). Nitrite was determined by diazotizing the sample with sulfanilamide and coupling with N-1 naphthyl ethylenediamine dihydrochloride to form an azo dye. The color produced is measured at 540 nm. Samples for nitrate analysis were passed through a cadmium column, which reduced nitrate to nitrite, and the resulting nitrite concentration (i.e. the sum of nitrate + nitrite which is signified as N+N) was then determined as described above. Nitrate concentrations were determined from the difference of N+N and nitrite. Phosphate was determined by reacting the sample with molybdic acid at a temperature of 55°C to form phosphomolybdic acid. This complex was subsequently reduced with hydrazine, and the absorbance of the resulting phosphomolybdous acid was measured at 820 nm. Silicic acid was analyzed by reacting the sample with molybdate in an acidic solution to form molybdosilicic acid. The molybdosilicic acid was then reduced with $SnCl_2$ to form molybdenum blue. The absorbance of the molybdenum blue was measured at 820 nm.

A typical analytical run consisted of distilled water blanks, standard blanks, working standards, a standard from the previous run, a deep sample from the previous run, samples, replicates, working standards, and standard and distilled water blanks. Replicates were usually run for the 4-7 deepest Niskin bottles from each cast, plus any samples with questionable peaks. The standard deviation of the deep replicates was used to estimate the overall precision of the method which was <1% full scale.

Table 4.1 Precision of Nutrient Measurements.

	Phosphate	Silicic Acid	Nitrate
Total number of replicates	849	887	891
Average standard deviation (μM)	0.006	0.1	0.1
Relative standard deviation*	0.36%	0.18%	0.36%

* for samples with PO4 concentrations >1 μM

Analytical precision and the measured nutrient content in deep water were similar to the AJAX cruise in 1983. Significant offsets in oxygen, nitrate and phosphate were observed compared to the 1993 Discovery cruise.

Temperatures in the ship's main laboratory fluctuated with temperatures ranging from 18.7°C to 25.5°C; however, temperatures were generally stable during an individual analytical run. During the cruise, pump tubes were changed about 3 times per channel as needed.

Standardization

A mixed stock standard consisting of silicic acid, phosphate and nitrate was prepared by dissolving high purity standard materials (KNO_3, KH_2PO_4 and Na_2SiF_6) in deionized water using a two step dilution for phosphate and nitrate. This standard was stored at room temperature. A nitrite stock standard was prepared about every 10 days by dissolving $NaNO_2$ in distilled water, and this standard was stored in the refrigerator. Working standards were freshly made at each station by diluting the stock solutions in low nutrient seawater. Mixed standards were verified against commercial standards purchased from Ocean Scientific.

Problems

Due to problems with the Alpkem 301 sampler, a Westco CS9000 sampler, with 20 ml plastic sample bottles, was used on Stations 3 to 9. There was not enough volume in these sample bottles for sample reruns. During these stations, there was unnoticed algal build-up in the sample lines that was coincident with increased analytical variability. On Station 10, the Alpkem sampler was back in use, and all the sample lines were changed. Thereafter, sample lines were rinsed with 10% HCl between runs.

On Station 99, the nitrate peaks became very erratic. Several stations were analyzed before it could be determined that the ship's water was the source of the problem. Several batches of Imidazole were made from various sources of water on the ship, but Cd column had very low efficiencies. Instead of Imidazole, we used Low Nutrient Seawater as a buffer for Stations 101 to 104. The column efficiency was not completely stable during these runs, so we reran about half of each cast and found the precision to be ~1.5%. To stabilize the column, we added 1 ml CuSO4 to 1200ml LNSW beginning at Station 105. For the remainder of the cruise, the column efficiency varied between ~80-100 percent (determined at the end of each run); however, the efficiency was stable for each individual run.

On Station 46, an offset occurred during the final standard analysis, and despite having numerous replicate samples, a correction could not be determined and the data was flagged as questionable.

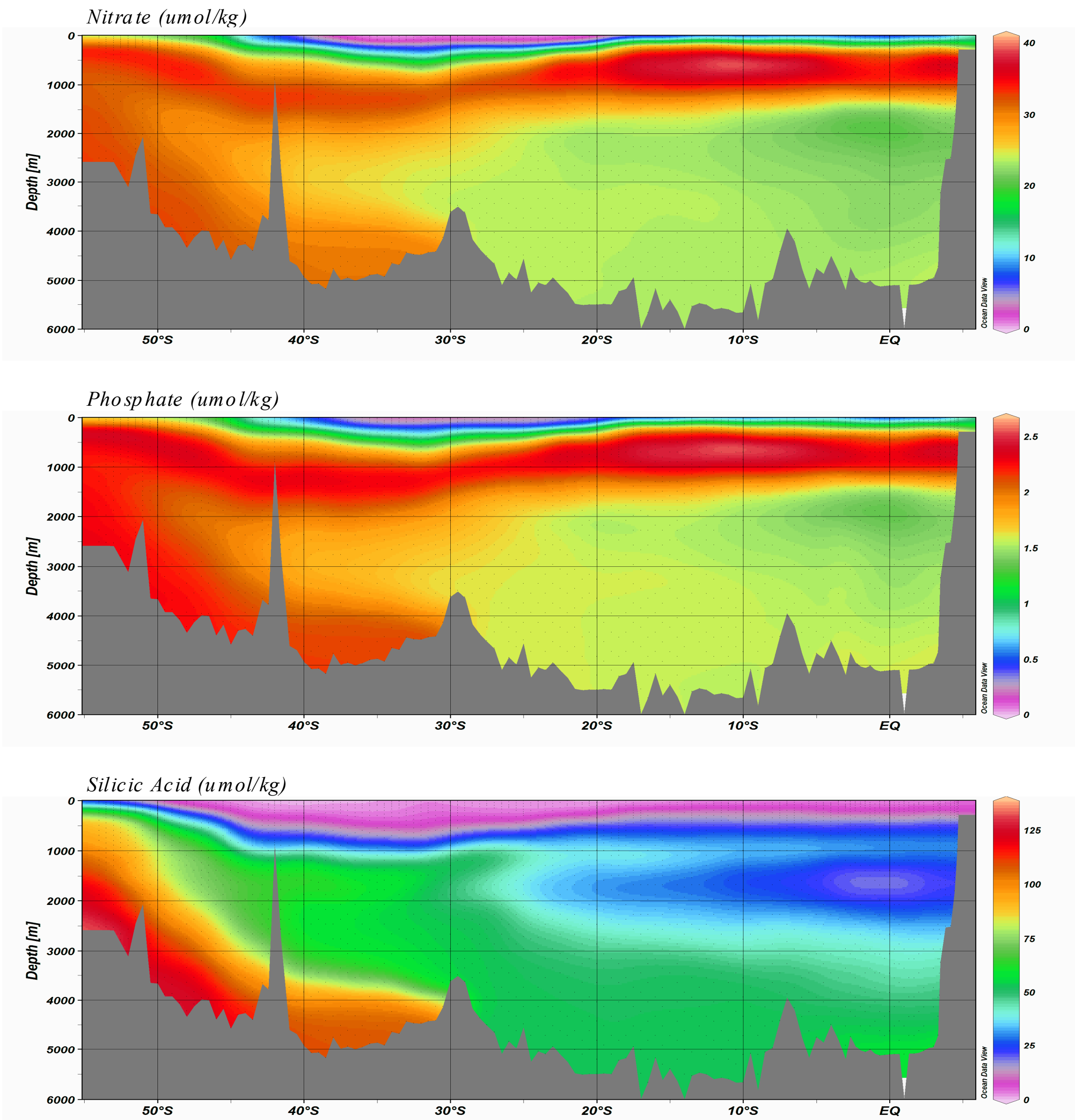

Figure 4.1 *Sections of nitrate, phosphate and silicic acid along the 2010 A13.5 cruise track.*

CFCs and SF_6

David Wisegarver, PMEL; Patrick Boylan, U, Colorado; Ivy Frenger, ETH
(PI: John Bullister, PMEL)

A PMEL analytical system (Bullister and Wisegarver, 2008) was used for CFC-11, CFC-12, and sulfur hexafluoride (SF_6) analyses on the CLIVAR A13.5 expedition. About 2800 seawater samples were analyzed for dissolved CFC-11, CFC-12 and SF_6 ('CFC/SF_6') concentrations. On some casts, the analysis was modified to include the analysis of nitrous oxide (N_2O) or carbon tetrachloride. These N_2O and carbon tetrachloride analyses were done as part of an experimental study to try to develop more reliable methods for measuring these compounds in seawater on future CLIVAR cruises, and are not included in the data report.

In general, the analytical system performed well. Typical dissolved SF_6 concentrations in modern surface water are ~1 fmol kg^{-1} seawater (1 fmol= femtomole = 10^{-15} moles), approximately 1000 times lower than dissolved CFC-11 and CFC-12 concentrations. The limits of detection for SF_6 on CLIVAR A13.5 were approximately 0.02 fmol kg^{-1}. SF_6 measurements in seawater remain extremely challenging. Improvements in the analytical sensitivity to this compound at low concentrations are essential to make these measurements more routine on future CLIVAR cruises.

Water samples on CLIVAR A13.5 were collected in bottles designed with a modified end-cap to minimize water contact with the end-cap O-rings after closing. Stainless steel springs covered with a nylon powder coat were substituted for the internal elastic tubing provided with standard Niskin bottles. When taken, water samples collected for dissolved CFC-11, CFC-12, and SF6 analysis were the first samples drawn from the 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, 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 place 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-1 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 l min-1) 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 along the cruise track. At each location, at least five air measurements were made to determine the precision of the measurements.

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 (1988) and Bullister and Wisegarver (2008) as outlined below. For seawater analyses, water was transferred from a glass syringe to a glass-sparging chamber (volume ~200 ml). 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-1. 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 22 cm section packed with Carboxen 1000, and a 2.5 cm section packed with molecular sieve MS5A. A Neslab Cryocool CC-100 was used to cool the trap to ~-70°C. After 6 minutes of purging, the trap was isolated, and it was heated electrically to ~160°C. The sample gases held in the trap were then injected onto a precolumn (~60 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 and SF6 from later eluting peaks.

After the SF_6 and CFC-12 had passed from the pre-column and into the second precolumn (5 cm of 1/8" O.D. stainless steel tubing packed with MS5A, 90°C) and into the analytical column #1 (240 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 (150 cm 1/8" OD stainless steel tubing packed with Carbograph 1AC, 80-100 mesh, held at 90°C). After CFC-11 had passed through the first pre-column, the flow was diverted to a third analytical column (1.7 m , Carbograph 1AC, 90°C). The gases remaining after CCl_4 had passed through the first pre-column, were backflushed from the pre-column and vented. Column #1 and the first pre-column were held in a Shimadzu GC8 gas chromatograph with an electron capture detector (ECD) held at 340°C. Column #2, column #3 and the second precolumn were in another Shimadzu GC8 gas chromatograph with ECD. The output from column #3 was plumbed to a Shimadzu Mini2 gas chromatograph with the ECD held at 250°C. This was done because the temperature stability of the Mini2 controller was not adequate for this analysis. On the stations in which nitrous oxide was analyzed, the content of the second precolumn was directed to column #3. This prevented the analysis of carbon tetrachloride on those samples.

The analytical system was calibrated frequently using a standard gas of known CFC/SF6 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, precolumn, 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 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 CFC-11 and CFC-12 in air, seawater samples, and gas standards are reported relative to the SIO98 calibration scale (Cunnold et al., 2000). Concentrations of SF_6 in air, seawater samples, and gas standards are reported relative to the SIO2005 calibration scale. Concentrations of CFC/SF_6 in air and standard gas are reported in units of mole fraction CFC/SF_6 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^{-1}) and SF_6 concentrations in fmol kg^{-1}. CFC/SF_6 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 analytical instrument. The response of the detector to the range of moles of CFC/SF_6 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 min^{-1} for 6 minutes, the purging efficiency for CFC-11, CFC-12 and SF_6 was about 99% or higher.

On this expedition, based on the analysis more than 200 pairs of duplicate samples, we estimate precisions (1 standard deviation) of about 1% or 0.002 pmol kg^{-1}(whichever is greater) for both dissolved CFC-11 and CFC-12 measurements. The estimated precision for SF_6 was 2% or 0.02 fmol kg^{-1} (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 about 2% or 0.004 pmol kg^{-1} for CFC-11 and CFC-12 and 4% or 0.04 fmol kg^{-1} for SF_6.

A small number of water samples had anomalously high CFC/SF_6 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., anomalous dissolved oxygen, salinity, or temperature features). This suggests that these samples were probably contaminated with CFCs/SF_6 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).

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Air Measurements on CLIVAR A13.5 cruise

Lat deg	Lon deg	SF6 ppt	CFC12 ppt	CFC11 ppt
-54.0	0.0	6.80	531.9	247.6
-54.0	0.0	6.88	532.7	243.3
-52.0	0.3	6.90	398.1	239.9
-44.0	1.3	6.87	533.4	232.9
-41.6	1.0	6.76	532.7	245.0
-38.5	1.0	6.75	533.8	153.8
-36.0	1.0	6.76	531.4	238.0
-26.0	1.6	6.86	533.4	237.8
-18.5	1.2	6.80	533.8	238.4
-14.6	1.0	6.77	-9.0	238.6
-7.0	-1.5	6.83	526.2	239.4
-6.0	-2.4	7.02	533.7	247.4
-2.0	-3.0	6.73	527.5	241.7
2.0	-3.0	6.92	535.8	247.5
4.7	-3.0	6.62	528.9	241.5

Dissolved Inorganic Carbon (DIC)

Cynthia Peacock, PMEL; Alex Kozyr, CDIAC
(PIs: Richard Feely, PMEL; Rik Wanninkhof, AOML)

The DIC analytical equipment was set up in a seagoing container modified for use as a shipboard laboratory. The analysis was done by coulometry with two analytical systems (PMEL-1 and PMEL-2) used simultaneously on the cruise. Each system consisted of a coulometer (UIC, Inc.) coupled with a SOMMA (Single Operator Multiparameter Metabolic Analyzer) inlet system developed by Ken Johnson (Johnson et al., 1985, 1987, 1993; Johnson, 1992) of Brookhaven National Laboratory (BNL). In the coulometric analysis of DIC, all carbonate species are converted to CO_2 (gas) by addition of excess hydrogen to the seawater sample. The evolved CO_2 gas is carried into the titration cell of the coulometer, where it reacts quantitatively with a proprietary reagent based on ethanolamine to generate hydrogen ions. These are subsequently titrated with coulometrically generated OH-. CO_2 is thus measured by integrating the total charge required to achieve this.

The coulometers were each calibrated by injecting aliquots of pure CO_2 (99.995%) by means of an 8-port valve outfitted with two sample loops (Wilke et al., 1993). The instruments were calibrated at the beginning of each station with two sets of the gas loop injections.

Secondary standards were run throughout the cruise (at least one per station) on each analytical system. These standards are Certified Reference Materials (CRMs), consisting of poisoned, filtered, and UV irradiated seawater supplied by Dr. A. Dickson of Scripps Institution of Oceanography (SIO). Their accuracy is determined shoreside manometrically. DIC data reported to the database have been corrected to the batch 98 CRM value.

Samples were drawn from Niskin-type bottles into cleaned, precombusted 300-mL Pyrex bottles using silicon tubing. Bottles were rinsed once and filled from the bottom, overflowing half a volume. Care was taken not to entrain any bubbles. The tube was pinched off and withdrawn, creating a 5-mL (2%) headspace, and 0.122 mL of 50% saturated $HgCl_2$ solution was added as a preservative. The sample bottles were sealed with glass stoppers lightly covered with Apiezon-L grease, and were stored in a 20°C water bath for a minimum of 20 minutes to bring them to temperature prior to analysis.

Over 3000 samples were analyzed for discrete DIC. Full profiles were completed at almost every station. Replicate samples were taken from the surface, oxygen minimum, and bottom bottles. Occasionally duplicates were not taken, due to high water use with other chemical analyses (determined by the chief scientist). The replicate samples were interspersed throughout the station analysis for quality assurance and integrity of the coulometer cell solutions.

DIC measurements were performed by Cynthia Peacock (lead) from the University of Washington, Joint Institute for the Study of the Atmosphere and Ocean (JISAO), a contractor for the National Oceanic and Atmospheric Administration (NOAA), Pacific Marine Environmental Laboratory (PMEL); and Alex Kozyr, from the Carbon Dioxide Information Analysis Center (CDIAC) at Oak Ridge National Laboratory.

A total of over 400 pure (99.995%) CO_2 gas calibrations were run on both SOMMA systems during this cruise. The precision and accuracy obtained from these calibrations can be described as follows:

1. The precision is estimated from ~300 replicate pairs.
   The absolute average difference from the mean of these replicates is 0.62 µmol/kg.
   No significant systematic differences were noted.
2. The accuracy is estimated from the analysis of 120 Certified Reference Materials (batch 98). The CRM value is 2013.85 µmol/kg. Our average value was 2011.7 µmol/kg with a standard deviation of 1.3 µmol/kg.

References:

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Alkalinity

Laura Fantozzi, SIO; Emily Bockmon, SIO
(PI: Andrew G. Dickson, SIO)

Samples were taken from all Niskin bottles. After thorough rinsing, samples were collected in 250 ml Pyrex serum bottles. Approximately 0.06 milliliters of a saturated mercuric chloride solution were added to each sample. A headspace of approximately 5ml was left for stations 001-069. This was increased to ~20ml for stations 070-129.

Starting at station 008 samples were allowed to equilibrate (using a heater for the coldest) until near 20 degrees Celsius. Stations 001-008 were not allowed to properly equilibrate.

Samples of volume 99.9 ml were dispensed using a Metrohm 765 Dosimat with a 50 ml burette. The temperature of the samples at time of dispensing was taken using a YSI 4600 thermometer, to convert this volume to mass for analysis. For some number of samples, bubbles formed in the burette, most likely displacing volume. This was especially a problem on stations 050-070. By allowing the samples to degas, using a larger headspace and vigorous shaking, most bubbles were avoided after Station 070. One large bubble, displacing sample volume, causes an approximate error of 2 umol/kg lower alkalinity.

Samples were analyzed using an open beaker titration procedure using two thermostated beakers; one sample being titrated while the second was being prepared and equilibrating to the system temperature of 20 degrees C. After an initial aliquot of approximately 2.5 mls of standardized hydrochloric acid (~0.1Molar HCl in ~0.6M NaCl solution), the sample was stirred for approximately 5 minutes to remove liberated carbon dioxide. The stir time has been minimized by bubbling carbon dioxide free air into the sample. After equilibration, 18 aliquots of 0.05 mls were added. The data within the pH range of 3.5 to 3.0 were processed using a non-linear least squares fit from which the alkalinity value of the sample was calculated (Dickson, et. al., 2007).

Dickson laboratory Certified Reference Materials (CRM) Batch B98 was used to estimate the accuracy of the analysis.

Usually two duplicates, surface and deep were taken, but sometimes a third duplicate at the oxygen minimum was also analyzed. Occasionally when limited by sample water, only one, or no duplicates were taken. Throughout the cruise, approximately 250 duplicates were analyzed. The pooled standard deviation was 1.4 μmol kg^{-1}.

The data should be considered preliminary since the correction for the difference between the CRMs stated and measured values has yet to be finalized and applied. Most likely this correction will be significant for part of the data, as a shift was seen in CRM values at several points throughout the cruise, most notably at Station 062. At this point it was necessary to change to the backup sample dispensing burette and it seems this shifted the CRM value down for a time.

Additionally, the correction for the mercuric chloride addition has yet to be applied. As part of the data evaluation, a determination was made for the possible contribution of the mercuric chloride to the alkalinity. The data indicate no contribution, either positive or negative, from the mercuric chloride.

Reference:

Dickson, Andrew G., Chris Sabine and James R. Christian, editors, "Guide to Best Practices for Ocean CO_2 Measurements", Pices Special Publication 3, IOCCP Report No. 8, October 2007, SOP 3b, "Determination of total alkalinity in sea water using an open-cell titration".

fCO_2 (discrete)

Kevin Sullivan, AOML; Geun-Ha Park, AOML)
(PI: Rik Wanninkhof, AOML)

Samples were drawn from the Niskin bottles into 500 ml volumetric flasks for measurement of the fugacity of the dissolved carbon dioxide (fCO_2). The samples were drawn using a Tygon© tube with a short length of silicone tubing to fit over the petcock to avoid contamination of CDOM samples. The flasks were rinsed while inverted and then filled from the bottom, overflowing half a volume while taking care not to entrain any bubbles. About 5 ml of water was withdrawn with a pipette to allow for expansion of the water as it warms and to provide space for the stopper, tubing, and frit of the analytical system. Mercuric chloride solution (0.244 ml at half-saturation) was added as a preservative. The sample flasks were sealed with a screw cap containing a polyethylene liner. The samples were stored in coolers at air-conditioned room temperature generally for no more than 4 hours.

The relatively time-consuming analyses would not permit samples to be drawn from all Niskins at all stations. For the majority of the stations, twenty six flasks were drawn on the twenty four Niskins. Two pairs of duplicate flasks were drawn on most casts. Until the station spacing was shortened near the equator, a partial cast of sixteen or eighteen flasks was drawn about every fourth station. Across the equator and to the end of the cruise, full and partial cast were alternated. The number of flasks in the partial cast was adjusted to avoid a large backlog of samples.

All analyses were done at 20°C. A secondary bath was used to get the samples close to the analytical temperature prior to analysis. As soon as space was available in the secondary or primary bath, sample flasks were moved into the more controlled temperature bath. No flask was analyzed without spending at least 1.5 hours in these water bathes.

The discrete fCO_2 system is patterned after the instrument described in Chipman et al. (1991) and is discussed in detail in Wanninkhof and Thoning (1993) and Chen et al. (1995). The major difference between the two systems is that the Wanninkhof and current instrument uses a LI-COR© model 6262 non-dispersive infrared analyzer, while the Chipman instrument utilizes a gas chromatograph with a flame ionization detector.

Once the samples reach the analytical temperature, a ~50-ml headspace is created by displacing the water using a compressed standard gas with a CO_2 mixing ratio close to the anticipated fCO_2 of the water. The headspace is circulated in a closed loop through the infrared analyzer that measures CO_2 and water vapor concentrations. The samples are equilibrated until the running mean of 20 consecutive 1-second readings from the analyzer differ by less than 0.1

ppm (parts per million by volume). This equilibration takes about 10 minutes. An expandable volume in the circulation loop near the flask consisting of a small, deflated balloon keeps the headspace of the flask at ambient pressure.

In order to ensure analytical accuracy, a set of six gas standards is run through the analyzer before and after every eight seawater samples. (cylinder serial numbers CA5998 [205.07 ppm], CA5989 [378.71 ppm], CA5988 [593.64 ppm], CA5980 [792.51 ppm], CA5984 [1036.95 ppm], and CA5940 [1533.7 ppm])

The standards were obtained from Scott-Marin and referenced against primary standards purchased from C.D. Keeling in 1991, which are on the WMO-78 scale.

The calculation of fCO_2 in water from the headspace measurement involves several steps. The CO_2 concentrations in the headspace are determined via a second-degree polynomial fit using the nearest three standard concentrations. Corrections for the water vapor, the barometric pressure, and the changes induced in the carbonate equilibrium by the mass transfer of CO_2 in or out of the water sample are made. The corrected results are reported at a reference temperature of 20.00°C.

At the beginning of the cruise one of the gas circulation channels was performing at an acceptable, though not optimal flow rate. The equilibrations were requiring more time than in the other channel. Efforts were made over two days to improve the flow rate in the slow channel. The flows improved significantly after station 41. With continuous use of the pumps, excellent flows developed starting at station 50.

During the analyses of station 45, the temperature of the water bath began to drift. After some efforts to stabilize the temperature, the water bath was replaced. One pair of samples was lost, and the analyses of most of the samples from station 45 were delayed an additional 4 hours. Because of the delay, no samples were collected on station 46.

There were 183 pairs of duplicate samples drawn from Niskins on 101 stations. The average relative difference between all the pairs was 0.250 % (+/- 0.287 %).

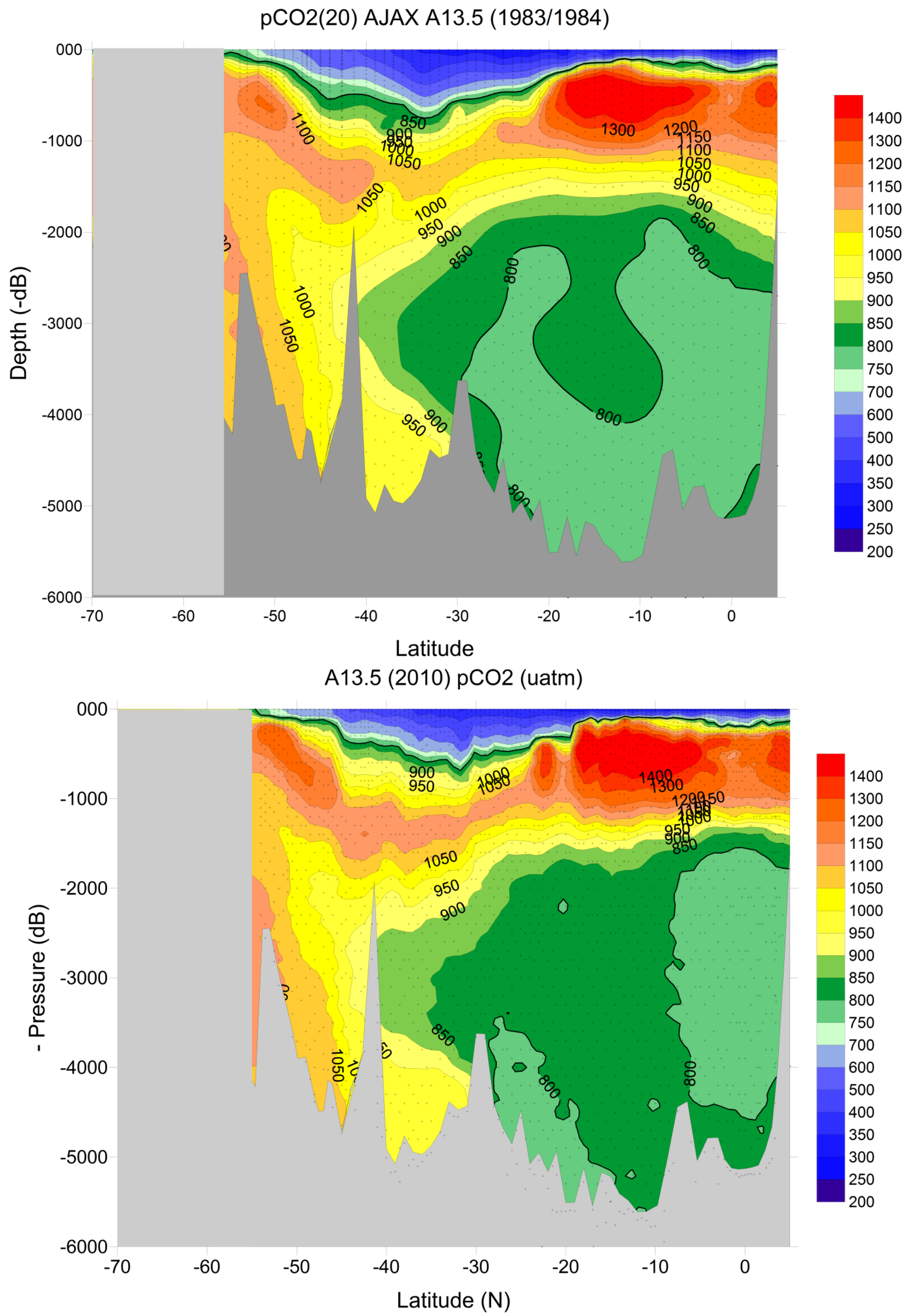

Figure 8-1: *Cross-section of $fCO_2(20)$ for the AJAX cruise in 1983/84 (top) and the CLIVAR/CO_2 cruise A13.5 along the same transect in 2010 (bottom). While the overall patterns are similar for the two cruises that are 26 years apart, increases of $fCO_2(20)$ in bottom water and in the intermediate water formation areas are apparent. The contours in the top panel were smoothed because of a five-fold less data density.*

Metadata for the discrete $fCO_2(20)$ measurements for cruise A13.5, 2010

The six gas standards used to calibrate the analyzer before and after every eight seawater samples are:

Cylinder serial#	Dry mole fraction CO_2 in air (ppm)
CA5998	205.07
CA5989	378.71
CA5988	593.64
CA5980	792.51
CA5984	1036.95
CA5940	1533.7

The standards were obtained from Scott-Marin and referenced against primary standards purchased from C.D. Keeling in 1991, which are on the WMO-78 scale.

The mass transfer of CO_2 in or out of a water sample during analysis induces a change in the carbonate equilibrium affecting the DIC and fCO_2 but not the TAlk. The analytical results for other parameters (DIC, phosphate, and silicate) from the same Niskin are used in calculations to correct for this small change. If any of these parameters are missing or flagged as questionable (QF= 3) or bad (QF= 4), a value consistent with the surrounding data is assigned. This assignment of the auxiliary parameters was done for thirty-six CO_2 analyses that were flagged as good (QF = 2). The assignment of values was rarely necessary for the CTD salinity and potential temperature, which were also used in producing the final result. Analyses were performed at an accurately measured temperature of nominally 20˚C. Small adjustments to 20.00˚C were performed using the temperature coefficients of the carbonate dissociation constants. The final result is the fugacity of CO_2 at a reference temperature of 20°C, $fCO_2(20)$.

The $fCO_2(20)$ was plotted as vertical profiles and as sections at discrete pressure intervals versus latitude. The pressure intervals used were: 5-51 dB, 59-153 dB, 160-550 dB, 574-1552 dB, 1598-3537 dB, and 3350-5800 dB. Anytime an appreciable anomaly was observed the $fCO_2(20)$, TAlk, pH, and DIC were scrutinized to assess if the $fCO_2(20)$ should be flagged.

In addition to the examination of the fCO_2 analyses in its spatial context, an examination of the fCO_2 analyses for internal consistency within the carbonate equilibrium chemistry was done. For this check, $fCO_2(20)$ was calculated from

(a) DIC and TAlk, referred to as fCO_2(DIC,TA) and
(b) DIC and $pH_T(20)$ (= pH on total scale at 20˚C), referred to as fCO_2(DIC,pH)

using the CO2sys macro in Excel developed by Pierrot based on the original BASIC program of Lewis and Wallace. Salinity, silicate, and phosphate as provided in the bottle data file were used as auxiliary parameters. The calculations were performed with the carbonic acid dissociation constants of Mehrbach as refit by Dickson and Millero, and the sulfate dissociation constant from Dickson. Note that the Alkalinity and pH values were the preliminary ship-based values. These two $fCO_2(20)$ values were only calculated if the DIC, TAlk, and pH measurements were flagged as good (QF=2). Anomalous differences drew scrutiny.

The differences between the analytical $fCO_2(20)$ and the two calculated $fCO_2(20)$ values are summarized.

	Avg Difference (µatm)	StdDev (µatm)
$fCO_2(20)$ - fCO_2(DIC,TA)	-14.06	26.68
$fCO_2(20)$ - fCO_2(DIC,pH)	11.86	6.17

From these examinations, twenty-two Niskins associated with outlying fCO_2 analyses were identified as likely miss-trips. Seven of these fCO_2 analyses are flagged as bad (QF=4); fifteen are flagged as questionable (QF=3). Two of the fifteen questionable values were actually averages of duplicate samples (Stn# 79, N# 15 and Stn# 103, N# 5). The duplicates are included in the precision statistics reported below, since the placement of the Niskin in the water column does not matter to the reproducibility of the sample draw and analysis.

There were fifteen fCO_2 analyses that were outliers from Niskins that were not likely miss-trips. Eleven of these analyses are flagged as bad; nine are flagged as questionable. There was one sample from a duplicate pair that was an outlier, so the other samples was reported and flagged as good (QF=2). The decision whether an fCO_2 analysis was bad or questionable was based on how inconsistent the value was relative to the surrounding data. The contextual QC check was done by Kevin Sullivan; additional contextual and the internal consistency QC checks were done by Rik Wanninkhof.

There were 183 pairs of duplicate samples drawn from Niskins on 101 stations. The average relative difference between all the pairs was 0.250 % (+/- 0.287 %). If the four relative differences above 1% are excluded (~95% confidence interval), the average relative difference was 0.220 % (+/- 0.209 %).

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Chen, H., R. Wanninkhof, R. A. Feely, and D. Greeley (1995), "Measurement of fugacity of carbon dioxide in sub-surface water: an evaluation of a method based on infrared analysis." [NOAA technical report] ERL AOML-85, 52 pp, NOAA/AOML.

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fCO_2 (underway)

Kevin Sullivan, AOML
(PI: Rik Wanninkhof, AOML)

An automated underway fCO_2 system from AOML has been situated in the hydro lab of the R/V *Ronald H. Brown* since it was commissioned in July 1997. The current system has been aboard since September, 2008, and is a model 8050 from General Oceanics, Inc (GO). Access to the data can be found at AOML's global carbon cycle web page (http://www.aoml.noaa.gov/ocd/gcc/rvbrown_introduction.php).

Early instrument designs are discussed in Wanninkhof and Thoning (1993) and in Feely et al. (l998). The current design as well as the data processing procedure is detailed in Pierrot et al. (2009).

Seawater continuously flows through a closed equilibration chamber at approximately 2 liters/minute. A spiral nozzle creates a conical spray that enhances the gas exchange with the enclosed gaseous headspace. During 'water' analyses this overlying headspace is pushed through an infrared analyzer and returned to the equilibrator. During air analyses, outside air is pulled from an inlet on the forward mast and pushed through the analyzer. The pressure and temperature inside the equilibrator are constantly being measured. With knowledge of the sea-surface temperature and salinity, along with all the parameters measured by the system, one can calculate the fugacity of CO_2 in the seawater and the atmosphere above it.

To ensure the accuracy of analyzer output, every 2.6 hours four standard gases are analyzed. (serial numbers CA06709 [284.75 ppm], CA02813 [363.24 ppm], CA07921 [423.57 ppm], and CA07931 [545.88 ppm]) They were purchased from NOAA/ESRL in Boulder, CO and are directly traceable to the WMO scale. After the standards, five air analyses and then fifty water analyses are done. With continuous operation, the current system provides over 920 water analyses per day. During this cruise, the operation was interrupted while the ship was maintaining station several times for testing and upgrades.

The first upgrade was done before the ship left Cape Town. A new equilibrator with a water jacket was installed. The new equilibrator has a seawater flow of approximately 1.5 liters/minute flowing through a concentric enclosure around the vertical walls. This thermal insulation improves the stability and accuracy of the temperature measured in the main equilibrator, especially with very cold waters.

Additional upgrades were associated with the firmware and software used to control the hardware. On 12 March 2010, a new version of the software was installed and worked well. On 2 April 2010, a new firmware and the necessary software were installed. These upgrades yielded a more stable and adaptable analytical system. On 9 April 2010 the GPS signal was switched from the dedicated deck box that comes with the GO system to the ship's GPS that is broadcast through the ship.

Other than these planned service events, the system ran continuously during the entire cruise. Preliminary examinations of the data confirm good analyses. Calculation of final values of fugacity will require some time given the volume of data.

References:

Wanninkhof, R., and K. Thoning (1993), "Measurement of fugacity of CO_2 in surface water using continuous and discrete sampling methods." *Mar. Chem.*, **44**, 189-205.

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pH_T

Adam Radich, UCSD-SIO; Yuichiro Takeshita, UCSD-SIO
(PI: Andrew Dickson, UCSD-SIO)

During this cruise approximately 3300 water samples were analyzed from rosette casts at 129 stations and 1 test station. Samples were analyzed using the method described in Dickson et al [2007] Analyses were made with an Agilent 8453 spectrophotometer equipped with a 10 cm jacketed flow cell using the sulfonephthalein indicator m-cresol purple (mCP). Sample introduction to the cell and dye addition were automated using a Kloehn V6 syringe pump. Results are reported on the total hydrogen ion scale at XX°C .

All stations were sampled on the cruise, and the sampling scheme was to sample every bottle where an alkalinity or total carbon measurement was taken in order to generate a complete characterization of the carbon system. This resulted in full coverage of all tripped bottles. Samples were drawn from Niskin bottles on the rosette using silicone tubing into 300 mL Pyrex glass serum bottles. The serum bottles were rinsed three times, filled and allowed to overflow by one additional bottle volume. The samples were poisoned with 0.02% saturated HgCl2 solution and capped with a rubber stopper without allowing any headspace. Analyses were completed within three hours of sampling. Prior to measurement, samples were brought to 20°C by partially submerging the serum bottles in a Neslab RTE7 temperature bath for 16 minutes.

Data precision was evaluated by analysis of duplicate samples (multiple samples from the same Niskin bottle on the rosette). The pooled standard deviation of the ~450 duplicate analyses is 0.0007 pH units.

Accuracy of spectrophotometric pH measurements is difficult to constrain with no agreed upon calibration procedure. For this cruise two approaches were made. First, since both total alkalinity and total carbon were measured on the same Niskin bottles as pH, an independent estimate of pH can be obtained from equilibrium equations. However, there are uncertainties involved in these calculations, and the pH can only be calculated accurately to 0.01 pH units. Second, pH analyses of 25 Certified Reference Materials (currently only certified for DIC and alkalinity) were performed. A review of the accuracy of the pH measurements is currently underway, and large changes (~0.01) in the final reported values are likely. Despite these uncertainties, confidence in the precision of the measurements remains high. Any changes will most likely be the addition of constant or an offset based on a function of pH.

No correction for $HgCl_2$ addition has been made for the reported preliminary pH values. However, previous experiments suggest a very small correction for HgCl2 (~0.0003 pH unit increase) might be appropriate for all measured values.

Reference:

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.), (2007): Guide to Best Practices for Ocean CO_2 Measurements.

Carbon Isotopes (C-13/C-14)

Darcy Metzler, RSMAS
(PIs: Robert Key, Princeton; Ann McNichol, WHOI)

13C/14C water samples were drawn routinely from the Rosette casts. Approximately every 5 degrees of latitude the entire water column was sampled (24 samples). In between most of the full profiles, the shallowest 16 bottles were sampled. Vertical profiles were collected at 34 of the 129 total stations.

Samples were collected in 500 ml glass stoppered bottles. First, the stopper was removed from the dry flask and placed aside. Using silicone tubing, the flasks were rinsed well with the water from the Niskin bottle. While keeping the tubing near the bottom of the flask, the flask was filled and allowed to overflow about half its volume. Once the sample was taken, a small amount (~30 cc) of water was removed to create a headspace and ~0.2ml of 50% saturated mercuric chloride solution was added. This was the same supply and volume of mercuric chloride solution used for the DIC samples.

After all samples were collected from a station, the neck of each flask was carefully dried using Kimwipes. The stopper, previously lubricated with Apiezon grease, was inserted into the bottle. The stopper was examined to insure that the grease formed a smooth and continuous film between the flask and bottle. A rubber band was wrapped over the bottle to secure the stopper. The filled bottles were stored inside the ship's laboratory prior to being loaded into a container and shipped to Woods Hole, MA after the ship returned the to the U.S. The samples will be analyzed at the National Ocean Sciences AMS lab in Woods Hole, MA using published techniques developed for the WOCE program.

Dissolved Organic Carbon

Darcy Metzler, RSMAS
(PI: Dennis Hansell, RSMAS)

DOC and TDN samples were taken from every Niskin bottle at approximately every other station. 1594 samples were taken from 68 stations in total. Samples from depths shallower than 250 m 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 Mili-Q water rinsed. Filters were combusted at 450°C overnight. Filter holders were 10% HCl cleaned and Mili-Q water rinsed. Samples were introduced into the sample bottles by a pre-cleaned silicone tubing. Bottles were rinsed by sample for 3 times before filling. 40-50 ml of water were taken for each sample. Samples were kept frozen in the ship's freezer room. Frozen samples were shipped back by express shipping to RSMAS for analysis.

Tritium and Helium

Anthony Daschille, LDEO
(PIs: Peter Schlosser, LDEO; William Jenkins, WHOI)

(no report provided)

LADCP

Francois Ascani, U. Hawaii
(PI: Eric Firing, U. Hawaii)

Ocean current velocity by Lower Acoustic Doppler Profiler (LADCP)

A University of Hawaii (UH) system was used to collect horizontal ocean current velocity from a Lowered Acoustic Doppler Current Profiler (LADCP). Final processing was completed using the Lamont-Doherty Earth Observatory (LDEO) LADCP software [Thurnherr, 2008].

LADCP System Setup

One 24-bottle CTD rosette was used during the whole cruise. On deck, the rosette laid on a platform that could be tracked in and out the hangar. This system was necessary for LADCP operations as the LADCP cables are purposely short (to limit noise) and could not have reached the rosette outside the hangar.

The rosette had two WH300-kHz LADCP, one up-looker and one down-looker, and an oil-filled 58V rechargeable lead-acid battery pack. The installation on deck consisted of a Lenovo S10e for data acquisition and processing, as well as a TDK-Lambda battery charger/power supply. The LADCP heads and battery pack were mounted inside the 24-bottle rosette frame and connected using a custom designed, potted star cable assembly. One head (master) was placed looking downward underneath the bottles at approximately the same height as the CTD instruments, the other head looking upwards (slave) above the bottle trigger mechanism. The battery pack and LADCP were mounted on opposite sides of the rosette frame center to avoid unequal balancing.

Power supply and data transfer was handled independently from any CTD connections. While on deck the instrument communication was set up by means of a network of RS-232 and USB cables, using a UH python software for instrument control and data transmission, and version IX_6beta of the LDEO software for data processing in Matlab [Thurnherr, 2008].

The set up of the two LADCP heads follows the master-slave set-up: one instrument (master) dictates when the second instrument (slave) starts and stops to ping. For deployment, the slave was first prepared and started to ping only once the master did. For retrieving the data, the master was first stopped to ping which immediately stopped the slave. The command file of the master (downlooker) is:

```
CR1
WM15
TC2
```

TB 00:00:02.00
TE 00:00:00.80
TP 00:00.00
WP 1
WN20
WS0800
WF0800
WV330
EZ0011101
EX00100
CF11101
SM2
SA001
ST0

The command file for the slave (up-looker) is:
CR1
WM15 T
C2
TB 00:00:02.00
TE 00:00:00.80
TP 00:00.00
WP 1
WN20
WS0800
WF0800
WV330
EZ0011101
EX00100
CF11101
SM1
SA001
SW05000

In the command files, SM1 and SM2 tell if the instrument is a master or slave, respectively. The slave was set-up to ping 500 ms after the master in order to avoid interference: this is indicated by the command SW05000 in the master file.

At the beginning of the cruise, it was necessary to assure that the LADCP and CTD acquisition computer clocks be both in sync with the ship clock to assure that the absolute time recorded by the CTD and LADCP be the same.

LADCP Operation and Data Processing

On arrival at each station the LADCP heads were switched on for data acquisition by using the LADCP software. Then communications and power cabling were disconnected and all connections were sealed with dummy plugs. After each cast the data cable and the power supply were rinsed, reconnected, the data acquisition terminated, the battery charged, and the data downloaded. It took about 20 minutes to download the data from each data and during this time, the new battery was fully charged.

Immediately after each cast, preliminary processing was executed, combining CTD, GPS, and shipboard ADCP data with the data from the LADCP to produce both a shear and an inverse solution for the absolute velocities. The preliminary processing produced velocity profiles, rosette frame angular movements, and velocity ASCII and Matlab files. Plots and data files were put on the ship website for immediate visualization.

Problems

No major problem was encountered. On station 12, the communication failed between the computer and the down-looker instrument so the cast was done only with the up-looker with no master-slave set up. Communication was re-established afterwards.

For station 72, LADCP data were taken for CTD cast #1 (from surface down to bottom then up to 1600 m) and #2 (1600 m up to the surface). CTD cast #1 and #2 were part of the same physical cast and CTD data acquired from the CTD group from both casts were merged to form one complete cast, renamed cast #1 for LADCP processing. No LADCP data were taken at Station 72 for CTD cast #3.

A similar procedure was followed for station 79 except that LADCP data were acquired for CTD cast #3. The official cast is the first one.

For station 82, there were two CTD casts, one full and one down to 1600 m only. LADCP data were acquired in both cases and the official cast will be the first one.

Between 102 and 103, we removed the up-looker ADCP to replace the rubber pads that were sliding down with the ADCP. The ADCP was then put back. The rubber pads used and the method to fix them on the ADCP frames were not preventing the ADCP from sliding down about 0.5-1 mm a day. The down-looker ADCP was secured by a line at the beginning of the cruise and stopped sliding down immediately. This was not the case for the up-looker and explains why we had to add a layer of rubber and re-position the instrument between station 102 and 103.

Data distribution

LADCP data are distributed separately from the rest of the cruise data. They can be found at: http://currents.soest.hawaii.edu/clivar/ladcp/index.html

References

Thurnherr, A.M., "How To Process LADCP Data With the LDEO Software." (version IX.5), July 9, 2008.

SADCP

(PI: Julia Hummon, U. Hawaii)

Shipboard Acoustic Doppler Current Profiler

The Ronald H Brown has a 75kHz acoustic Doppler current profiler ("ADCP", Teledyne R.D. Instruments) for measuring ocean velocity. Specialized software developed at the University of Hawaii has been installed on this ship for the purpose of ADCP acquisition, processing, and figure generation during each cruise.

The acquisition system ("UHDAS", University of Hawaii Data Acquisition System) is an Open Sources suite, written in C and Python; processing software is in C, Python, and Matlab. UHDAS acquires data from the OS75 instrument, gyro heading (for reliability), Mahrs heading (for increased accuracy), and GPS positions from various sensors. Single-ping data are converted from beam to earth coordinates using known transducer angles and gyro heading, and are corrected by the average mahrs-gyro difference over the duration of the 5-minute profile.

Groups of single-ping ocean velocity estimates must be averaged to decrease measurement noise. These groups commonly comprise 5 minutes. Bad pings must be edited out prior to averaging. This is done by UHDAS using a collection of criteria tailored to the instrument type and frequency, and to the specific installation.

UHDAS uses a CODAS (Common Oceanographic Data Access System) database for storage and retrieval of averaged data. Various post-processing steps can be administered to the database after a cruise is over, but the at-sea data should be acceptable for preliminary work.

UHDAS provides access to regularly-updated figures and data over the ship's network via samba share and nfs export, as well as through the web interface. The web site has regularly-updated figures showing the last 5-minute ocean velocity profile with signal return strength, and hourly contour and vector plots of the last 3 days of ocean velocity.

Shipboard Doppler sonar work on this cruise

During the cruise, the Ocean Surveyor was run in "interleaved" pinging mode, where it can sample in broadband mode (higher resolution, reduced range) and in narrowband mode (coarser resolution, increased depth range) with alternating pings. These are processed into two separate datasets.

Data quality

Typical ADCP data quality issues are

- clock errors
- heading correction
- data loss or compromise:
  - data loss due to bad weather, bubbles, etc
  - data compromise due to deep scattering layers
  - depth penetration

Clock:

The ADCP computer was synced to the network time server during the cruise. This worked fine; times are in UTC; decimal days for processed ADCP data are zero-based, i.e. 2010/01/01 12:00:00 is 0.500000

Heading:

Gyro headings were corrected using the Mahrs. Heading correction is critical to minimize cross-track errors induced by errors in heading. A one degree heading error results in a 10cm/s cross-track error in shipboard ADCP data if the ship is traveling at 12kts. The Mahrs was reliable, and within the constraints of the calibration mechanisms available, appeared to do a good job of correcting the heading. The compass correction varied from near 0-1deg at low latitudes and increased to 3 degrees at the southern reaches of the cruise.

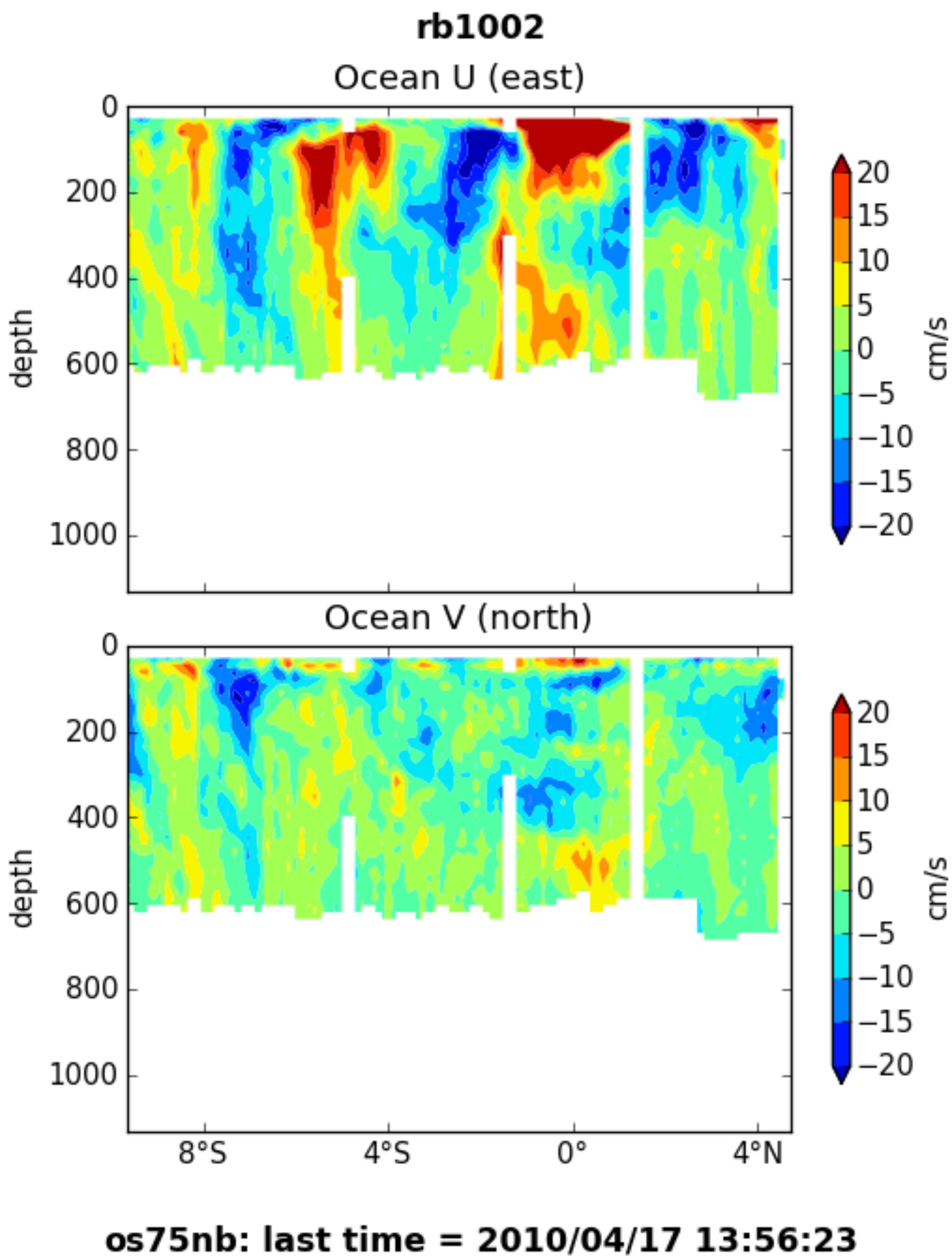
Data loss or compromise:

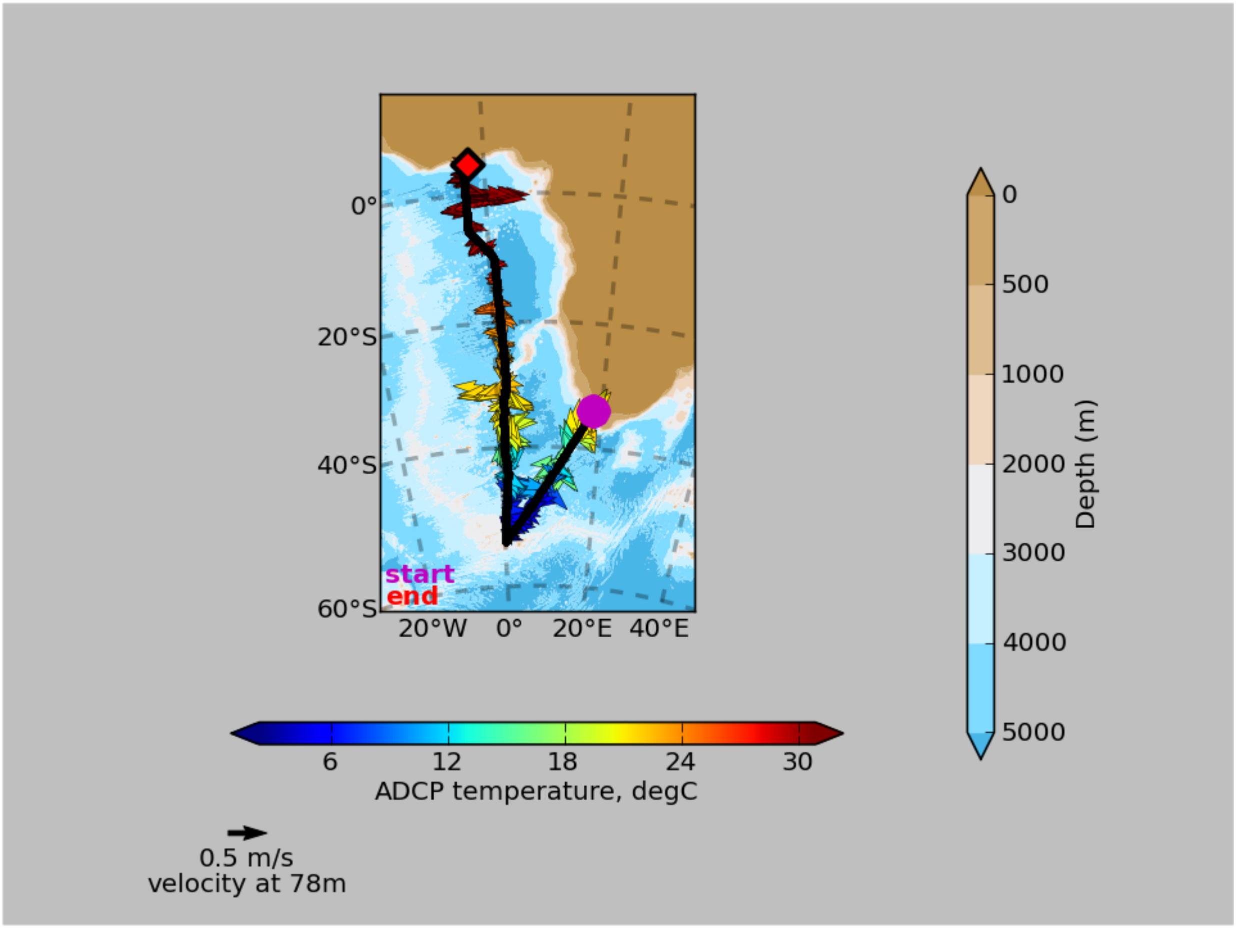
The broadband dataset (8m vertical bins) was negatively impacted by weather, especially south of 30°S. Much of the underway data was missing and range rarely exceeded 200m. Between 30°S and 20°S, there were fewer gaps, but the range was still only 200m. Approaching the equator, the range increased to 300-400m.

The narrowband dataset had fewer gaps and better range. South of 30°S, there were few gaps and the range was 400m-500m. Between 30°S and 20°S, range was 500-600m. North of 20°S, the range was 600m throughout.

Overview

All in all, the instrument, ancillary devices, and acquisition system performed well.


rb1002
Ocean U (east)
depth
0
200
400
600
800
1000
20
15
10
5
0
−5
−10
−15
−20
cm/s
Ocean V (north)
8°S
4°S
0°
4°N
os75nb: last time = 2010/04/17 13:56:23


0°
20°S
40°S
60°S
20°W
0°
20°E
40°E
start
end
0
500
1000
2000
3000
4000
5000
Depth (m)
6
12
18
24
30
ADCP temperature, degC
0.5 m/s
velocity at 78m

Drifter Deployments

(PI: Shaun Dolk, AOML)

A total of eighteen SVP drifters, provided by the Global Drifter Program, were deployed during the cruise. The deployment procedure involved removing the start up 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 thrown off 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 eighteen drifters were deployed:

	ID	mm/dd/10		hh:mm	DD	mm.mm	N/S	DDD	mm.mm	E/W
18-	75452	04/02	at	16:06	17	59.915	S	001	10.499	E
17-	75451	04/03	at	06:38	16	59.457	S	001	06.481	E
16-	90167	04/03	at	21:19	15	59.938	S	001	00.229	E
15-	90169	04/04	at	12:09	14	59.885	S	001	00.007	E
14-	90165	04/05	at	18:27	13	59.755	S	000	57.491	E
13-	90166	04/06	at	10:51	12	58.931	S	000	55.452	E
12-	90168	04/06	at	23:46	11	59.891	S	000	51.948	E
11-	90191	04/07	at	13:22	10	59.986	S	000	49.604	E
10-	90190	04/08	at	03:13	09	59.864	S	000	46.656	E
09-	90192	04/08	at	17:13	08	59.999	S	000	08.366	E
08-	90193	04/09	at	07:31	07	59.906	S	000	43.073	W
07-	75449	04/09	at	20:36	06	59.961	S	001	33.714	W
06-	75450	04/10	at	09:59	05	59.811	S	002	24.617	W
05-	90184	04/10	at	23:25	04	59.861	S	003	00.006	W
04-	90182	04/11	at	12:38	16	59.457	S	001	06.481	W
03-	90180	04/12	at	00:32	02	59.924	S	002	59.974	W
02-	90181	04/12	at	16:56	02	00.012	S	002	59.957	W
01-	90183	04/13	at	09:30	00	59.807	S	003	00.031	W

Argo Float Deployments

(PI: Gregory C. Johnson, PMEL)

Eight 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.usgodae.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 startup 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).

Argo float deployment information is summarized in the table below.

Float Time(UTC) Date Latitude Longitude

ID	Start Date & Time	Deployment Date & Time	DD mm.mmm N/S DDD mm.mmm E/W	Wind Speed/ Direction Sea State
967	03-26-10	03-28-10	26 58.809 S	4.5 Kts/29Deg
64517	15:00	03:57	001 39.577 E	calm seas
968	03-26-10	03-30-10	21 59.977 S	12 Kts/112Deg
64518	15:10	19:16	001 39.577 E	Seas 4-6'
969	03-31-10	04-02-10	17 59.915 S	5 Kts/126Deg
64570	17:17	16:06	001 39.499 E	calm seas
970	04-05-10	04-06-10	12 58.931 S	12.1 Kts/200Deg
78480	18:00	10:51	000 55.452 E	seas 4-6'
862	04-07-10	04-08-10	09 59.864 S	12.3 Kts/135Deg
80388	17:04	03:12	000 46.656 E	seas 4-6'
869	04-08-10	04-09-10	07 59.906 S	11.1 Kts/117Deg
80392	22:41	07:31	000 43.073 w	seas 2-4'
707	04-09-10	04-10-10	05 59.811 S	12.8 Kts/133Deg
71535	15:35	09:59	002 24.617 w	seas 2-4'
863	04-11-10	04-12-10	02 00.012 S	9.9 Kts/126Deg
80389	22:09	16:56	002 59.957 W	seas 1-2'

MAERI

Darcy Metzler, RSMAS
(PI: Peter Minnett, RSMAS)

For many years scanning radiometers on satellites have been providing global fields of sea-surface temperature (SST) and these have found many applications in oceanography, air-sea exchange studies, meteorology, including numerical weather forecasting, and climate change research.

The utility of the satellite-derived SSTs is determined by their uncertainties and these are largely determined by the residual errors in the correction for the effects of the intervening atmosphere. The most reliable way to determine these uncertainties is to compare the satellite-derived values with those from an independent data source taken at the same time in the same place. Given the effects of variable near-surface temperature gradients, the best sources of validating data are ship-board radiometers, but for these to provide useful data they have to be very accurate (uncertainties <0.1K) with calibration traceable to National Institute of Standards and Technology reference standards. The Marine-Atmospheric Radiance Interferometer (M-AERI) is one of a few such radiometers, and the track of the NOAA S Ronald H Brown provides the opportunity to take validation measurements in a very under-sampled part of the ocean.

The M-AERI is a Fourier-Transform Infrared (FTIR) Spectroradiometer that operates in the range of infrared wavelengths from ~3 to ~18μm and measures spectra with a resolution of ~0.5 cm^-1 . It uses two infrared detectors to achieve this wide spectral range, and these are cooled to ~78^{o} K (close to the boiling point of liquid nitrogen) by a Stirling cycle cryo-cooler to reduce the noise equivalent temperature difference to levels well below 0.1K. The M-AERI includes two internal black-body cavities for accurate real-time calibration. A scan mirror, which is programmed to step through a pre-selected range of angles, directs the field of view from the interferometer to either of the black-body calibration targets or to the environment from nadir to zenith. The sea-surface measurement also includes a small component of reflected sky radiance, so the derivation of the skin SST from the M-AERI spectra requires compensation of the reflected sky radiances that are part of the sea-viewing measurement, and of the emission from the atmosphere between the instrument and the sea surface. The interferometer integrates measurements over a few tens of seconds, to obtain a satisfactory signal to noise ratio, and a typical cycle of measurements including two view angles to the atmosphere, one to the ocean, and calibration measurements, takes about ten minutes. The instrument is run continuously so that measurements are taken within minutes of the satellite overpasses.

Appendix: Data Quality Evaluation (DQE) and Sample Log Notes

This section contains WOCE quality codes [Joyce, 1994] used during this cruise, and remarks regarding bottle data.

Table 1 A13.5 Water Sample Quality Code Summary

Property	1	2	3	4	5	6	7	8	9	Total
Bottle	0	3035	8	49	0	0	0	0	42	3134
13C/14C	681	0	0	0	0	0	0	0	0	681
DOC	1564	0	0	0	0	0	0	0	1	1565
3He	488	0	0	0	0	0	0	0	0	488
TDN	1565	0	0	0	0	0	0	0	0	1565
Tritium	422	0	0	0	0	0	0	0	0	422
Salinity	0	3012	13	29	5	0	0	0	0	3059
O2	0	2768	9	58	3	233	0	0	0	3071
Ammonium	0	0	0	0	3048	0	0	0	22	3070
Nitrite	0	3026	1	21	0	0	0	0	22	3070
Nitrate	0	3002	1	45	0	0	0	0	22	3070
Phosphate	0	3020	6	21	1	0	0	0	22	3070
Silicic Acid	0	3001	25	22	0	0	0	0	22	3070
DIC	0	2675	17	15	14	321	0	0	23	3065
fCO2	0	2594	4	12	3	180	0	0	14	2807
pH	0	2536	21	21	6	462	0	0	31	3077
Total Alkalinity	0	2661	33	24	18	309	0	0	19	3064
CCl4	0	2193	12	34	376	0	0	0	21	2636
CFC-11	0	2524	16	35	40	0	0	0	21	2636
CFC-12	0	2518	21	36	40	0	0	0	21	2636
SF6	0	2475	35	65	40	0	0	0	21	2636

Comments from the Sample Logs and the results of investigations into bottle problems and anomalous sample values are included in this report. Units used in these comments are degrees Celsius for temperature, PSS-78 salinity, and micromoles/kg for oxygen and nutrient data. The sample number is the cast number times 100 plus the bottle number.

Table 2 A13.5 Bottle Quality Codes and Comments

Station /Cast	Sample No.	Property	Quality Code	Comment
1/1	ALL		-	boom did not retract, CTD/rosette in the air for some minutes, then put back in water until boom fixed, which took approximately half an hour.
1/1	101	Bottle	2	ran out of water for salt
1/1	103	Bottle	3	leaking at vent (no samples drawn except for nutrients/salt)
1/1	105	O2	4	outlier (high) compared to CTDO
1/1	109	Bottle	2	ran out of water for salt/nutrients/tritium
1/1	111	Bottle	3	leaking at vent (no samples drawn except for nutrients/salt)
1/1	113	O2	4	bottle o2 value high compared to CTDO, flask 13 calibration is suspect; flask removed from service after station 17. Code o2 bad.
1/1	117	Bottle	3	leaking at vent (no samples drawn except for nutrients/salt)
1/1	121	Bottle	2	ran out of water for salt/nutrients

Station /Cast	Sample No.	Property	Quality Code	Comment
1/1	121	Refc.Temp.	3	SBE35RT slightly low vs CTDT, unstable reading.
1/1	123	Bottle	2	ran out of water for salt
2/1	103	Bottle	3	leaking (possibly empty because of leaking); only salinity drawn.
2/1	113	O2	4	bottle o2 value high compared to CTDO, flask 13 calibration is suspect; flask removed from service after station 17. Code o2 bad.
2/1	120	Bottle	4	o2 draw temperature, o2, nuts, pH, dic, alkalinity are all similar to values for bottle 21, mis-trip.
2/1	120	CCl4	4	bottle mis-trip.
2/1	120	CFC-11	4	bottle mis-trip.
2/1	120	CFC-12	4	bottle mis-trip.
2/1	120	DIC	4	outlier, similar to values for bottle 21. mis-trip.
2/1	120	Nitrite	4	outlier, similar to values for bottle 21. mis-trip.
2/1	120	Nitrate	4	outlier, similar to values for bottle 21. mis-trip.
2/1	120	O2	4	outlier, similar to values for bottle 21. mis-trip.
2/1	120	fCO2	4	outlier, similar to values for bottle 21. mis-trip.
2/1	120	pH	4	outlier, similar to values for bottle 21. mis-trip.
2/1	120	Phosphate	4	outlier, similar to values for bottle 21. mis-trip.
2/1	120	Salinity	4	outlier, similar to values for bottle 21. mis-trip.
2/1	120	SF6	4	bottle mis-trip.
2/1	120	Silicate	4	outlier, similar to values for bottle 21. mis-trip.
2/1	120	TAlk	4	outlier, similar to values for bottle 21. mis-trip.
2/1	123	Bottle	3	leaking (no samples drawn except for nutrients)
3/1	ALL		-	bottle 124 not used
3/1	110	Bottle	2	all nutrients, talk, dic slightly low vs P; salinity, pH, sf6 slightly hi; small salinity/CTDS max at bottle 10, probably all values ok.
3/1	110	Nitrate	2	rmk: no3 a bit low vs P/T, mark 3. mcj: see bottle comment, no3 probably ok.
3/1	112	O2	4	bottle o2 value high compared to CTDO, flask 52 calibration is suspect; flask removed from service after station 17. Code o2 bad.
3/1	120	Bottle	2	possibly leaking (all samples drawn); all parameters look ok, bottle ok.
3/1	121	Refc.Temp.	3	SBE35RT high vs CTDT, unstable reading.
4/1	113	O2	4	bottle o2 value high compared to CTDO, flask 13 calibration is suspect; flask removed from service after station 17. Code o2 bad.
5/1	106	Bottle	9	not tripped (lanyard hang-up prevented both bottles from closing)
5/1	107	Bottle	9	not tripped (lanyard hang-up prevented both bottles from closing)
5/1	112	O2	4	bottle o2 value high compared to CTDO, flask 52 calibration is suspect; flask removed from service after station 17. Code o2 bad.
5/1	117	Bottle	2	leaking from vent (all samples drawn); all parameters look ok, bottle ok.
6/1	112	O2	4	bottle o2 value high compared to CTDO, flask 52 calibration is suspect; flask removed from service after station 17. Code o2 bad.
6/1	112	Phosphate	3	hi vs no3,ph,dic
6/1	115	Bottle	9	not tripped
6/1	116	Phosphate	3	hi vs no3,ph,dic
6/1	117	Bottle	2	leaking (all samples drawn); all parameters

Station /Cast	Sample No.	Property	Quality Code	Comment
				look ok, bottle ok.
7/1	105	Bottle	2	cap moved by lanyard (not in proper position), but bottle not leaking; no water for salt (did not run out of water as thought because vent had been closed again)
7/1	105	Phosphate	3	a bit lo vs P and T
7/1	112	O2	2	rmk: hi vs P and pH; ok compared to CTDO, code 3. mcj: looks ok vs all other parameters, code 2.
7/1	113	O2	4	bottle o2 value high compared to CTDO, flask 13 calibration is suspect; flask removed from service after station 17. Code o2 bad.
7/1	117	Bottle	3	leaking (no samples drawn except for salt; CFCs/Helium/Tritium sampled from 118 instead)
7/1	119	Bottle	2	ran out of water for salt
7/1	121	O2	4	very hi vs P; outlier (high) compared to CTDO data
7/1	121	Refc.Temp.	3	SBE35RT high vs CTDT, unstable reading.
8/1	104	Silicate	3	lo vs P, code 3
8/1	111	Bottle	2	bottle at small salinity/CTDS maximum; o2, talk, pH, salinity, sf6 slightly hi; nutrients, dic, cfc11/12 low; probably all values ok.
8/1	111	Phosphate	2	rmk: po4 a bit low vs P, CTDO; mark 3. mcj: correlates with small salinity maximum, no3/sio3 also a bit low. value ok.
8/1	112	O2	4	bottle o2 value high compared to CTDO, flask 52 calibration is suspect; flask removed from service after station 17. Code o2 bad; rmk: o2 very high
8/1	117	Bottle	3	leaking (no samples drawn); bottle replaced after this cast due to repeated leaking.
9/1	102	Bottle	4	draw temperature high (O2), bottle possibly tripped at the surface; mcj: nutrients, oxygen low; salinity high - suspect mis-trip at shallower pressure. Code bottle as mis-trip.
9/1	102	CCl4	4	cfcs low, mis-trip.
9/1	102	CFC-11	4	cfcs low, mis-trip.
9/1	102	CFC-12	4	cfcs low, mis-trip.
9/1	102	DIC	4	dic low, mis-trip.
9/1	102	Nitrite	4	nutrients low, mis-trip.
9/1	102	Nitrate	4	nutrients low, mis-trip.
9/1	102	O2	4	o2 low, mis-trip.
9/1	102	fCO2	4	fCO2 low, mis-trip.
9/1	102	pH	4	pH low, mis-trip.
9/1	102	Phosphate	4	nutrients low, mis-trip.
9/1	102	Salinity	4	salinity high, mis-trip.
9/1	102	SF6	4	bottle mis-trip.
9/1	102	Silicate	4	nutrients low, mis-trip.
9/1	102	TAlk	4	alk low, mis-trip.
9/1	104	TAlk	3	alk low vs P; other parameters ok. code alkalinity bad.
9/1	106	Bottle	4	oxygen, nutrients, dic, alkalinity slightly low; salinity, pH slightly high, probable mis-trip near/at bottle 7 pressure.
9/1	106	CCl4	3	slightly low, mis-trip.
9/1	106	CFC-11	3	slightly low, mis-trip.
9/1	106	CFC-12	3	slightly low, mis-trip.
9/1	106	DIC	3	slightly low, mis-trip.
9/1	106	Nitrite	3	bottle mis-trip.
9/1	106	Nitrate	3	slightly low, mis-trip.
9/1	106	O2	3	slightly low, mis-trip.
9/1	106	fCO2	3	bottle mis-trip.
9/1	106	pH	3	slightly hi, mis-trip.
9/1	106	Phosphate	3	slightly low, mis-trip.
9/1	106	Salinity	3	slightly hi, mis-trip.
9/1	106	SF6	3	bottle mis-trip.
9/1	106	Silicate	3	slightly low, mis-trip.

Station/Cast	Sample No.	Property	Quality Code	Comment
9/1	106	TAlk	3	slightly low, mis-trip.
9/1	112	Bottle	4	Draw temperature high (O2), bottle possibly tripped at the surface
9/1	112	O2	4	bottle o2 value high compared to CTDO, flask 52 calibration is suspect; flask removed from service after station 17. Code o2 bad.
9/1	117	Bottle	9	not tripped this cast (lanyard of the neighboring bottle got hung up and prevented closing)
10/1	113	O2	4	bottle o2 value high compared to CTDO, flask 13 calibration is suspect; flask removed from service after station 17. Code o2 bad.
11/1	102	O2	4	flier; outlier (low) compared to CTDO
11/1	104	Bottle	9	Not tripped
11/1	106	Bottle	4	nutrients, oxygen slightly low; salinity high - mis-trip at/near bottle 8 pressure.
11/1	106	CCl4	4	cfcs low, probable mis-trip.
11/1	106	CFC-11	4	cfcs low, probable mis-trip.
11/1	106	CFC-12	4	cfcs low, probable mis-trip.
11/1	106	DIC	4	dic low; mis-trip.
11/1	106	Nitrite	4	nutrients slightly low; mis-trip.
11/1	106	Nitrate	4	nutrients slightly low; mis-trip.
11/1	106	O2	4	oxygen slightly low compared to CTDO; mis-trip.
11/1	106	fCO2	4	fCO2 low; mis-trip.
11/1	106	pH	4	ph high; mis-trip.
11/1	106	Phosphate	4	nutrients slightly low; mis-trip.
11/1	106	Salinity	4	salinity high compared to CTDS; mis-trip.
11/1	106	SF6	4	probable mis-trip.
11/1	106	Silicate	4	nutrients slightly low; mis-trip.
11/1	106	TAlk	4	talk low; mis-trip.
11/1	112	O2	4	bottle o2 value high compared to CTDO, flask 52 calibration is suspect; flask removed from service after station 17. Code o2 bad.
12/1	102	Bottle	2	ran out of water for nutrients/salt
12/1	113	O2	4	bottle o2 value high compared to CTDO, flask 13 calibration is suspect; flask removed from service after station 17. Code o2 bad.
13/1	113	O2	4	bottle o2 value high compared to CTDO, flask 13 calibration is suspect; flask removed from service after station 17. Code o2 bad.
13/1	119	Salinity	5	salt marked as sampled on sample log, but not reported.
13/1	120	pH	3	lo vs P, CTDS; code 3
14/1	104	Bottle	9	not tripped
14/1	106	Bottle	4	bad bottle based on multiple parameter values; code as mis-trip
14/1	106	DIC	4	outlier (low); mis-trip.
14/1	106	Nitrite	4	bottle mis-trip.
14/1	106	Nitrate	4	outlier (low); mis-trip.
14/1	106	O2	4	slightly low compared to CTDO; mis-trip.
14/1	106	pH	4	outlier (high); mis-trip.
14/1	106	Phosphate	4	outlier (low); mis-trip.
14/1	106	Salinity	4	outlier (high) compared to CTDS; mis-trip.
14/1	106	Silicate	4	outlier (low); mis-trip.
14/1	106	TAlk	4	outlier (low); mis-trip.
14/1	113	O2	4	bottle o2 value high compared to CTDO, flask 13 calibration is suspect; flask removed from service after station 17. Code o2 bad.
15/1	112	O2	4	bottle o2 value high compared to CTDO, flask 52 calibration is suspect; flask removed from service after station 17. Code o2 bad.
16/1	102	Bottle	9	not tripped
16/1	104	Bottle	9	not tripped
16/1	113	O2	4	bottle o2 value high compared to CTDO, flask 13 calibration is suspect; flask removed from service after station 17. Code o2 bad.
17/1	102	Bottle	4	lifted up by 3cm after previous cast to

Station/Cast	Sample No.	Property	Quality Code	Comment
				hopefully make it trip more reliably; draw temperature too high; mis-tripped (possibly tripped at surface)
17/1	102	CCl4	4	cfcs low, mis-tripped.
17/1	102	CFC-11	4	cfcs low, mis-tripped.
17/1	102	CFC-12	4	cfcs low, mis-tripped.
17/1	102	DIC	4	very low; mis-tripped.
17/1	102	Nitrite	4	very high; mis-tripped.
17/1	102	Nitrate	4	very low; mis-tripped.
17/1	102	O2	4	outlier (very high) compared to CTDO; mis-tripped.
17/1	102	pH	4	very high; mis-tripped.
17/1	102	Phosphate	4	very low; mis-tripped.
17/1	102	Salinity	4	outlier (very low) compared to CTDS; mis-tripped.
17/1	102	SF6	4	cfcs low, mis-tripped.
17/1	102	Silicate	4	very low; mis-tripped.
17/1	102	TAlk	4	very low; mis-tripped.
17/1	104	Bottle	2	lifted up by 3cm after the last cast to hopefully make it trip more reliably (repeated non-tripping before)
17/1	114	Bottle	2	ran out of water for salt
19/1	117	Bottle	4	o2 temp bit off, all parameters indicate mis-trip.
19/1	117	CFC-11	4	cfcs low, mis-trip.
19/1	117	CFC-12	4	cfcs low, mis-trip.
19/1	117	DIC	4	very hi vs P, mis-trip.
19/1	117	Nitrite	4	no2 low, mis-trip.
19/1	117	Nitrate	4	no3 high, mis-trip.
19/1	117	O2	4	very lo vs P,T; outlier (low) compared to CTDO, mis-trip.
19/1	117	fCO2	4	fCO2 high, mis-trip.
19/1	117	pH	4	very very lo vs P, mis-trip.
19/1	117	Phosphate	4	po4 high, mis-trip.
19/1	117	Salinity	4	outlier (high) compared to CTDS, mis-trip.
19/1	117	SF6	4	cfcs low, mis-trip.
19/1	117	Silicate	4	very hi vs P,S, mis-trip.
19/1	117	TAlk	4	very hi vs P,S, mis-trip.
20/1	106	Bottle	4	o2 temp a bit off and other parameters indicate mis-trip.
20/1	106	DIC	4	bottle mis-trip.
20/1	106	Nitrite	4	bottle mis-trip.
20/1	106	Nitrate	4	bottle mis-trip.
20/1	106	O2	4	outlier (low) compared to CTDO; mis-trip.
20/1	106	fCO2	4	bottle mis-trip.
20/1	106	pH	4	bottle mis-trip.
20/1	106	Phosphate	4	bottle mis-trip.
20/1	106	Salinity	4	outlier (low) compared to CTDS; mis-trip.
20/1	106	Silicate	4	bottle mis-trip.
20/1	106	TAlk	4	bottle mis-trip.
21/1	107	Bottle	2	rmk: probable mis-trip based on all parameters. mcj: see o2 comment, probably a real feature, code all parameters ok.
21/1	107	CCl4	2	outlier, probable mis-trip.
21/1	107	CFC-11	2	outlier, probable mis-trip.
21/1	107	CFC-12	2	outlier, probable mis-trip.
21/1	107	DIC	2	dic slightly high, see o2 comment.
21/1	107	Nitrite	2	nutrients slightly high, see o2 comment.
21/1	107	Nitrate	2	nutrients slightly high, see o2 comment.
21/1	107	O2	2	o2 seems low vs pressure, but correlates well with CTDO feature seen down and upcasts.
21/1	107	fCO2	2	fCO2 slightly high, see o2 comment.
21/1	107	pH	2	pH slightly low, see o2 comment.
21/1	107	Phosphate	2	nutrients slightly high, see o2 comment.
21/1	107	Salinity	2	salinity agrees well with CTDS.
21/1	107	SF6	2	outlier, probable mis-trip.
21/1	107	Silicate	2	nutrients slightly high, see o2 comment.

Station/Cast	Sample No.	Property	Quality Code	Comment
21/1	107	TAlk	2	talk ok, see o2 comment.
24/1	101	Salinity	5	salt marked as sampled on sample log, but not reported.
24/1	102	Bottle	9	not tripped (got stuck on a knot in the lanyard, CFCs took duplicate from 103 instead)
24/1	103	Salinity	5	salt marked as sampled on sample log, but not reported.
24/1	104	Bottle	9	not tripped (lanyard didn't come off hook)
24/1	109	Silicate	4	total flier
24/1	110	Bottle	9	not tripped (lanyard/hook got stuck on green part attached to frame that holds up transmissometer, CFCs took sample from 111 instead)
25/1	ALL		-	bottles 123-124 not used: very shallow cast.
25/1	102	Bottle	2	bottles 1/2 same trip depth, o2 drawn from bottle 1 only.
25/1	105	Bottle	2	bottles 4/5 same trip depth, o2 drawn from bottle 4 only.
25/1	109	O2	3	rmk: o2 low vs P, sio3; probable mis-trip or leak. mcj: bottles 9/10 tripped at same pressure, nuts, salt and ph from both bottles match. NOT a mis-trip.
25/1	110	Bottle	2	bottles 9/10 same trip depth, o2 drawn from bottle 9 only.
25/1	110	pH	2	rmk: pH low vs CTDS, flag 3. mcj: correlates with CTDO feature; bottles 9/10 salinity, nutrients, pH all agree (tripped at same pressure). value probably ok.
25/1	111	O2	4	rmk: o2 low vs P, sio3, probable mis-trip or leak. mcj: bottle data seem to align ok, not a mis-trip.
25/1	118	Bottle	2	bottles 17/18 same trip depth, o2 drawn from bottle 17 only.
25/1	122	Bottle	2	bottles 21/22 same trip depth, o2 drawn from bottle 21 only.
27/1	114	TAlk	3	alk low vs CTDS, P; other parameters ok. code alkalinity bad.
28/1	105	TAlk	3	alk low vs P; other parameters ok. code alkalinity bad.
28/1	121	O2	4	outlier (high) compared to CTDO as well as in an o2 section plot
31/1	107	O2	4	value extremely low vs other properties & compared to neighbors; outlier (low) compared to CTDO
31/1	110	O2	4	value very very low vs P,T,DIC, etc.; outlier (low) compared to CTDO
31/1	118	TAlk	3	value very hi vs S,T,no3,pH
31/1	123	Bottle	2	ran out of water for salt
33/1	104	Bottle	4	draw temperature too high, apparently tripped shallower; no samples drawn by pH/fCO2/DIC/Alk/C14/DOC
33/1	104	CCl4	4	cfcs slightly high, mis-trip.
33/1	104	CFC-11	4	cfcs slightly high, mis-trip.
33/1	104	CFC-12	4	cfcs slightly high, mis-trip.
33/1	104	Nitrite	4	nutrients low, mis-trip.
33/1	104	Nitrate	4	nutrients low, mis-trip.
33/1	104	O2	4	outlier (high) compared to CTDO. mis-trip.
33/1	104	Phosphate	4	nutrients low, mis-trip.
33/1	104	Salinity	4	outlier (high) compared to CTDS. mis-trip.
33/1	104	SF6	4	cfcs slightly high, mis-trip.
33/1	104	Silicate	4	nutrients low, mis-trip.
33/1	119	Bottle	9	lanyard did not release, no samples drawn
35/1	116	Bottle	2	upper hose clamp broke
36/1	104	Bottle	9	not tripped (hook came unlocked but did not release lanyard)
37/1	102	Bottle	2	upper hose clamp broke
37/1	106	Bottle	2	bubbles (helium)

Station /Cast	Sample No.	Property	Quality Code	Comment
37/1	112	Bottle	2	ran out of water for salt
37/1	114	Bottle	2	ran out of water for salt; bubbles (helium)
37/1	116	Bottle	2	ran out of water for salt
37/1	118	O2	2	ph accidentally sampled before o2
40/1	119	Bottle	2	o2, pH, CCl4 slightly low; cfcs, dic, fCO2 slightly high vs P, theta; ok, correlates with CTDO feature on down/upcasts and neighboring casts; bottle ok.
40/1	119	O2	3	value hi vs T,P,Si,Alk
40/1	119	Salinity	4	outlier (high) compared to CTDS; too big to correspond with feature seen in other parameters, possibly sampled from bottle 21 by mistake.
40/1	119	TAlk	2	TAlk low compared to neighboring casts vs P, theta; seems more out of line than other parameters in this CTDO feature. Re-check.
40/1	123	Refc.Temp.	3	SBE35RT high vs CTDT, unstable reading.
41/1	104	Bottle	9	lanyard did not release, no samples
41/1	109	Bottle	2	no water left for salt
41/1	118	O2	3	lo vs P,T,no3
42/1	122	Refc.Temp.	3	SBE35RT low vs CTDT, unstable reading.
43/1	117	O2	4	totally unrealistic; outlier (low) compared to CTDO as well as in an o2 section plot
44/1	106	Bottle	2	no water left for salt
44/1	120	Bottle	2	upper hose clamp broke on deck
45/1	102	Bottle	4	draw temperature could be ok or a bit hi. Bottle values indicate tripped about 300dbar shallower, near niskin 3.
45/1	102	CCl4	4	cfcs low, mis-trip.
45/1	102	CFC-11	4	cfcs low, mis-trip.
45/1	102	CFC-12	4	cfcs low, mis-trip.
45/1	102	DIC	4	dic low, mis-trip.
45/1	102	Nitrite	4	bottle mis-trip.
45/1	102	Nitrate	4	nutrients low, mis-trip.
45/1	102	O2	4	hi vs P,T; outlier (high) compared to CTDO, mis-trip.
45/1	102	fCO2	4	fCO2 low, mis-trip.
45/1	102	pH	4	pH slightly hi, mis-trip.
45/1	102	Phosphate	4	nutrients low, mis-trip.
45/1	102	Salinity	4	hi vs P,T; outlier (high) compared to CTDS, mis-trip.
45/1	102	SF6	4	cfcs low, mis-trip.
45/1	102	Silicate	4	nutrients low, mis-trip.
45/1	102	TAlk	4	bottle mis-trip.
45/1	117	Bottle	2	lower hose clamp broken.
47/1	123	Refc.Temp.	3	SBE35RT slightly high vs CTDT, unstable reading.
48/1	105	Bottle	2	upper hose clamp broke
49/1	114	Bottle	2	ran out of water for salt
49/1	116	Bottle	2	ran out of water for salt
49/1	117	CFC-11	2	rmk: cfcs low vs P, T and/or CTDS. mcj: correlates with sharp o2/CTDO minimum, values ok.
49/1	117	CFC-12	2	rmk: cfcs low vs P, T and/or CTDS. mcj: correlates with sharp o2/CTDO minimum, values ok.
49/1	117	SF6	2	rmk: cfcs low vs P, T and/or CTDS. mcj: correlates with sharp o2/CTDO minimum, values ok.
49/1	121	Bottle	2	ran out of water for salt
50/1	102	Salinity	3	outlier (high) compared to CTDS
50/1	117	Bottle	4	draw temperature relatively high for 116 or relatively low for 117; bottle 117 identified as the mis-trip when compared to CTD data.
50/1	117	DIC	4	dic slightly high, mis-trip.
50/1	117	Nitrite	4	no2 slightly high, mis-trip.
50/1	117	Nitrate	4	no3 slightly low, mis-trip.

Station/Cast	Sample No.	Property	Quality Code	Comment
50/1	117	O2	4	outlier (high) compared to CTDO as well as o2 section plot; draw temp low but o2 much further off than other parameters; suspect o2 problem in addition to mis-trip.
50/1	117	fCO2	4	fCO2 slightly low, mis-trip.
50/1	117	pH	4	pH slightly high, mis-trip.
50/1	117	Phosphate	4	po4 slightly low, mis-trip.
50/1	117	Salinity	4	outlier (high) compared to CTDS, mis-trip.
50/1	117	Silicate	4	sio3 slightly high, mis-trip.
50/1	117	TAlk	4	bottle mis-trip.
51/1	123	Refc.Temp.	3	SBE35RT low vs CTDT, unstable reading.
52/1	102	Bottle	9	not tripped, latch ok, but lanyard not released
53/1	116	pH	4	very very hi vs no3 and others, flier
54/1	103	TAlk	3	very lo vs P,S
54/1	106	Bottle	9	not tripped
54/1	107	Bottle	2	spigot replaced before cast
54/1	116	Bottle	2	spigot replaced before cast
54/1	118	Bottle	2	spigot replaced before cast
54/1	123	Refc.Temp.	3	SBE35RT low vs CTDT, unstable reading.
54/1	124	Bottle	2	spigot replaced before cast; O-ring replaced after cast before samples were drawn
55/1	102	pH	4	unreasonable value
55/1	110	Bottle	9	lower niskin cap hung up on trans. frame
56/1	102	Bottle	4	draw temperature too high, mis-tripped near surface. cfc, fCO2, dic, alk, nutrients not drawn.
56/1	102	O2	4	outlier (high) compared to CTDO, mis-trip.
56/1	102	pH	4	outlier (high), mis-trip.
56/1	102	Salinity	4	outlier (high) compared to CTDS, mis-trip.
56/1	113	TAlk	3	very hi vs P,S,pH, etc.
57/1	106	Bottle	2	bubbles (helium)
58/1	106	Bottle	4	draw temperature a bit high, all parameters indicate bottle mis-tripped near niskin 13 trip pressure.
58/1	106	CCl4	4	cfcs high, mis-trip.
58/1	106	CFC-11	4	cfcs high, mis-trip.
58/1	106	CFC-12	4	cfcs high, mis-trip.
58/1	106	DIC	4	dic high, mis-trip.
58/1	106	Nitrite	4	bottle mis-trip.
58/1	106	Nitrate	4	no3 high, mis-trip.
58/1	106	O2	4	outlier (low) compared to CTDO, mis-trip.
58/1	106	fCO2	4	fCO2 high, mis-trip.
58/1	106	pH	4	pH low, mis-trip.
58/1	106	Phosphate	4	po4 high, mis-trip.
58/1	106	Salinity	4	outlier (low) compared to CTDS, mis-trip.
58/1	106	SF6	4	cfcs high, mis-trip.
58/1	106	Silicate	4	sio3 low, mis-trip.
59/1	111	SF6	4	extremely hi vs P, other gases
59/1	119	O2	4	o2 high, probably bubbles in o2 titrant: apparently started running out earlier than bottles 22-23.
59/1	120	O2	4	o2 high, probably bubbles in o2 titrant: apparently started running out earlier than bottles 22-23.
59/1	121	O2	4	o2 high, probably bubbles in o2 titrant: apparently started running out earlier than bottles 22-23.
59/1	122	O2	5	o2 100+ umol/kg high, burette ran low on titrant.
59/1	123	O2	5	o2 100+ umol/kg high, burette ran low on titrant.
60/1	106	Bottle	9	not tripped (although lanyard released)
60/1	113	SF6	3	sf6 low vs P (f11/f12 rise slightly with other parameters at this bottle); flag 3.
61/1	101	Bottle	2	rosette was lowered again after this bottle was closed (from 2100db back to 2773db) because of bad wraps of wire on drum

Station/Cast	Sample No.	Property	Quality Code	Comment
61/1	102	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins. Rosette was lowered again after this bottle was closed (from 2100db back to 2773db) because of bad wraps of wire on drum
61/1	103	Bottle	2	rosette was lowered again after this bottle was closed (from 2100db back to 2773db) because of bad wraps of wire on drum
61/1	104	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins. Rosette was lowered again after this bottle was closed (from 2100db back to 2773db) because of bad wraps of wire on drum
61/1	105	Bottle	2	rosette was lowered again after this bottle was closed (from 2100db back to 2773db) because of bad wraps of wire on drum
61/1	106	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins. Rosette was lowered again after this bottle was closed (from 2100db back to 2773db) because of bad wraps of wire on drum
61/1	107	Bottle	2	rosette was lowered again after this bottle was closed (from 2100db back to 2773db) because of bad wraps of wire on drum
61/1	108	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins. Rosette was lowered again after this bottle was closed (from 2100db back to 2773db) because of bad wraps of wire on drum
61/1	110	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins
61/1	111	SF6	3	sf6 hi vs P,T (other cfcs show no change at this bottle); flag 3.
61/1	112	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins
61/1	113	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins
61/1	114	Bottle	2	draw temperature too high, possibly delayed trip; mcj: all parameters look ok, o2 and salinity agree well with CTD. Code bottle ok.
61/1	115	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins
61/1	116	Bottle	2	difficult to push the spigot
61/1	117	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins
61/1	118	Bottle	2	difficult to push the spigot
61/1	119	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins
61/1	121	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins
61/1	123	Bottle	2	all inner row bottles moved higher to improve angle of lanyards to carousel pins
62/1	116	O2	4	outlier (low) compared to CTDO
62/1	119	Bottle	2	spigot replaced before cast
62/1	121	Phosphate	3	very low vs pressure and neighbors
63/1	106	Salinity	4	outlier (high) compared to CTDS
63/1	118	O2	3	hi in all prop-prop plots
63/1	119	fCO2	2	rmk: hi in several prop-prop plots, code 3. mcj: min/max in other parameters, possibly ok. coded 2.
64/1	109	DIC	3	hi in prop-prop plots
65/1	104	Bottle	4	hi compared to CTDO, also vi hi vs neighbors and pressure
65/1	104	CCl4	4	bottle mis-trip.
65/1	104	CFC-11	4	bottle mis-trip.
65/1	104	CFC-12	4	bottle mis-trip.
65/1	104	DIC	4	outlier (low), mis-trip.

Station/Cast	Sample No.	Property	Quality Code	Comment
65/1	104	Nitrite	4	bottle mis-trip.
65/1	104	Nitrate	4	bottle mis-trip.
65/1	104	O2	4	outlier (high) compared to CTDO, neighbors and pressure; mis-trip.
65/1	104	fCO2	4	slightly hi, mis-trip.
65/1	104	pH	4	slightly low, mis-trip.
65/1	104	Phosphate	4	bottle mis-trip.
65/1	104	Salinity	4	outlier (low) compared to CTDS, mis-trip.
65/1	104	SF6	4	bottle mis-trip.
65/1	104	Silicate	4	outlier (low), mis-trip.
65/1	104	TAlk	4	outlier (low), mis-trip.
65/1	112	Bottle	2	bubbles (helium)
65/1	122	ctds	2	CTDS1 offsets 185db upcast to surface; use CTDS2 for bottles 122-124. CTDS acceptable now.
65/1	122	CTDS1	4	not in agreement with CTDS2 and bottle salinity + abrupt shift at ~195db
65/1	122	CTDS2	2	CTDS1 offsets 185db upcast to surface; use CTDS2 for bottles 122-124. CTDS acceptable now.
65/1	123	ctds	2	CTDS1 offsets 185db upcast to surface; use CTDS2 for bottles 122-124. CTDS acceptable now.
65/1	123	CTDS1	4	not in agreement with CTDS2 and bottle salinity + abrupt shift at ~195db
65/1	123	CTDS2	2	CTDS1 offsets 185db upcast to surface; use CTDS2 for bottles 122-124. CTDS acceptable now.
65/1	124	ctds	2	CTDS1 offsets 185db upcast to surface; use CTDS2 for bottles 122-124. CTDS acceptable now.
65/1	124	CTDS1	4	not in agreement with CTDS2 and bottle salinity + abrupt shift at ~195db
65/1	124	CTDS2	2	CTDS1 offsets 185db upcast to surface; use CTDS2 for bottles 122-124. CTDS acceptable now.
66/1	ALL		-	upcast took 3 hours (winch slowed down)
66/1	104	SF6	4	very very hi vs P, unreal
66/1	123	Refc.Temp.	3	SBE35RT low vs CTDT, unstable reading.
67/1	104	Bottle	2	rosette was lowered again after bottle 104 was closed (from 4335db back to 4430db) because of bad wraps of wire on drum
68/1	101	Salinity	3	outlier (high) compared to CTDS
68/1	112	TAlk	3	analysis low compared to other parameters and neighbors
68/1	122	Salinity	3	hi vs other parameters appears to be mis-sampled from bottle 23; outlier (high) compared to CTDS, agree that it appears to have been flipped with 123
68/1	123	Salinity	3	hi vs other parameters appears to be mis-sampled from bottle 22; outlier (low) compared to CTDS, agree that it appears to have been flipped with 122
70/1	113	Bottle	2	vent not closed during cast
70/1	114	Bottle	2	vent not closed during cast
70/1	115	Bottle	2	vent not closed during cast
70/1	116	Bottle	2	vent not closed during cast
70/1	117	Bottle	2	vent not closed during cast
70/1	118	Bottle	2	vent not closed during cast
70/1	119	Bottle	2	vent not closed during cast
70/1	120	Bottle	2	vent not closed during cast
70/1	121	Bottle	2	vent not closed during cast
70/1	122	Bottle	2	vent not closed during cast
70/1	123	Bottle	2	vent not closed during cast
70/1	123	TAlk	3	very very lo vs CTDS; other parameters ok. code alkalinity bad.
70/1	124	Bottle	2	vent not closed during cast
72/1	ALL		-	bottles 11-12 triggered at 1600db: no confirmation from carousel; cast restarted as number 2, still no trips. bottles 13-24 not tripped: cast was taken back on deck after failed confirmations. merged 2 parts of cast 1 together after cast.

Station/Cast	Sample No.	Property	Quality Code	Comment
72/1	101	TAlk	3	rmk: bottles 1-10 TAlk low vs P, and vs nearby casts. mcj: theta-TAlk plot of stations 71-73 shows 1,4,10 low; 3,9 also somewhat low. flag 1, 4, 10 questionable.
72/1	103	TAlk	2	rmk: bottles 1-10 TAlk low vs P, and vs nearby casts. mcj: theta-TAlk plot of stations 71-73 shows 1,4,10 low; 3,9 also somewhat low. flag 1, 4, 10 questionable.
72/1	104	TAlk	3	rmk: bottles 1-10 TAlk low vs P, and vs nearby casts. mcj: theta-TAlk plot of stations 71-73 shows 1,4,10 low; 3,9 also somewhat low. flag 1, 4, 10 questionable.
72/1	107	Salinity	3	outlier (high) compared to CTDS
72/1	109	TAlk	2	rmk: bottles 1-10 TAlk low vs P, and vs nearby casts. mcj: theta-TAlk plot of stations 71-73 shows 1,4,10 low; 3,9 also somewhat low. flag 1, 4, 10 questionable.
72/1	110	TAlk	3	rmk: bottles 1-10 TAlk low vs P, and vs nearby casts. mcj: theta-TAlk plot of stations 71-73 shows 1,4,10 low; 3,9 also somewhat low. flag 1, 4, 10 questionable.
72/3	300	Bottle	2	another cast numbered 3 to cover the upper profile; CTD replaced (now #209)
72/3	301	Bottle	2	after 306 tripped rosette was taken from 780db back to 1500db because of wire problems
72/3	302	Bottle	2	after 306 tripped rosette was taken from 780db back to 1500db because of wire problems
72/3	303	Bottle	2	after 306 tripped rosette was taken from 780db back to 1500db because of wire problems
72/3	304	Bottle	2	after 306 tripped rosette was taken from 780db back to 1500db because of wire problems
72/3	305	Bottle	2	after 306 tripped rosette was taken from 780db back to 1500db because of wire problems
72/3	306	Bottle	2	after 306 tripped rosette was taken from 780db back to 1500db because of wire problems
73/1	114	Bottle	2	ran out of water for salt
73/1	116	Bottle	2	ran out of water for salt
73/1	118	Bottle	2	ran out of water for tritium/nutrients/salt
73/1	119	Bottle	2	ran out of water for nutrients/salt; bubbles (tritium)
74/1	103	O2	4	outlier vs pressure and vs CTD value
76/1	102	O2	3	outlier (low) vs pressure/CTDO
77/1	106	SF6	3	very high vs T, P
78/1	102	SF6	3	very high vs T, P
78/1	111	Bottle	9	spigot broke when CFCs started to sample, replaced right away. No samples drawn.
79/1	ALL		-	enter key was apparently left depressed after bottle 1 was tripped; all bottles apparently triggered at the bottom approximately 1 second apart. Restarted upcast as cast 2, later merged with downcast as cast 1.
79/1	101	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	101	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	101	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	101	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	101	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	101	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	101	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	102	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.

Station /Cast	Sample No.	Property	Quality Code	Comment
79/1	102	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	102	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	102	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	102	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	102	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	103	Bottle	4	o2 very low, salt very high vs CTD; niskin likely closed later than other bottles: mis-trip.
79/1	103	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	103	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	103	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	103	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	103	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	103	O2	4	o2 very low vs CTDO; niskin likely closed later than other bottles; mis-trip.
79/1	103	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	103	Salinity	4	salt very high vs CTDS; niskin likely closed later than other bottles; mis-trip.
79/1	103	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	103	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	104	Bottle	9	bottle 4 did not close.
79/1	105	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	105	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	105	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	105	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	105	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	105	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	105	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	105	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	105	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	105	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	105	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	106	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	106	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	106	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	106	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	106	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	106	Nitrite	9	samples collected but not analyzed due to

Station /Cast	Sample No.	Property	Quality Code	Comment
				tripping uncertainty.
79/1	106	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	106	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	106	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	106	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	106	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	107	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	107	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	108	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	108	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	109	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.

Station/Cast	Sample No.	Property	Quality Code	Comment
79/1	109	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	109	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	110	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	110	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	111	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	111	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	Bottle	4	o2 and salt values indicate all bottles but 3

Station/Cast	Sample No.	Property	Quality Code	Comment
				and 4 tripped at bottom of cast.
79/1	112	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	112	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	113	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	113	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	114	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	fCO2	9	samples collected but not analyzed due to tripping uncertainty.

Station /Cast	Sample No.	Property	Quality Code	Comment
79/1	114	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	114	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	115	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	115	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	116	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	116	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	117	Bottle	4	ran out of water for nutrients/salt; most likely tripped at the bottom like other bottles.
79/1	117	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	117	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.

Station/Cast	Sample No.	Property	Quality Code	Comment
79/1	117	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	117	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	117	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	117	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	117	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	117	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	118	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	118	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	119	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	119	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	120	CCl4	9	samples collected but not analyzed due to

Station/Cast	Sample No.	Property	Quality Code	Comment
				tripping uncertainty.
79/1	120	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	120	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	121	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	121	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	122	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	SF6	9	samples collected but not analyzed due to tripping uncertainty.

Station/Cast	Sample No.	Property	Quality Code	Comment
79/1	122	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	122	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	123	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	123	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	Bottle	4	o2 and salt values indicate all bottles but 3 and 4 tripped at bottom of cast.
79/1	124	CCl4	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	CFC-11	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	CFC-12	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	DIC	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	Nitrite	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	Nitrate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	fCO2	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	pH	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	Phosphate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	SF6	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	Silicate	9	samples collected but not analyzed due to tripping uncertainty.
79/1	124	TAlk	9	samples collected but not analyzed due to tripping uncertainty.
79/3	300	Bottle	2	return to station 79 and do a full cast numbered 3; bottle 4 did not close.
79/3	304	Bottle	9	bottle 4 did not close
80/1	104	Bottle	2	raised by another 2.54 cm after last cast
81/1	109	SF6	3	outlier relative to adjacent samples
81/1	111	SF6	3	outlier relative to adjacent samples
82/1	103	Bottle	9	bottle 3 did not close, reason unknown.
82/1	105	Bottle	2	cfcs, o2, pH, DIC show local minimum at this bottle; fCO2, salinity slight maximum; nuts slightly off; possible mis-trip, or ok?
82/1	105	O2	3	bottle o2 slightly low compared to CTDO, down

Station/Cast	Sample No.	Property	Quality Code	Comment
				or upcast.
82/1	105	Salinity	3	salinity slightly high compared to CTDS, down or upcast.
82/1	113	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/1	114	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/1	115	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/1	116	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/1	117	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/1	118	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/1	119	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/1	120	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/1	121	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/1	122	Bottle	9	bottle 122 destroyed by bottle 23 implosion
82/1	123	Bottle	9	apparently tripped in air on the way in, imploded at depth (inner spring compressed): destroyed bottle 22, parts of bottle 23 prevented the other bottles from tripping; bottles 22/23 replaced after cast.
82/1	124	Bottle	9	bottles 13-24 did not close: piece of bottle 23 cap lodged under trip levers.
82/2	200	Bottle	2	second cast to cover the upper profile of station 82
82/2	205	Bottle	4	draw temperature too high, bottle mis-tripped based on o2, salt, other parameters. pco2, talk, dic not sampled.
82/2	205	CCl4	4	cfcs high, mis-trip.
82/2	205	CFC-11	4	cfcs high, mis-trip.
82/2	205	CFC-12	4	cfcs high, mis-trip.
82/2	205	Nitrite	4	bottle mis-trip.
82/2	205	Nitrate	4	no3 high, mis-trip.
82/2	205	O2	4	outlier (low) compared to CTDO, mis-trip.
82/2	205	pH	4	pH very low, mis-trip.
82/2	205	Phosphate	4	po4 high, mis-trip.
82/2	205	Salinity	4	outlier (high) compared to CTDS
82/2	205	SF6	4	cfcs high, mis-trip.
82/2	205	Silicate	4	sio3 low, mis-trip.
82/2	216	Bottle	2	draw temperature high but salt/o2 ok compared to CTDS/CTDO.
83/1	102	Bottle	9	pin did not fully release bottle
83/1	114	CFC-12	3	outlier vs T, P
83/1	119	Bottle	9	pin did not fully release bottle
83/1	122	Bottle	2	tripped the same depth as 121
84/1	105	Bottle	4	draw temperature too high; parameters indicate bottle mis-tripped. pH, pco2, talk, dic not sampled.
84/1	105	CCl4	4	cfcs high, mis-trip.
84/1	105	CFC-11	4	cfcs high, mis-trip.
84/1	105	CFC-12	4	cfcs high, mis-trip.
84/1	105	Nitrite	4	bottle mis-trip.
84/1	105	Nitrate	4	no3 high, mis-trip.
84/1	105	O2	4	outlier (very low) compared to CTDO, mis-trip.
84/1	105	Phosphate	4	po4 high, mis-trip.
84/1	105	Salinity	4	outlier (very low) compared to CTDS, mis-trip.
84/1	105	SF6	4	cfcs high, mis-trip.
84/1	105	Silicate	4	sio3 low, mis-trip.
84/1	114	SF6	4	very very high relative to neighbors
85/1	103	O2	3	outlier (high) compared to CTDO
85/1	109	Salinity	4	hi compared to CTDS and to neighboring stations

Station/Cast	Sample No.	Property	Quality Code	Comment
88/1	110	Bottle	2	adjusted (height/direction) to make spigot better accessible
89/1	111	SF6	3	hi vs pressure and cfc12
89/1	113	O2	4	outlier (high) compared to CTDO; rmk: hi vs NO3, Si, PO4, sigma
90/1	113	SF6	3	hi vs pressure and cfc12
91/1	122	DIC	3	rmk: dic anomalous vs P, CTDO, pH by a fair bit, flag 3. mcj: aligns with CTDO feature, other properties also unusual. rmk: but dic is a bit too far off. flagged questionable.
93/1	101	Bottle	2	vent was not closed, o2 sample not drawn
94/1	108	Bottle	3	draw temperature high
96/1	ALL		-	altimeter cleaned and reseated cable connector on altimeter
97/1	121	Bottle	2	raised to the same height as the inner bottles
98/1	103	O2	3	slightly high (4300db)
98/1	118	SF6	3	lo vs adjacent stations and in comparison to other cfc and ccl4
99/1	105	TAlk	4	flier - TAlk very, very low.
100/1	116	CCl4	3	hi vs neighbors and in ratio to other cfcs and sf6
101/1	101	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	102	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	103	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	104	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	105	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	106	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	107	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	108	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	109	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	110	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	111	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	111	SF6	3	sf6 high vs P (f11/f12 drop slightly with other parameters at this bottle); flag 3.
101/1	112	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	113	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	114	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	115	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	116	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	117	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	118	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	119	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	120	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	121	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	122	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)

Station/Cast	Sample No.	Property	Quality Code	Comment
101/1	123	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
101/1	124	Nitrate	4	chemistry problem with nuts. All nitrate bad (low)
103/1	105	Bottle	4	based on chem.evidence, bottle mis-tripped.
103/1	105	CCl4	4	bottle mis-trip.
103/1	105	CFC-11	4	bottle mis-trip.
103/1	105	CFC-12	4	bottle mis-trip.
103/1	105	DIC	4	outlier (low) vs pressure and others, mis-trip.
103/1	105	Nitrite	4	bottle mis-trip.
103/1	105	Nitrate	4	slightly low, mis-trip.
103/1	105	O2	4	outlier (low) compared to CTDO, mis-trip.
103/1	105	fCO2	4	slightly low, mis-trip.
103/1	105	pH	4	slightly low, mis-trip.
103/1	105	Phosphate	4	slightly low, mis-trip.
103/1	105	Salinity	4	outlier (high) compared to CTDS, mis-trip.
103/1	105	SF6	4	bottle mis-trip.
103/1	105	Silicate	4	outlier (low) vs pressure and others, mis-trip.
103/1	105	TAlk	4	outlier (low) vs pressure and others, mis-trip.
104/1	123	Refc.Temp.	3	SBE35RT high vs CTDT, unstable reading.
105/1	102	pH	3	hi compared to neighbors in pressure space
106/1	105	Bottle	4	draw temperature very high, mis-trip (surface trip); only cfc, helium, nuts, salinity sampled.
106/1	105	CCl4	4	outlier, mis-trip.
106/1	105	CFC-11	4	outlier, mis-trip.
106/1	105	CFC-12	4	outlier, mis-trip.
106/1	105	Nitrite	4	bottle mis-trip.
106/1	105	Nitrate	4	outlier vs p with neighbors, mis-trip.
106/1	105	Phosphate	4	outlier vs p with neighbors, mis-trip.
106/1	105	Salinity	4	outlier (high) compared to CTDS, mis-trip.
106/1	105	SF6	4	outlier, mis-trip.
106/1	105	Silicate	4	outlier vs p with neighbors, mis-trip.
106/1	119	Bottle	4	draw temperature high, o2 and salt high vs CTD, nuts low, cfcs hi; mis-trip.
106/1	119	CCl4	4	outlier, mis-trip.
106/1	119	CFC-11	4	outlier, mis-trip.
106/1	119	CFC-12	4	outlier, mis-trip.
106/1	119	DIC	4	outlier (low), mis-trip.
106/1	119	Nitrite	4	outlier (high), mis-trip.
106/1	119	Nitrate	4	outlier (low), mis-trip.
106/1	119	O2	4	outlier (high) compared to CTDO, mis-trip.
106/1	119	fCO2	4	outlier (low), mis-trip.
106/1	119	pH	4	outlier (high), mis-trip.
106/1	119	Phosphate	4	outlier (low), mis-trip.
106/1	119	Salinity	4	outlier (high) compared to CTDS, mis-trip.
106/1	119	SF6	4	outlier, mis-trip.
106/1	119	Silicate	4	outlier (low), mis-trip.
106/1	119	TAlk	4	outlier (high), mis-trip.
107/1	105	Bottle	2	raised before this cast
107/1	106	pH	3	hi vs pressure relative to neighboring samples and stations
107/1	111	Bottle	2	draw temperature high
107/1	114	Refc.Temp.	3	SBE35RT very high vs CTDT
107/1	121	Bottle	2	draw temperature very high. pH, pco2, dic, talk not sampled. o2, salinity agree well with CTD, other parameters also ok. code bottle ok.
108/1	102	Bottle	2	raised 1 inch before this cast
108/1	104	Bottle	9	not tripped (trigger released but lanyard not)
108/1	123	Refc.Temp.	3	SBE35RT high vs CTDT, unstable reading.
109/1	102	SF6	4	very very hi vs pressure and ccl4, unrealistic
110/1	104	Salinity	3	a bit high compared to CTDS, low vs pot T
111/1	104	Bottle	4	draw temperature high; cfcs, pH, pco2, dic, talk not sampled. o2, salinity, nutrients indicate mis-trip.
111/1	104	Nitrite	4	bottle mis-trip.
111/1	104	Nitrate	4	outlier (high), mis-trip.

Station/Cast	Sample No.	Property	Quality Code	Comment
111/1	104	O2	4	outlier (low) compared to CTDO, mis-trip.
111/1	104	Phosphate	4	outlier (high), mis-trip.
111/1	104	Salinity	4	outlier (low) compared to CTDS, mis-trip.
111/1	104	Silicate	4	outlier (low) vs pressure, bulls-eye on section plot; mis-trip.
112/1	103	CFC-12	4	very very hi and high in ratio
112/1	103	SF6	4	very very hi
112/1	105	TAlk	3	lo vs pressure and salt compared to adjacent and neighbors
112/1	106	CFC-12	4	very very hi and high in ratios
112/1	106	SF6	4	very very hi in profile
112/1	116	SF6	4	very very hi in profile
113/1	104	Bottle	4	all parameters indicate mis-trip.
113/1	104	DIC	4	outlier (low), mis-trip.
113/1	104	Nitrite	4	bottle mis-trip.
113/1	104	Nitrate	4	outlier (low), mis-trip.
113/1	104	O2	4	slightly low compared to CTDO; mis-trip.
113/1	104	pH	4	outlier (high), mis-trip.
113/1	104	Phosphate	4	outlier (low), mis-trip.
113/1	104	Salinity	4	outlier (high) compared to CTDS; mis-trip.
113/1	104	Silicate	4	very very low vs pressure, neighbors and section plot; mis-trip.
113/1	104	TAlk	4	outlier (low), mis-trip.
114/1	108	Salinity	4	lo vs CTD and pressure relative to other data
115/1	118	Bottle	2	no water left for salt sample.
115/1	118	CFC-11	4	unrealistic value (low)
116/1	ALL		-	no software confirmations at first three bottle stops, two trip attempts each; fired second try from deck unit for 2nd and 3rd levels from bottom, and ONLY from deck unit for next 18 bottles; bottles 21-24 did not close.
118/1	102	Salinity	3	low compared to CTDS
119/1	102	Salinity	3	high compared to CTDS
119/1	105	Phosphate	3	hi vs pressure and redfield off significantly. no3 ok
119/1	112	O2	4	very low (1350db)
120/1	101	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	102	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	103	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	104	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	105	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	106	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	107	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	108	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	109	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	110	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	111	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	112	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	113	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	114	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	115	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	116	Silicate	3	entire cast high by about 4% (deep water) or 2

Station /Cast	Sample No.	Property	Quality Code	Comment
				umol/kg
120/1	117	Bottle	2	o-ring replaced before sampling
120/1	117	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	118	Bottle	2	rmk: bad bottle? anomalous in various property-property plots, including pressure. mcj: bottle is in a distinct feature/rise (down-/up-cast CTDO maximum from approx. 400-460dbar). o2 agrees with CTDO. Re-code sio3, cfcs from 3 to 2.
120/1	118	CCl4	2	CTDO shows a distinct feature/rise here, cfcs are probably ok.
120/1	118	CFC-11	2	CTDO shows a distinct feature/rise here, cfcs are probably ok.
120/1	118	CFC-12	2	CTDO shows a distinct feature/rise here, cfcs are probably ok.
120/1	118	O2	2	o2 agrees with down-/up-cast CTDO, bottle taken in middle of a distinct CTDO feature/rise.
120/1	118	pH	2	rmk: pH for 18 a bit hi vs CTDS, pH for 19 a bit low vs CTDS; looks as if samples collected backward, flag 3. mcj: bottle 18 aligns with CTDO feature, flag both ok.
120/1	118	SF6	2	CTDO shows a distinct feature/rise here, cfcs are probably ok.
120/1	118	Silicate	2	CTDO shows a distinct feature/rise here, sio3 is probably ok.
120/1	119	pH	2	rmk: pH for 18 a bit hi vs CTDS, pH for 19 a bit low vs CTDS; looks as if samples collected backward, flag 3. mcj: bottle 18 aligns with CTDO feature, flag both ok.
120/1	119	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	120	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	121	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	122	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	123	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
120/1	124	Silicate	3	entire cast high by about 4% (deep water) or 2 umol/kg
121/1	102	Bottle	4	draw temperature high; pco2, dic, talk, nuts not sampled.
121/1	102	CCl4	4	cfcs high, mis-trip.
121/1	102	CFC-11	4	cfcs high, mis-trip.
121/1	102	CFC-12	4	cfcs high, mis-trip.
121/1	102	O2	4	outlier (very low) compared to CTDO; mis-trip.
121/1	102	pH	4	outlier (very low), mis-trip.
121/1	102	Salinity	4	outlier (high) compared to CTDS; mis-trip.
121/1	102	SF6	4	cfcs high, mis-trip.
121/1	111	Bottle	2	dripping, possibly leaking; all parameters seem ok, bottle ok.
122/1	102	Bottle	2	raised by 1.5 inches prior to cast
122/1	104	Bottle	9	not tripped
123/1	104	Bottle	4	draw temperature high; only o2, cfcs sampled. o2 indicates bottle mis-tripped.
123/1	104	O2	4	outlier (low) compared to CTDO; mis-trip.
123/1	110	Bottle	2	draw temperature a little bit high
124/1	108	O2	4	outlier (low) compared to CTDO
124/1	109	O2	4	outlier (low) compared to CTDO
124/1	123	Salinity	3	salt hi vs CTDS; high gradient
125/1	102	Bottle	4	multiple parameters slightly off, similar to bottle 3 values. probable mis-trip.
125/1	102	CCl4	4	bottle mis-trip.
125/1	102	CFC-11	4	bottle mis-trip.
125/1	102	CFC-12	4	bottle mis-trip.

Station /Cast	Sample No.	Property	Quality Code	Comment
125/1	102	DIC	4	dic slightly low, similar to niskin 3 value; mis-trip.
125/1	102	Nitrite	4	bottle mis-trip.
125/1	102	Nitrate	4	nutrients slightly low, similar to niskin 3 value; mis-trip.
125/1	102	O2	4	o2 similar to niskin 3 value; mis-trip.
125/1	102	pH	4	similar to niskin 3 value; mis-trip.
125/1	102	Phosphate	4	nutrients slightly low, similar to niskin 3 value; mis-trip.
125/1	102	Salinity	4	salinity slightly high vs CTDS, similar to niskin 3 value; mis-trip.
125/1	102	SF6	4	bottle mis-trip.
125/1	102	Silicate	4	nutrients slightly low similar to niskin 3 value; mis-trip.
125/1	102	TAlk	4	alk low, lower than bottle 3; mis-trip.
126/1	102	Bottle	2	spigot fixed
126/1	104	Bottle	4	multiple outliers, most parameters similar to bottle 6 values instead of bottle 5 (tripped at same pressure); mis-trip.
126/1	104	Nitrite	4	bottle mis-trip.
126/1	104	Nitrate	4	outlier (high), mis-trip.
126/1	104	O2	4	outlier (low) compared to CTDO, mis-trip.
126/1	104	pH	4	outlier (low), mis-trip.
126/1	104	Phosphate	4	outlier (high), mis-trip.
126/1	104	Salinity	4	outlier (low) compared to CTDS, mis-trip.
126/1	104	Silicate	4	outlier (low), mis-trip.
126/1	104	TAlk	4	outlier (low), mis-trip.
126/1	114	O2	4	outlier (low) compared to CTDO
126/1	123	Salinity	3	salt hi vs CTDS; high gradient
126/1	123	TAlk	3	hi vs P, CTDS
127/1	118	Refc.Temp.	3	SBE35RT slightly low vs CTDT, unstable reading.
127/1	123	Salinity	4	salt very hi vs CTDS
129/1	117	Bottle	2	rmk: nutrient data apparently assigned to niskins backwards. mcj: data re-assigned to correct bottles by analyst, silicate now increases with depth; ok now.
129/1	118	Bottle	2	rmk: nutrient data apparently assigned to niskins backwards. mcj: data re-assigned to correct bottles by analyst, silicate now increases with depth; ok now.
129/1	119	Bottle	2	rmk: nutrient data apparently assigned to niskins backwards. mcj: data re-assigned to correct bottles by analyst, silicate now increases with depth; ok now.
129/1	119	Refc.Temp.	3	SBE35RT very low vs CTDT
129/1	120	Bottle	2	rmk: nutrient data apparently assigned to niskins backwards. mcj: data re-assigned to correct bottles by analyst, silicate now increases with depth; ok now.
129/1	121	Bottle	2	rmk: nutrient data apparently assigned to niskins backwards. mcj: data re-assigned to correct bottles by analyst, silicate now increases with depth; ok now.
129/1	122	Bottle	2	rmk: nutrient data apparently assigned to niskins backwards. mcj: data re-assigned to correct bottles by analyst, silicate now increases with depth; ok now.
129/1	123	Bottle	2	rmk: nutrient data apparently assigned to niskins backwards. mcj: data re-assigned to correct bottles by analyst, silicate now increases with depth; ok now.
129/1	123	Salinity	3	salt hi vs CTDS; high gradient
129/1	124	Bottle	2	rmk: nutrient data apparently assigned to niskins backwards. mcj: data re-assigned to correct bottles by analyst, silicate now increases with depth; ok now.

Data Processing Notes

Date	Person	Data Type	Action	Summary
2010-03-09	Steve Diggs	Metadata/Docs		Expocode Updated
	Expedition code now reflects accurate port departure date.from Robert Key Tue, Mar 9, 2010 at 11:58 We sailed on Mon around 14:00L. Current location 38d52mS x 15d0mE, heading SSW to first station at 54Sx0W. Test station tomorrow at noon local. Current time 20:57 local			
2010-05-18	Kristy McTaggart	CTDO	Submitted	to go online (woce format)
	Date: 2010-03-08 Action: Place Online Notes: Preliminary CTDO profiles in the old WOCE format.			
2010-05-19	Kristy McTaggart	SUM	Submitted	to go online
	Date: 2010-03-08 Action: Place Online Notes: .SUM file from CTDO cast logs for use with preliminary profile data.			
2010-05-27	Carolina Berys	CTDO	Website Update	online under "Updates"
	The following submission has been put online under "Updates" for A13.5 33RO20100308. a13_prelim_ctdo.zip submitted on 2010-05-18 by Kristy McTaggart. Notes: Preliminary CTDO profiles in the old WOCE format.			
2010-05-27	Carolina Berys	SUM	Website Update	online under "Updates"
	The following submission has been put online under "Updates" for A13.5 33RO20100308. rh110.sum submitted on 2010-05-19 by Kristy McTaggert. Notes: SUM file from CTDO cast logs for use with preliminary profile data.			
2010-06-02	Kristy McTaggart	CTDO	Submitted	updates to go online
	Action: Place Online Notes: Replace those profiles online in the Updates section with these 29 newly despiked profiles.			
2010-06-02	Mary C. Johnson	BTL	Submitted	Preliminary data to go online
	Action: Place Online Notes: Preliminary A13.5 bottle data with SIO/STS/ODF preliminary data in CTDO fields (3 files - .sea, .sum, _hy1.csv - in one zipped file).			
2010-06-02	Mary C. Johnson	Cruise Report	Submitted	Preliminary
	Action: Place Online Notes: Preliminary documentation for A13.5 CTD and bottle data, minus narrative (19 files, numbered to reflect sequence in combined documentation, in a single zipped file)			
2010-06-21	Danie Bartolocci	BTL	Website Update	Preliminary Data online
	20100611 DBK Reformatting notes for a13.5 sum, woce and exchange bottle files. SUM: As per Mary Johnson, edited UNC DEPTH to COR DEPTH. Ran sumchk with no errors. Added header and WHP-ID. Renamed a13.5_33RO20100308su.txt. WOCE HYD: Added name/date stamp. Edited: DEG_C to DEG C UATM@T to UATM Ran wctcvt, which did not recognize the following parameters: CCL4, PCO2, PCO2TMP, PH_TOT, PH_TMP, SF6, DOC, TDN, REFTMP It also indicated that there was a mismatch between asterisked columns and total quality bytes, however this is not the case. This could be because it does not recognize all the parameters.			

Date	Person	Data Type	Action	Summary
	In order to confirm, I converted the woce file into exchange and format checked the resultant exchange file with copy_bottle_data.rb. The file converted without error. Therefore the formatted WOCE file was used. Renamed a13.5_33RO20100308hy.txt EXCHANGE HYD: Edited: DEG_C to DEG C UATM@T to UATM REFTEMP to REFTMP M to METERS DBARS to DBAR Added DBAR to CTDRAW units Ran file through copy_bottle_data.rb to re-order parameters according to the CCHDO preferred order list. Added previous/original stamp back into file. Renamed a13.5_33RO20100308_hy1.csv NETCDF: Created netCDF files from exchange file with no errors. These files opened in JOA, however viewing data within JOA was problematic. This is believed to be a bug in JOA and not an error in netCDF format. A ncdump of the file to the screen, shows correct formatting. Therefore, the files were zipped together and placed online. File is a13.5_33RO20100308_nc_hyd.zip Ran update script and sent notes file to Jerry.			
2010-06-21	Danie Bartolocci	CTD	Website Update	Preliminary Data under "Updates"
	I have placed the updated CTD files sent by Kristy McTaggert on 2010.06.02 in to the queue directory for this cruise. They are in WOCE format at this time and currently contain transmissometer data in voltages. Kristy indicated that Wilf requested this as well as the calibration voltages and will at some point convert them to percent transmission numbers.			
2010-06-04	Mary C. Johnson	BTL	Submitted	header correction
	Action: Updated Parameters Notes: Updated documentation file. Final residual plots should replace figures 1-4.			
2010-09-16	Kristy McTaggart	CTDOXY	Submitted	Final data & flags, exchange format
	Action: Place Online Notes: Final CTDO profiles in Exchange format. Action: Updated Parameters Notes: Final calibrated CTDO discrete data and sample salinity flags to overwrite in .SEA file.			
2010-09-16	Kristy McTaggart	CTDOXY Report	Submitted	To Update online report
	Action: Updated Parameters Notes: Updated documentation file. Final residual plots should replace figures 1-4.			
2010-10-07	Carolina Berys	BTL	Website Update	online 'as received'
	Data file a13_all_tso_flags_shortk.zip is now available online in the 'as received' section and will be placed in the regular data area shortly.			
2010-10-07	Kristy McTaggart	BTL	Submitted	CTDSAL, CTDOXY flags updated
	Attached is an abbreviated .SEA file that should replace the one submitted on 9/16/2010. CTDSAL and CTDOXY flags were recently amended and should be overwritten in the final .SEA file posted. No other variables were changed.			
2010-10-19	Alex Kozyr	DIC/TCARBN	Submitted	Final data to go online
	Action: Merge Data, Place Online Notes: The final and public DIC (TCARBN) data was received by CDIAC from R. Feely and Rik Wanninkhof. Please, merge the data.			
2010-10-20	Alex Kozyr	DOC/TDN	Website Update	Available under 'Updates'
	File A13_5_DOC_TDN.csv containing DOC/TDN data submitted by Alex Kozyr on 2010-10-20, available under 'as received', unprocessed by CCHDO.			

Date	Person	Data Type	Action	Summary
2010-10-20	Justin Fields	CTDOXY	Website Update	Data online
	• Used the 20101007 bottle data submitted by Kristy McTaggert and the current online sumfile to create an exchange format version of the submission. • Checked submission file and compared it with our current file. No problems found. • The following parameters have now been updated: OXYGEN_FLAG, SALNTY_FLAG, THETA, CTDOXY, CTDOXY_FLAG, CTDSAL, CTDSAL_FLAG, CTDRAW, CTDTMP, CTDPRS. • Double checked the merge using the bottle compare tool, everything looked good. • Added a listing of all of the data PIs that were noted in the cruise doc. • Converted the exchange bottle file to woce format and netCDF. I placed all three files online			
2010-10-20	Justin Fields	TCARBN	Website Update	Available under 'Updates'
	• Used the 20101007 bottle data submitted by Kristy McTaggert and the current online sumfile to create an exchange format version of the submission. • Checked submission file and compared it with our current file. No problems found. • The following parameters have now been updated: OXYGEN_FLAG, SALNTY_FLAG, THETA, CTDOXY, CTDOXY_FLAG, CTDSAL, CTDSAL_FLAG, CTDRAW, CTDTMP, CTDPRS. • Double checked the merge using the bottle compare tool, everything looked good. • Added a listing of all of the data PIs that were noted in the cruise doc. • Converted the exchange bottle file to woce format and netCDF. I placed all three files online			
2010-10-20	Alex Kozyr	DOC/TDN	Submitted	to go online
	Date: 2010-03-08 Action: Merge Data, Place Online Notes: Here are the DOC and TDN final and public data for merge into the master file. The data was sent to CDIAC by Dennis Hansell of RSMAS. Please, let me know when you done merging.			
2010-10-25	Justin Fields	TCO2/DOC/TDN	Website Update	exchange/WOCE/NetCDF files online
	• I merged the TCARBN, and TCARBN_FLAG_W parameters from Alex Kozyr's 2010.10.19 submission. • The data merged without issue, and I double checked it with the bottle compare tool. • Before merging TDN and DOC data from Alex Kozyr's 2010.10.20 submission I changed the units for Depth from CORR.M to METERS, and I change the pressure units from DBARS to DBAR. • Overall, I merged TCARBN, TCARBN_FLAG_W, TDN, TDN_FLAG_W, DOC, and DOC_FLAG_W. Data merged cleanly and no problems were found. • I double checked the new file in JOA, everything looked fine. I converted the exchange data to woce and netCDF, and I placed these files online.			
2010-10-27	Steve Diggs	CTD	Website Update	Exchange files now online.
	CTD/CTDO profiles in Exchange format from K. McTaggart on 2010.09.16.			
2010-12-05	Chris Langdon	Oxygen	Submitted	Discrete Oxygen data and flags
2010-12-08	John Bullister	Cruise Report	Submitted	Revised
	Attached is revised cruise report for CLIVAR a13.5 cruise in 2010			
2010-12-08	John Bullister	CFCs/SF6	Submitted	33RO2010_d
2010-12-09	John Bullister	CFCs/SF6	Submitted	calibration error corrected
	There was a small calibration error in the CFC/SF6 file: 33RO20100308_CFC_SF6_dec_8_2010.txt I submitted yesterday. Please use the corrected file: 33RO20100308_CFC_SF6_dec_9_2010.txt			
2010-12-09	Eric Wisegarver	NUTs	Submitted	None
2010-12-15	Alex Kozyr	fCO2	Submitted	to go online
	Cruise: 33RO20100308, A13.5_2010 line, R/V Ronald H. Brown: These are final and public discrete fCO2, fCO2 temperature, and fCO2 quality flags values CDIAC received from Rik Wanninkhof of AOML on 12/10/2010. The data were checked by CDIAC (Alex Kozyr) and Princeton (Bob Key) and ready to be released for public use.			
2010-12-20	Alex Kozyr	NUTS/CFC/SF6	Submitted	by S. Diggs for A. Kozyr merge
	Steve Diggs submitted these data for Alex Kozyr (who got them from John Bullister). Diggs made a ZIP archive of the two files submitted as to simplify the submission process.			